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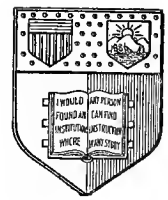

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SUPPLEMENT

TO THE

REFERENCE HANDBOOK

OF THE

MEDICAL SCIENCES

BY VARIOUS WRITERS

ILLUSTRATED BY CHROMOLITHOGRAPHS AND FINE WOOD-ENGRAVINGS

EDITED BY ALBERT H. BUCK, M.D.
NEW YORK CITY

VOLUME IX

NEW YORK
WILLIAM WOOD & COMPANY
1893

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TROW DIRECTORY
PRINTING AND BOOKBINDING COMPANY
NEW YORK

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PREFACE.

THE present volume is the outcome of a decision to bring THE REFERENCE HANDBOOK OF THE MEDICAL SCIENCES fully up to date. It was at first contemplated to revise the volumes of the work and issue a new edition of the whole; but as this would practically make obsolete the great number of sets of the HANDBOOK now in the libraries of physicians all over the world, it was considered preferable to publish a supplementary volume, which could be added to those already issued, completing, rather than destroying, the original edition, and at the same time enabling present possessors of the work to obtain the new matter at a comparatively small cost. Although the original work was published at short intervals during the period from 1885 to 1889, and consequently is not very old in point of years, nevertheless in some of its departments—especially those of Pathology, Materia Medica, and Therapeutics—the changes that have taken place in even this brief period of time are so great as to be almost startling in their magnitude. Much of this newly acquired knowledge still lies scattered throughout periodical medical literature, and has not yet been incorporated into the text-books that are used by a large proportion of the profession. The present, therefore, seemed a good time in which to gather together into a single supplementary volume all this scattered knowledge.

Soon after the work was inaugurated, it was found—as we then believed—that all of the available space would not be required for the adequate presentation of this recently acquired knowledge. Accordingly, provision was made for the introduction of a number of articles on different topics which had not been discussed at all in the original work. Many of these, it was thought, would add materially to the usefulness of the book as a work of reference.

In the progress of the undertaking the Editor has received valuable assistance from the following individuals, to all of whom he would now offer his grateful acknowledgments: Dr. John Green, of St. Louis, Mo.; Dr. Thomas Lathrop Stedman, of New York; Professor Charles Sedgwick Minot and Dr. William N. Bullard, of Boston, Mass.; Dr. Beaumont Small, of Ottawa, Canada; Professor Burt G. Wilder and Professor Simon H. Gage, of Ithaca, N. Y.; and Lieutenant-Colonel Charles R. Greenleaf, Major Alfred A. Woodhull, and Major John Van R. Hoff, of the Medical Staff of the United States Army.

He also takes pleasure in acknowledging the generosity manifested by the publishers in the present undertaking; for when it became evident that the volume could not be kept within the limits (number of pages) set by them beforehand, and so announced in their published circulars, unless some articles should be omitted altogether, and others very much shortened, they authorized him to publish all this material in its entirety, notwithstanding the great increase in cost to which they would thereby be subjected, without any addition in the pecuniary returns to them. In consequence of this decision the volume, as may be noticed, far exceeds any of its predecessors in the number of pages which it contains.

ALBERT H. BUCK.

SUPPLEMENT TO THE

REFERENCE HANDBOOK

OF THE

MEDICAL SCIENCES.

ABANO. An Italian watering-place, known to the Romans as Aquæ Aponi, or Aquæ Patavinæ.

LOCATION.—In the province of Venetia, six miles from Padua.

ACCESS.—From Paris, *via* the Paris, Lyons & Mediterranean Railroad; then through the Mont Cenis, Turin, Milan, Padua; or by steamer from New York to Genoa, and thence to Padua.

INDICATIONS.—These celebrated hot (200° F.) sulphur springs are much used in rheumatism, gout, scrofula, and all cutaneous and syphilitic affections. There are ten bathing establishments, with modern appliances. The waters contain bromine and iodine, but a reliable analysis is not at hand. Peat baths are also employed.

ACCOMMODATION.—Hotels and lodging-houses are not of the best. The village is interesting, but not clean.

Edmund C. Wendt.

ABBAZIA. One of the newer and most popular health-resorts of Austria.

LOCATION.—Abbazia is situated on a pretty bay of the Adriatic, in Istria, district of Finme, and about one hour's drive from the city of that name. It is fairly well sheltered from the north, east, and west winds. The Monte Maggiore acts as a protecting barrier. It is known as a resort on the "Austrian Riviera."

ACCESS.—By the Austrian "Südbahn," one hour from the station Matuglie.

INDICATIONS.—Abbazia has become decidedly popular recently as a winter station for neurasthenic people; also for subacute and chronic catarrhal affections of the respiratory organs. On account of its attractive location it is also used by the natives as a summer resort. Sea-bathing, promenades in pretty parks, establishments for inhalation, massage, mechano-therapy, etc., are among its resources.

Dr. Glax maintains the superiority of the winter climate of Abbazia over many other similar stations (*Aerztliche Mittheilungen aus Abbazia*, Wien, 1892). He gives elaborate tables of meteorological observations in substantiation of his views. But the impartial observer will only perceive that the climate of this resort somewhat resembles that of the Riviera generally, but is rather more moist than that district. The sanitary arrangements of the place are said to be satisfactory, and of its natural attractiveness there is no doubt. Nevertheless, Dr. Glax must be regarded as a local enthusiast.

ACCOMMODATION.—There is a large hotel, the Grand Hotel Abbazia, several minor ones, and a *Kuranstalt* called "Quisisana." Five or six physicians are in attendance. The winter season lasts from October to May. Splendid promenade along the shore.

Edmund C. Wendt.

ACETANILIDE (Phenylacetamide, Antifebrin). Of the host of new remedies that have been received during the past few years, this is one that has received general approbation and has sustained the reputation with which it was introduced. In Great Britain it has received official recognition by being placed in the Pharmacopœia of 1890. Since its introduction in 1886, by Drs. Kahn and Hepp, it has been extensively employed, without detracting from their estimate of its virtues. Further study has established its antipyretic and analgesic properties, and were it not that in phenazone and phenacetine we have drugs with a similar action it would be prized as of inestimable value. The tendency it has to cause profuse sweating and a condition of cyanosis has unfortunately engendered in many a sense of dread which has restricted its use. This toxicity is greatly over-estimated and should not be feared if the dose and mode of administering are attended to. It is rather a danger-signal far in advance of any serious consequences.

Kahn and Hepp in their original papers stated that one-fourth of a gramme (3.85 grains) was a sufficient dose, and subsequent writers have insisted on the efficacy of even smaller quantities.

Instead of the seven or ten grains so frequently given, the consensus of opinion now points to three or four grains as a more proper initial dose in every case where its use is begun, to be increased as the individual susceptibility is learned. There are also many points to be considered in its administration which influence its action. As the effect of the dose is continued for two or three hours the dose should not be repeated until that interval has elapsed. Where the use of the drug is persisted in for some time a day of freedom from its use should occasionally be allowed to intervene, as it undoubtedly possesses a sort of cumulative action. Many instances are reported where severe toxic symptoms have followed the same dose that had been given for some days with only beneficial effects. When the patient is anæmic, and in the debilitated and aged, the toxic symptoms more readily supervene, and in women, during the few days previous to menstruation, the condition of the blood is supposed to favor the decomposition of the drug and increase its action. The time of the dose, in relation to the natural rise or decline of temperature, is of importance; when given with the increase of fever its action is slower and within control, but if its effect coincides with the decline the fall will be rapid and probably in excess of what is expected.

Although the toxic symptoms are alarming it is a question as to how far they are dangerous. The cyanosis and sense of depression is not of long duration and is rapidly overcome. Fatal cases are rare and very large quantities of the drug have been taken without causing death. A case is reported in which teaspoonful doses were taken at short intervals until one ounce was disposed of, and in another instance seven and a half drachms were taken with suicidal intent. In both cases recovery followed.

Acetanilide possesses many advantages over other antipyretics. Its action is rapid and certain; the amount required is small and easily taken by the patient; it has no irritating effect on the digestive organs, but rather promotes digestion and improves the well-being of the body; and, what is of greater importance, it is devoid of any depressive action on the heart or circulation.

The toxic condition arises from an altered state of the blood and disordered function of the medulla and spinal

cord. The early symptoms are profuse perspiration and a bluing of the finger-nails and lips, accompanied by a sense of oppression; then follow vertigo and giddiness, singing in the ears, dilated pupils, cold extremities, subnormal temperature, slow and shallow breathing, feeble pulse, nervous twitchings, and convulsions.

How the drug produces its action is as yet undetermined. There is a lessening of the oxidizing property of the blood and the production of methæmoglobin, the arterial blood becomes of a dirty brown color, the serum becomes colored and hæmoglobinuria supervenes. In extreme cases and where the drug is administered for a prolonged period, it produces a state of anæmia. The disturbances in the medulla are considered to be secondary to the condition of the blood and not due to any direct action of the drug on the nerve-centres.

To counteract the poisoning, stimulating treatment is indicated. Warmth to the extremities and surface; alcohol, ether, and camphor by the mouth or hypodermically; belladonna is particularly recommended for its stimulant action on the centres, four drops of the tincture every half hour for four doses, afterward at longer intervals, having proved of service. Strychnine is also useful. The inhalation of oxygen is indicated. In extreme prostration the transfusion of saline solution has been adopted with benefit.

Acetanilide in fever is used solely as an antipyretic, and as such it has been classed as one of the best we possess. It is utilized in typhoid fever, pneumonia, phthisis, erysipelas, acute rheumatism, and in all conditions in which hyperpyrexia is present. It was thought by some to have specific properties in many of these disorders, but such views are no longer tenable; the duration of the disease is not affected, complications are not prevented, nor does it guard the patient against relapses. It reduces the high temperature and relieves the discomfort and distress that are present, and its sedative action on the nervous system adds to its calming and refreshing effect. Its continuous administration is not advised, but only its use when the temperature is such as to require interference.

In phthisis it proves particularly soothing, and by judiciously controlling the pyrexia night-sweats are lessened and prevented. In the hyperpyrexia of pneumonia it is used with advantage, but in this condition, as well as in advanced phthisis, where the respiratory tissue is reduced, it must be given with caution.

In acute rheumatism it relieves the painful and swollen joints and reduces the temperature. When the pains are severe it requires larger doses than in other febrile affections. Its action is generally thought not to be so efficacious as that of antipyrin or salicylate of soda, but it has not their disturbing influence on the digestive organs, and may be given where these drugs are not well borne.

Its analgesic properties have proved almost as decided as its power of reducing pyrexia. It is particularly useful in all pains due to irritation of the sensory nerves or pains of a reflex character, such as pains of locomotor ataxia, neuralgia, sciatica, lumbago, pains after operations, ovarian and menstrual irritation; also in migraine, nervous headaches, the headaches of growing children, and all paroxysmal pains it has proved equally successful.

It has been recommended and tried in epilepsy and chorea but without much advantage.

In the diseases of infancy it has proved of decided usefulness. Its effects are of longer duration and the toxic symptoms are not so liable to follow its use. In scarlet fever, measles, pneumonia, etc., its action has been most gratifying, reducing fever and restlessness and inducing a quiet and refreshing sleep. In whooping-cough it is also used with success; its action promotes expectoration and reduces the frequency and duration of the paroxysms.

Beaumont Small.

ACIREALE. A much-frequented climatic health-resort with thermal waters in Sicily, Italy.

Location.—Acireale is situated in the province of Catania, on the southern slope of Mount Etna. It has an elevation of 560 feet above sea-level, and has an old-established reputation, the springs having been known to the ancients as Aqua Santa Venere.

Access.—It is two hours' ride from Messina, on the Messina-Catania Railroad.

Indications.—The native Italians regard Acireale as an all the year round resort, but foreigners go there only in the winter season. The waters are sulpho-saline, and also contain iodides. The springs have a temperature of 70° F. They are used with advantage in rheumatism, gout, scrofula, and metallic poisoning; also in paralysis and neuralgia. The climate is said to benefit phthisis, emphysema, chronic respiratory troubles, anæmia, chlorosis, and neurasthenia.

The winter climate of Acireale is dry and mild. The death-rate is stated to be only nineteen per thousand. Mean winter temperature, 55° F. The variations are never more than ten degrees. The number of rainy days in the year range between thirty and fifty, but do not exceed the latter. Snow and fogs are unknown. Windy days are less in number than on the Riviera, and there is a complete absence of dust. The prevailing winds are the S.E., S.W., S.S.E., and E.S.E. The air is rich in ozone, owing to the vicinity of the sea. The luxuriance of the vegetation is almost tropical.

Accommodation.—The principal hotel is the *Grand Hotel des Bains*, facing due south. The town has 30,000 inhabitants. There are several medical establishments.

Edmund C. Wendt.

ACROMEGALY, or Akromegaly (*ακρον*, extremity; *μεγας*, great). Synonyms: Acromégalie; akromegalie; acromegalia; pachyacrie; Marie's disease.

Definition.—Acromegaly is a chronic disease, characterized by an abnormal increase in the size of the extremities of the body, viz., hands, feet, and generally head, due to an hypertrophy of the bones and soft parts of these regions.

History.—The first to recognize this disease as a separate entity was P. Marie, who wrote upon this subject in 1886. This first article of Marie's describes two cases which he had discovered while first assistant to Professor Charcot. He named this disease "Acromégalie" because he found all the extremities of the body enlarged, viz., hands, feet, and cephalic extremity, while von Recklinghausen suggests the name of "pachyaerie." Since the publication of Marie's first paper in 1886, a number of cases, reported in literature under various titles, have been discovered, which in all probability were cases of acromegaly. A few of the titles under which these cases were reported, all of which have unquestionably not yet been discovered, are "Exophthalmic Goître," "Myxœdema," "Hypertrophy of the Tongue," and, more frequently than all the rest, "Gigantism," or giant growth.

On the other hand, since 1886, a number of cases have been reported as acromegaly, which I do not believe to be cases of that disease. Thus far, somethiug more than one hundred cases have been published, some few of which, as just stated, are probably not acromegaly. The first cases discovered and reported as acromegaly (in 1885 Wadsworth reported a case as myxœdema, which was undoubtedly acromegaly) in America were those of Drs. O'Connor and Adler, both of which were published in 1888. In 1890, Marie published an article on a second new disease, which was at first confounded with acromegaly, but which clinically and pathologically is a distinct and entirely different disease ("De l' ostéoarthropathie hypertrophiante pneumique," *Revue de méd.*, 1890).

Most of the literature on acromegaly will be found at the end of this article, but the disease can be readily studied, as a whole, in the following publications: "De l'acromégalie, Maladie de P. Marie," Souza-Leite, Paris, 1890, gives a complete description, in detail, of all of the cases up to that date, thirty-eight in number. A translation of Souza-Leite's article in the New Sydenham Society, London, 1891, contains the above thirty-eight cases, and adds abstracts of ten more. In our own country,

Dr. Joseph Collins, of New York, in a most carefully prepared article, has brought the subject of acromegaly up to 1893, giving abstracts of all the cases reported since the publication of the above Sydenham Society report (*The Journal of Nervous and Mental Diseases*, December, 1892, and January, 1893).

Clinical History.—In acromegaly all of the projecting portions of the body are generally enlarged, hands, feet, chin, lips, nose, tongue, ears, and often the genitalia. Of these parts the bones, cartilages, and soft tissues are all hypertrophied. There is more or less progressive increase in weight, and generally increased appetite and increased thirst. Menstruation almost invariably ceases in the female, and the sexual appetite is generally diminished in the male. There is generally constipation; there may or may not be dyspepsia or polyuria.

Fig. 1.—Author's Case of Acromegaly. General View of Body.

The lower jaw is almost invariably enlarged, and generally to such an extent that prognathism is present. The superior maxillary bones may or may not be enlarged. The malar bones are generally enlarged, rendering the cheek-bones prominent. The supra-orbital ridges are generally projecting, and the forehead retreating.

The cartilages of the nose are enlarged, as are generally the cartilages of the ears and eyelids.

The soft parts of the nose and ears are also generally enlarged, and the nose is often massive. The cranial bones are rarely affected. The lower lip is more frequently enlarged than the upper, and always in excess of it. The face is oval, the cheeks flattened, the forehead retreating and low, the hair of the head strong and thick, and exophthalmos may be present.

The bones of the thorax are always enlarged, notably the extremities of the clavicles, the costal cartilages, especially at their junction with the ribs and the sternum, more especially at the xiphoid appendix. The ribs are generally widened, the scapulæ may or may not be enlarged, and sooner or later the vertebræ and the intervertebral cartilages become affected, the latter thickening and ossifying, causing kyphosis and other deformities of the spinal column. On account of the kyphosis and the shortening of the neck, the long projecting chin often almost rests upon the sternum.

The bones of the arm are generally not enlarged, except the lower part of the radius and ulna, thus causing an enlarged wrist. The bones of the hands, the metacarpal bones and the phalanges especially, are all widened and thickened. The soft parts of the hands are especially hypertrophied, giving the immense and often enormous acromegalic hands.

The pelvic bones are generally enlarged, this being particularly noticeable at the pubis and the crests of the ilia.

The thigh-bones are generally not affected except at the condyles, which are enlarged, and together with the almost constantly enlarged patellæ produce enlarged knee-joints. The tibiæ and fibulæ may or may not be enlarged, though frequently there is some hypertrophy of the extremities of these bones. The ankle-joints are generally enlarged, and the feet-bones and soft parts are affected similarly to the hands, and, like the latter, are enormous.

The heart, lungs, spleen, and liver are normal, although the heart may be slightly hypertrophied. The kidneys are generally normal, although there is often polyuria, but diabetes and albuminuria have sometimes been present.

Pain in the head is the most frequent subjective symptom, often severe and even terrific. There may be, and frequently are, joint-pains, or pains referred to various parts of the body, more or less persistent, but neuralgic in character. Frequently there is tingling of the hands, feet, or ears, often with numbness of the fingers, but with no great loss of sensibility.

There may be muscular hypertrophy, local or general, but later there is atrophy of the muscles.

Taste and smell are rarely affected, hearing is occasionally disturbed, sight is frequently impaired. The voice is loud and deep. The reflexes are generally normal, at least not markedly impaired, and electrical reactions are normal.

The intellectual faculties may or may not be impaired, but the memory is generally poor. Somnolency is sometimes present.

The superficial veins of the body are often enlarged, giving rise to hemorrhoids and varicose veins of the legs.

The skin may be dry and harsh, and is generally greatly thickened on the affected parts. There is often increased perspiration, local or general. The subcutaneous cellular tissue may be hypertrophied or atrophied. There is frequently an increased growth of hair on the body, especially on the arms and legs. The skin is often of a yellow color, especially marked on the face. Frequently molluscous growths appear on the face, neck, or body. Such are the notable symptoms of this interesting and peculiar disease. We will now enter into a more explicit description of the several symptoms.

General Condition.—The acromegalic patient comes to the physician complaining of headache, disturbances of vision, severe joint-pains or ringing of the ears (one case, at least, Osborne); or the case is discovered while the patient is under treatment for an entirely different dis-

ease. The head appears too large for the body, and more careful inspection shows the face to be entirely too large for the rest of the head. The hands and feet are enormous, and out of all proportion to the arms and legs, and, if the case is at all advanced, humpback or kyphosis is present.

The family history and the previous history of the patient himself have, up to the present time, been of no interest, so far as showing exciting or predisposing causes of this disease. There is never increased temperature unless due to an intercurrent affection. The pulse has been almost invariably normal, although it was stated to have increased in rapidity in one of the forty-six cases whose histories I have carefully examined (Godlee's case). There is rarely dyspnœa, and if present, only on exertion. The appetite is generally increased, and may be ravenous, although it is often stated to have been only normal. Thirst may or may not be increased. Constipation is frequently present. Polyuria and dyspepsia may be.

Early History.—In women the cessation of the menstruation is generally the first symptom of the disease. In two cases there was a history, in the early stages, of profuse and recurring epistaxis (Osborne's and Barclay-Symmer's cases). From the patient or his family proof of the continuous growth of the head, hands, feet, and body can generally be elicited, and commonly an approximate date for the beginning of the disease can be estimated.

The increase in size of the hats, shirts, gloves, or shoes can always be ascertained, and are positive evidences of growth.

In women the increase in the size of the fingers, as shown by the inability to longer wear the wedding-ring, which in many cases has been sawed off, is a positive evidence of growth frequently mentioned in the histories of the cases; also in many instances earlier photographs of the patient can be obtained and compared with the present condition. These signs and facts show a positive and continuous growth, and careful examination of the parts affected shows that this growth is largely of the bones.

I could find no definite data as to an increase of height, but it probably does invariably somewhat increase until the period when kyphosis develops, at which time some loss of height may take place, even to six inches in Paget's case. The weight always, at least for a time, increases.

Now, to examine the conditions more in detail we will begin with the head.

Head.—We find the forehead low and retreating, due to the growth forward of the superciliary ridges, which, with the elongation and forward projection of the lower jaw, gives the oval or elliptical face so characteristic of this disease. The hair is thick and strong, and the eyebrows are often heavy. (In Boltz's case the hair was gray.) We next notice that the face is entirely too large, that it is out of all proportion to the cranium proper. The skin of the face is thickened, and of a yellowish brown color, most marked on the eyelids, with, perhaps, here and there a molluscous growth.

The skin of the forehead is often redundant, and thrown into many transverse wrinkles or folds. The cheeks are generally flattened, and often appear sunken, largely due to the prominence and projection of the malar bones. The circumferences of the orbits are prominent, and the eyelids are large, due to the thickening and widening of the tarsal cartilages, with more or less hypertrophy of the skin, especially of the lower lid, where it may fall in folds, with occasionally the appearance of œdema. (In Holsti's case the eyelids were œdematous.) The eyeballs are large and generally more or less prominent, even to the condition of exophthalmos.

The nose, even for the size of the face, is too large, often immense, due to the thickening and enlarging of the nasal cartilages and to the great hypertrophy of the soft parts. It is wide, thick, and may be pugged.

The superior maxillary bones may or may not be enlarged, but are frequently lengthened from above downward; nevertheless, they are never enlarged to the same extent as is the lower jaw.

The upper lip is generally thick and projecting, but never attains the size of the lower lip.

The lower lip is almost invariably large, thick, everted and projecting, and is one of the characteristic features.

The enlargement of the lower jaw is one of the landmarks of this disease, although acromegaly can unquestionably occur without the enlargement of this bone. The angle of junction between the rami and the body becomes obtuse, and, while the rami may grow to considerable extent, the chief growth is in the body. The body of this bone widens and thickens all over, but especially on its alveolar border and at the symphysis, where the mental process becomes very prominent. The rami, however, may be so enlarged and widened as to force outward the lower part of the external ear (Dulles' case). The teeth rarely partake of this growth (in the congenital case described by Cènas the teeth were all enlarged); hence the growth of the alveolar process soon tends to separate the teeth from each other by continually increasing intervals. The teeth may fall out spontaneously (Mosler's case, aged forty-one years).

Sooner or later prognathism generally occurs, due not only to the growth of the body of the lower jaw, but also to the widening of the angle and the changes in the glenoid fossa (see description under Pathological Anatomy). This prognathism is of all degrees, and reached in Gause's case fifteen millimetres.

The external ear is generally increased in size, sometimes even appearing immense.

The cartilages and the soft parts both take part in the growth, and the former may become in places as hard as bone. (The cartilage of the helix of the left ear in the writer's case has apparently developed into bone, while the helix of the right ear is very thick and hard.)

The cartilages which form the outer portion of the external auditory canal, as well as the bony walls of the canal, may take part in this disease, as in the writer's case, where the canals are lengthened by the growth of the cartilages, and the bony canals are narrowed by the growth of exostoses from the superior walls.

The bones of the cranium are generally not enlarged, but the ridges and eminences may be abnormally prominent, especially the occipital protuberance (Adler's, Cènas's, and Campbell's cases). In Massalongo's case there were spiky, osseous protuberances along the sutures of the skull, especially the lambdoid. The entire cranium is stated to have been enlarged in the cases reported by Adler and S. Solis-Cohen, while O'Connor's case showed some very atypical enlargements, or tumors, on the parietal bones.

The mucous membrane of the nostrils is frequently found hypertrophied. The sense of smell is very rarely affected. (Much impaired in Godlee's case.)

The tongue is broad and thick, and frequently of double its normal size, almost entirely filling the cavity of the mouth, so that the sides show indentations from the teeth. The upper surface of the tongue is often deeply corrugated, marked by deep lines and fissures, and the papillæ may be prominent and projecting. During speech the massive tongue gives the impression of weight and clumsiness. By the large tongue and the prognathism the speech is rendered thick, heavy, and often slow, while the labial and dental sounds are poorly articulated. The tongue is generally clean, but Long found it, in his case, always covered with a grayish-yellow coating.

The soft palate is often thickened, the uvula may be wide and long, even as large as a little finger (Boltz's case), and the epiglottis has been found considerably thickened. The larynx is enlarged, either as a whole, or in one or more sets of its cartilages. The ary-epiglottic ligaments have been found thickened (Gause's case), and the vocal cords hypertrophied (Fratrich's case). These conditions render the voice loud and harsh, the voice in women becoming masculine, and in men of much lower pitch.

The thyroid cartilage is often enlarged, as is also the

cricoid cartilage and frequently the hyoid bone. The submaxillary and other glands (lymphatics) of the neck may be enlarged (Adler's case). The thyroid gland may be normal in size, hypertrophied, cystic (Godlee's case), or so atrophied that it cannot be found.

The neck is short and thick, and the head leans forward, which with the cervico-dorsal kyphosis causes the long projecting chin to almost rest on the sternum.

Body.—Sooner or later, but almost invariably if the case is far enough advanced, the irregular formation and laying on of bone in the spinal column causes deformities of the spine. This deformity is almost constantly a cervico-dorsal kyphosis (Hare's case was dorsal), giving a humpback appearance very characteristic of this disease. Occasionally scoliosis is also present, and sometimes a compensatory lumbar, or dorso-lumbar, lordosis. The spinous processes of the vertebræ are frequently found abnormally prominent, especially the lower cervical.

The circumference of the chest is greatly increased, especially at the level of the ensiform cartilage, where it is the greatest. Laterally the chest appears flattened, while the antero-posterior diameter is often enormous. The sternum is generally widened and thickened, and projects outward, especially the hardened and enlarged xiphoid cartilage.

There are often prominent transverse ridges on the sternum, and there may be a hollowing or apparent sinking-in in the region of the manubrium, due to the irregular growth of the sternal segments. There may be triangular-shaped hollows at the sides of the sternum. A dulness on percussion is sometimes found at the upper end of the sternum, attributed by Erb and Verstraeten to an enlarged or persistent thymus gland, but though this gland has occasionally been found enlarged, Arnold has shown that the dulness is due to a thickening of the bone.

The clavicles are most enlarged at the sternal extremity, but the acromial end is also generally thickened.

The ribs are wide and very oblique, and at their junction with the more or less enlarged and ossified costal cartilages are generally found bony nodules, not unlike the rachitic rosary. The ribs are rendered oblique, and the lower ones are forced outward, by the great growth of the costal cartilages. The hardening of the ligaments and cartilages of the chest causes a peculiar stiff and constrained up-and-down, or out-and-in, motion of the lower part of the thorax during respiration, and the abdominal respiration is increased. In Packard's case the chest was very irregular, some of the ribs being very large and having numerous nodosities on their surfaces. In O'Connor's case there were distinct, circumscribed tumors on some of the ribs, and on each clavicle, at the sternal junction, was a sharp, inward projecting exostosis.

The abdomen is generally flattened and even appears retracted from the forward projection of the sternum and costal cartilages, though in Massalongo's case the abdomen is stated to have been "bulky and pendant."

The pelvis is generally enlarged in all parts, but the most marked hypertrophy occurs in the pubic bones, and in those at the symphysis pubis. The ilia seem to be wider apart, and the crests are broad and prominent. The penis is often enlarged, notably so in Cènas's case. The labiæ majoræ, as well as the labiæ minoræ may or may not be enlarged, the clitoris may be hypertrophied, and the vagina may be lengthened, but the uterus is generally small and atrophied.

Upper Extremity.—The shoulder-joint may be, but rarely is, much enlarged; the arm is small, at least not enlarged; the elbow-joint may be increased in size; the forearm is often enlarged at its lower third, especially just above and at the wrist; the wrist-joint is almost always large. The hand, widened, thickened, and often lengthened, is massive and enormous, and appears heavy and cumbersome for the relatively small arm to carry. The ends of the metacarpal bones and phalanges are enlarged, giving prominent joints. The skin of the hand and the subcutaneous tissues are greatly hypertrophied, so that the normal lines of the palm are greatly deepened, even to the appearance of fissures in the flesh. At the upper part of the hand, and over the metacarpal bone of the thumb, and on the ulnar border, the hypertrophy of the soft parts is excessive.

The fingers, by the growth of phalanges and soft parts, become of the same width and thickness at the tips as at the bases, giving the appearance called "sausage-shaped," which is a characteristic feature of this disease.

The above-shaped fingers, with the great thickness of the soft parts over the metacarpal bone of the thumb and on the ulnar border of the hand, with the exaggerated palmar lines, and the abnormal proportion of the hand to the size of the forearm, render the acromegalic hand a landmark not easily forgotten.

The fingers may appear somewhat flattened, and, according to Marie, there is often a manifest swelling at the articulation of the first and second phalanges.

FIG. 2.—Author's Case of Acromegaly. View of Enlarged Right Hand.

The nails are flattened, short, and sometimes widened, but always appear too small for the enlarged fingers, whose redundant flesh laps over them at the sides. The lateral borders of the nails sometimes curve upward when the hand is examined with the palm resting on the table (Marie). There are strongly marked longitudinal striations, sometimes even with ridges, and there may be transverse striations on the nails. They are also often brittle, breaking off or cracking easily.

In Cènas's case the nail of one finger fell off spontaneously and a new one developed.

Lower Extremity.—The thighs are generally not increased in size, although the condyles of the femurs are generally prominent and enlarged, which with the hypertrophy of the patellæ causes a marked enlargement of the knees. The upper ends of the tibiæ and fibulæ may or may not be enlarged, but the lower ends of the leg-

bones are generally found hypertrophied, causing prominent malleoli and large ankle-joints. The tendo Achillis is frequently prominent and hardened, or "rope-like" (Barclay-Symmer's case). The foot is described as "massive," "colossal," and "enormous." The bones of the feet are all enlarged and especially the os calcis, which projects backward, giving a marked prominence to the heel. The foot is thick and broad, with a prominent cushion of thickened skin and subcutaneous tissue on the external border, a characteristic feature of the foot in acromegaly. The toes are all large, but more especially the big toe, which is immense, and crowds the other toes together. The skin of the foot is redundant, hypertrophied, and thickened, especially on the toes, causing them to appear pushed back and turned up, throwing the skin into great folds on the upper surface of the toes. The nails of the toes present appearances similar to those of the fingers.

The projecting os calcis, covered with a cushion of hypertrophied skin and fat, with the pad of hypertrophied tissue on the external border of the foot, with the immense big toe pushing against the other toes, and the redundant skin, makes the acromegalic foot as prominent a landmark as the hand.

Asymmetry.—Acromegaly is primarily a symmetrical

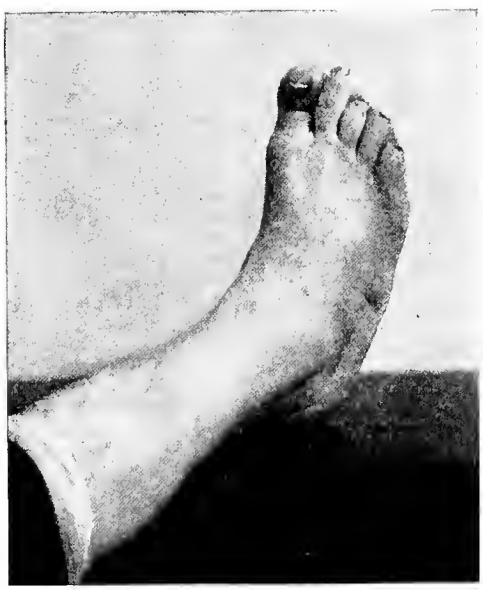

Fig. 3.—Author's Case of Acromegaly. View of Foot with Enlarged Toes.

disease, one part enlarging correspondingly with its fellow on the other side, but in many cases it is recorded that one side of the body was larger than the other, and that the right half of the body was more frequently the larger. In a number of cases data are given showing the growth to have commenced in one foot or one hand, or both feet or both hands, before other parts of the body were affected.

In fact, the growth probably generally starts in the hands and feet; later, the face and lower jaw are attacked; next, the lower ends of the arm and leg bones; next, the crests, tubercles, ridges, and eminences show growth, and about this time kyphosis develops, while lastly cartilages and tendons all over the body show bone-development. Besides the slight asymmetry of the two sides of the body, some atypical cases have occurred. In Kanthack's case the second toe of the left foot was enormously enlarged, far beyond the size of the other toes. In Cènas's case the face, head, hard palate, cheeks, lips, and tongue were much larger on the right side than on the left. All the fingers of the right hand were affected, but only the thumb and first finger of the left hand were enlarged; while, on the other hand, all the toes of the left foot were hypertrophied, and only the first, second, and fifth toes of the right foot. Also peculiar in this case was the fact that the fifth toes on both feet were larger than the third and fourth toes. Litthauer's case showed a slight talipes valgus.

Muscles.—At first the muscle-growth and muscular power are increased, and sometimes the development of the muscles may be very great, as in Virchow's case of the man Westphalen. Sooner or later, however, the muscles become atrophied in greater or less degree, and the muscular power is greatly diminished, even to the point of compelling the patient to remain in a sitting or reclining posture, or even forcing him to remain in bed. There may be recurrent attacks of great loss of muscular power, so that the patient must be assisted in his dressing, to be followed by periods of improved strength.

The muscles of the arms and legs at this period are flaccid and shrunken, and Virchow suggests that some of the kyphosis and scoliosis may be due to muscular debility. Some of the muscles may be found atrophied, as Boltz observed in his case the pectoralis major and the supra- and infra-spinatus in that condition. On the other hand, even while this condition of muscular weakness is present, there may be hypertrophies of certain muscles.

Mosler found the deltoid, supra-spinatus, rhomboideus, and biceps hypertrophied. In the writer's case, the supra-spinatus on the right side is so greatly hypertrophied as to constitute a large muscle-tumor, adding greatly to the kyphotic deformity.

Skin.—The subcutaneous fat may be increased or diminished, but later is generally found diminished, except, perhaps, on the diseased portions of the body. The skin on the affected parts is hypertrophied, and generally, especially where exposed, is olive-brown or yellowish in color. This yellow color is most marked on the face, and here most noticeably on the eyelids. The face may, however, be pale, or the nose may be red, as in Mosler's case. The skin may be dry and harsh from diminished sebaceous secretion. There is frequently increased perspiration, coming on with slight exercise, or even without exercise, either general or local on the diseased portion of the body, and especially frequent on the legs. This perspiration may have a disagreeable odor. The growth of the hair all over the body is generally increased. That of the head is thick, strong, and coarse, while the hair on the hands and forearms, and more especially on the legs, is greatly increased. There may be pigmentations on the skin, as in one of Marie's, in Barclay-Symmer's, and in Massalongo's cases. Litthauer speaks of the hands in his case as being of a light bluish color, while in the very interesting case of Cènas there were various-sized and -shaded violet spots on the hands, feet, legs, and body, with also a stripe-like line of vitiligo on the inner and back part of the thighs and legs. Growths of molluscum fibrosum frequently occur on the face, especially on the eyelids, and on the chest or back, generally pendulous in character. Multiple fibromata of the skin may occur, of the size of a millet-seed, and, according to Mosler, are especially apt to occur on the neck and in the hypochondriac regions. Fatty nodules may be found beneath the skin, and Litthauer reports, in his case, a 10 ctm. long and wide lipoma in the right supra-spinatus fossa.

Blood-vessels.—There are always vaso-motor disturbances of the affected portions of the body, as shown by the tingling, flushing, and local sweating. The flushing is often accompanied by a "burning pain." Besides these signs, which denote the dilatation of the small blood-vessels, there is a marked tendency to a dilated and varicose condition of the superficial veins, which is frequently found on the legs. Hemorrhoids are often present, and Graham's first case had a double varicocele, and profuse epistaxis may occur. O'Connor's case had enlarged veins of the neck, and Cènas's case had dilated veins on the forearm. Hare's case had a hemorrhage from the lungs. Mosler says that the arteries, radial and temporal, may show signs of beginning atheroma.

The blood has been many times examined, but, though the red corpuscles or the hæmoglobin may be decreased, no marked or constant changes have been found.

Internal Organs.—The lungs are normal, although there may be some dyspnœa, especially on exertion. The heart is normal, though often enlarged by simple hypertrophy; the pulse is generally normal, but tachycardia was present in Massalongo's case. Boltz found a soft systolic blowing sound at the apex in his case, probably hæmic, while in Holsti's case there was mitral disease. The liver and spleen are almost constantly normal in size.

The kidneys, as interpreted by the examination of the urine, are generally normal, although polyuria is often present, and albuminuria may be (writer's case). Sugar has been several times present and persistent, and two cases, at least, are recorded as having died of diabetes (Bury's and Thomson's). Peptone has been found in the urine in acromegaly in a few cases (Graham's first case, Cènas's case), being first discovered by Professor Bouchard.

Sight.—The eyes may be normal, but are frequently affected, in all degrees from occasional flashes of light (writer's case), or eye-blurs, to narrowing of the fields of vision and atrophy of the optic nerves, even to absolute blindness. Exophthalmos is often present, due both to actual enlargement of the eyeballs and to bone-growth in the orbital cavities. The pupils are generally normal in size but may be dilated (Long's and Ruttle's cases), and the reaction is generally as usual, though it may be slow to light but normal to accommodation. Nystagmus has been present in Boltz's case (rotatory nystagmus), in Long's case (which was blind) and in Packard's case (vertical nystagmus). Litthauer's case showed some strabismus divergens from insufficiency of both internal recti muscles, and Packard's case showed the same condition of the right eye. Marie says that we may early find, while vision is but slightly impaired, signs of optic neuritis caused by pressure. Narrowing of the visual fields has been found in all degrees even to bitemporal hemianopsia (Ruttle's, Packard's, Dulles's, Mosler's, Hare's, Boltz's, Schultze's, Strümpell's, Litthauer's, and Denti's cases). Optic atrophy, partial or complete, of one or both eyes, has frequently been found (Hadden and Ballance's, Ruttle's, Packard's, Hare's, and Boltz's cases, and in Long's case with total blindness). The retinæ may show venous congestion, the arteries may be small, or they may appear pale (Massalongo's case), or a congestion as of a neuro-retinitis may be present (Denti's case).

Hearing.—The hearing is not generally affected, but occasionally there has been decided deafness (Flemming's, Berkley's, and Osborne's cases). In two cases, at least, Barclay-Symmer's and the writer's, continuous and never-ceasing tinnitus aurium has been present, and Holsti's case complained of "rumbling and swashing" sounds in the ears. This ringing, or singing, in the ears is, in the writer's case, greatly increased on lying down, and often the patient, from this cause alone, cannot sleep at night but must remain in a sitting posture. The tinnitus in this case is increased on excitation as well as on lying down, and is often of a pulsating character, though of a fine, high-pitched tone, when he is at rest. He refers the tinnitus to the middle of his head. The drum may be hardened and thickened, and so stiffened as to be immovable.

Smell and Taste.—These are but rarely stated to have been affected, though in Godlee's case both were impaired, and in Brignini's case taste was slightly affected.

Nervous Phenomena.—A most constant symptom is pain in the head, which may be referred to any region, but is generally frontal or vertical, and in the writer's case was located in a small circumscribed spot, tender to pressure, over the region of the anterior fontanelle. This pain may be so mild that it is hardly complained of, or so severe, violent, and excruciating as to almost render the patient insane. Pain is often present in the joints, especially the knees, and is often severe in the fingers. Pain is frequently complained of in the chest, or abdomen, shooting around the body, or confined to one side, or it may be lumbar or sacral. Almost every case of acromegaly has pain, more or less constant and severe, in some part of the body, generally without any local cause. The pain in the head, however, I believe is often due to the enlarging pituitary body, though at other times probably to the dilatation of the blood-vessels of the brain; hence the increased headache on lying down, with the feeling of pressure, as has been the condition in several cases. Crepitations may be found in some of the joints, which, of course, would account for the pain there, though there is no swelling or signs of acute inflammation. Pain sometimes seems to centre at one of the small fibromata which occasionally develop in the skin.

Sometimes a peculiar nervous sensation is complained of, a sensation as of a nervous discharge, or electric shower, starting from the top of the head and passing quickly over the body to the feet. This is sometimes described as giving the sensation of the rolling of shot, hence it has been termed the "shot feel."

There are no marked or constant paræsthesiæ in acromegaly, though slight numbness or prickling of the affected parts is often found, most frequently in the fingers. The tactile sense of the fingers may be impaired, so that small objects cannot be readily handled, and sewing, knitting, or even dressing, becomes difficult. Where this condition is present it may become much improved, though the growth of the body and the advance of the disease may continue (Mosler's case). Of course, there is always clumsiness in the use of the fingers from the size alone. In Mosler's case the fingers would, at times, become pale and white, accompanied by severe pain, especially at night, evidently due to vaso-motor spasm. Formication of the affected parts may be complained of, and in Adler's case there was hyperæsthesia of all the hypertrophied parts, even slight pressure causing the patient pain. Ruttle's case had in the early part of the disease numbness all over the body. Permanent anæsthesia, analgesia, or impaired perception of heat or cold are certainly rare conditions in this disease.

The electrical responses of the muscles and nerves are rarely found abnormal.

The reflexes, both deep and superficial, are generally unimpaired. Occasionally the patellar reflexes are diminished, and sometimes absent on one or both sides (Packard's and Strembo's cases).

The mental faculties in the majority of cases are not impaired, but still in a large number of cases it is recorded that there was loss of memory, or apathy, or dulness and sluggishness of the mind, with or without a depressed state. Marie says that there may be a state of great good humor, but, on the contrary, the condition of melancholia is more frequent, and even suicidal tendencies may develop.

There may be great irritability (Packard's case), while there may be delusions, and the patient may be refractory and suspicious (Berkley's case). Pick's case showed at times decided insanity, and the patient finally committed suicide.

The writer's case, also, five years ago, for a period of four weeks, had frequent attacks of mental aberration, in which he not only attempted to commit suicide but showed homicidal tendencies.

Another interesting condition which seems to quite frequently occur in acromegaly is somnolency. An excessive example of this somnolency was Packard's case, which had three attacks, the first lasted for three weeks, and the second and third lasted even a longer time, the last becoming a profound stupor, so that for days at a time the patient lay with the eyes open, but could not be aroused. This patient, however, came out of this condition, and was able to leave the hospital. This somnolency is, however, generally only a drowsiness, with a constant desire to sleep.

Vertigo may occasionally occur, and be severe enough to cause the patient to grasp something for support, and also there may be attacks of syncope.

Ruttle's case, one year after the stoppage of menstrnation, was seized with a sudden attack of dizziness fol-

lowed by total loss of consciousness, and for three weeks it was thought that she could not live. Convalescence was slow, interrupted by relapses of agonizing pain and vertigo, with loss of consciousness. These attacks became less and less frequent, but loss of consciousness could be produced at any time by a playful slap on the shoulder, or by the slamming of a door.

Pituitary Enlargement.—Exactly how frequently pituitary enlargement takes place, of course, cannot be stated. A number of autopsies have been made in which the pituitary body was not enlarged. Clinically, I believe, a positive sign of the enlargement of this body to be impairment of vision. Out of thirty-three cases stating the condition of the eyes, eighteen had impairment of vision, of a greater or less degree, while in fifteen the vision was normal. In these eighteen cases there was pituitary enlargement, in all probability, with pressure on the optic tract or chiasma, and it is not at all improbable that some of the fifteen negative cases may later show loss of vision. In the cases in which tinnitus aurium is constantly present I believe it is often due to the pressure of the enlarging pituitary body, laterally, upon the cavernous sinuses. It also seems probable that the conditions showing sudden and serious brain trouble, as in Packard's, Berkley's, Pick's, Ruttle's, and the writer's cases, all of which point to cerebral tumor, are due to the first sharp pressure which the enlarged pituitary body exerts upon the brain, having perhaps suddenly burst from its bony moorings.

That in some cases one eye, in others both, and in still others the ears alone are affected, seems to me could be explained by the condition of the bony environments of the sella Turcica in the individual skull, the enlarging pituitary body tending to press in the direction of the least resistance. The middle clinoid processes being small the earlier will the pressure be exerted on the optic commissure, or if one of these processes is smaller than the other the pressure will first be exerted on that side, and one eye may be affected.

The following table shows the frequency of some of the most important symptoms of acromegaly · it has been compiled from thirty-four original articles of true cases of acromegaly, plus the abstracts of twelve cases for which I am indebted to Dr. Joseph Collins. These forty-six cases have been taken at random, and the completeness with which each case was reported varies greatly, but the statistics here appended may be of some value. In no case is a symptom considered as present or absent unless positively so stated to be ; consequently the frequency with which any symptom is present or absent must be compared with the number of cases reporting it, and not with the forty-six cases.

Important symptoms.	Number of cases.	Symptoms present.	Symptoms absent.
Hands enlarged	46	46	0
Feet enlarged	45	45	0
Lower jaw enlarged	37	36	1
Eyes affected	33	18	15
Kyphosis	23	21	2
Prognathism	17	15	2
Lower lip enlarged	27	26	1
Upper lip enlarged	18	15	3
Nose enlarged	29	29	0
Tongue enlarged	31	31	0
Voice changed	24	23	1
Taste impaired	14	2	12
Smell impaired	11	1	10
Hearing impaired	20	4	16
Ears enlarged	23	13	10
Face elliptical	20	18	2
Forehead low	10	9	1
Supra-orbital ridges large	16	13	3
Malar bones enlarged	21	17	4
Superior maxillæ enlarged	9	4	5
Exophthalmos	5	5	0
Eyelids enlarged	10	6	4
Cranium enlarged	10	3	7
Clavicles enlarged	21	18	3
Scapulæ enlarged	9	4	5
Sternum enlarged	12	10	2
Costal cartilages enlarged	8	8	0
Lordosis	7	4	3
Scoliosis	11	8	3
Pelvis enlarged	7	4	3
Generative organs enlarged	7	4	3
Arms enlarged	19	4	15
Forearms enlarged	12	5	7
Fingers sausage-shaped	9	9	0
Nails short and broad	16	14	2
Wrist enlarged	10	9	1
Crepitation in joints	8	3	5
Legs enlarged	19	10	9
Knees enlarged	5	5	0
Patellæ enlarged	8	7	1
Ankles enlarged	5	5	0
Varicose veins of legs	8	7	1
Albumin in the urine	19	2	17
Sugar in the urine	24	4	20
Skin yellow	8	7	1
Increased growth of hair	12	8	4
Paræsthesiæ	21	16	5
Muscular atrophy	12	11	1
Muscular hypertrophy	4	4	0
Increased strength	6	4	2
Diminished strength	22	20	2
Increased perspiration	15	13	2
Pain in some part of body	17	16	1
Headache	27	23	4
Somnolency	9	8	1
Intellectual faculties impaired	27	16	11
Increased appetite	20	10	10
Increased thirst	16	9	7
Polyuria	10	6	4
Constipation	9	8	1
Dyspepsia	6	2	4

Pathological Anatomy. — Eleven autopsies, at least, have been made upon cases that have died while suffering from acromegaly. Three of these cases were not diagnosed until after death, and after the autopsical reports had been on record for some time, viz.: Brigidi's, Henrot's, and Thomson's. The other cases are those of Klebs, Broca, Virchow (Fraentzel), Holsti, Bury, Arnold, Sarbo, and Gonzalez Cepeda.

Seven of these cases showed either a hypertrophied pituitary body (Brigidi's, Klebs's, Broca's, Gonzalez Cepeda's, Thomson's) or a tumor excavating the sella Turcica (Henrot's, Bury's). Brigidi's case furnishes a skeleton very typical of this disease. Henrot's case has been considered to be a case of myxœdema, but the positive bone enlargement certainly proves it to have been a case of acromegaly. In this case there was mucoid degeneration of the pneumogastric and glosso-pharyngeal nerves, of the brachial plexus, and of the ganglia and cord of the great sympathetic, while a tumor was located in the region of the pituitary body.

Thomson gives a very careful description of the skeleton of a case of acromegaly, the autopsy and history of which had been reported by Dr. D. J. Cunningham under the title of "A Large Subarachnoid Cyst Involving the Greater Part of the Parietal Lobe of the Brain."

The pituitary body in this case was greatly hypertrophied, being four or five times its usual size, and though soft and pulpy had caused considerable enlargement of the sella Turcica. The brain itself was also enlarged.

Klebs found not only enlargement of the pituitary body, but also a large thymus gland. The brain in this case was also enlarged, and there was thickening of the cranial nerves, especially the oculo-motor and optic.

Broca made the autopsy and described the skeleton of one of Marie's first cases. He also found an enlarged pituitary body.

Virchow showed and described the skeleton of the case of Fraentzel. In this case the pituitary body was normal.

Holsti found in his case an enlarged brain, and a large, pulpy pituitary body. He also considered the cranial nerves to be broader than normal. There was a fatty growth in the region of the thymus.

In Bury's case there was a large tumor at the base of the brain, a glioma, excavating the sella Turcica, pressing upon the optic chiasm, and extending to the cerebellum. There were traces of what may have been a persistent thymus.

Arnold gave a very exhaustive and careful description of the skeleton of Friedreich's case, viz., one of the brothers Hagner. Marie does not consider these brothers to have had acromegaly at all, and gives several valid reasons for his opinion, but I cannot but think with Virchow, Arnold, Mosler, and Erb that they did suffer from acromegaly. They are, however, very atypical cases, and there was unquestionable elephantiasis of the legs present. The pituitary body was normal in Arnold's case.

Sarbo found in his case, which had had syphilis, evidence of peri-encephalitis chronica. The pituitary body was normal.

Gonzalez Cepeda found an enlarged pituitary body.

Such are the special points of interest in these several cases.

The constant pathological findings in acromegaly are enlargement of the bones of the hands and feet, and almost invariably enlargement of the lower jaw. The ends of the long bones are very generally found enlarged. The pituitary body, as we have seen, may or may not be enlarged, but if we take into consideration the number of cases still living that have shown positive signs and symptoms of pituitary enlargement, we cannot but agree with Marie and Broca that it is a pathological finding of great importance.

On the other hand, an enlarged thymus gland (Klebs and Erb) or the possible fragments of a persistent thymus have been found so infrequently as to present no pathological importance in this disease, but is rather a curiosity. As to the thyroid gland, which Marie at first considered to be almost always atrophied in this disease, though still a factor of great interest and careful examination, it has not shown any very constant condition, either clinically or pathologically. It may be enlarged and hard (Holsti), enlarged and cystic (Bury), normal (Virchow, Sarbo), or diminished in size.

The lungs are not affected (Sarbo found phthisical processes in the lungs of his case); the heart may or may not be hypertrophied; the liver and spleen are normal (both diseased in Holsti's case, liver enlarged in Bury's case). The kidneys may or may not be found diseased.

The nerves, as stated above, may be affected, and Marie thought that there was constant hypertrophy of the cord and ganglia of the sympathetic system. The spinal cord does not seem to have been carefully examined. Syringomyelia was present in Holschewnikoff's case (if indeed this was a case of acromegaly) and mucoid degeneration in Henrot's case. The cerebrum has been found increased in weight, which is due to a general growth, and Klebs found that there was an increase of the neuroglia cells, but in direct proportion to the general enlargement of the brain-substance.

There is widening of the blood-vessels and thinning of their walls, especially of the veins, as was first pointed out by Klebs and Erb. The valves of the veins have been found enlarged. The thinning of the vessel-walls weakens them, especially the veins, and, as a result, we frequently find a varicose condition of the veins of the legs, hæmorrhoids, and enlarged veins of the arms, neck, or head. The epistaxis noticed in two cases (Osborne's, Barclay-Symmer's) may have been due to the same cause. Klebs found an increase of the cells in the walls of the blood-vessels, which he considered to be the cause of the widely distributed new growths of blood-vessels, or angiomatosis, and this the cause of the tissue hypertrophy. Von Recklinghausen, however, found no such indication of growth of new blood-vessels. The muscles at the time of death, unless the patient dies early in the disease from some intercurrent affection, are found very generally atrophied, although there may be local hypertrophies. Certain muscles, especially the deltoid or supraspinatus, may become markedly hypertrophied, forming veritable muscle-tumors. One side of the body, most frequently the right, may and often is, larger than the other, both in the size of the bones and of the soft parts, but more especially the latter. Von Recklinghausen, with Marie and Mosler, does not agree with Virchow in calling an enlarged extremity a "partial acromegaly."

The subcutaneous fat may be increased or decreased in thickness, but in the later stages it is probably nearly always decreased. The skin is hypertrophied over the affected portions of the body, sometimes enormously. All the layers of the skin take part in this thickening.

Elephantiasis has occurred in three cases—the brothers Hagner and in Lombroso's case. In the former cases the legs were affected; in the last case the forearms and face.

Von Recklinghausen says that fibromata and neuromata of the skin can be present in considerable number in acromegaly. Molluscous growths are of frequent occurrence.

Now turning to a critical survey of the skeleton, we find that we are indebted to Broca, Virchow, Arnold, and Thomson for the careful study of the condition of the bones found in this disease. Broca says that the enlargement of the bones is in the extremities, and at the ends of the bones. He also says that it is the spongy tissue of the short bones and flat bones that is affected, and the epiphyses of the long bones. Holsti, however, found the compact substance of the bones thicker than normal. This growth of bone is an hypertrophy, the bone growing from the periosteum, and in the medullary spongy tissue at the ends of the long bones. The growth in the early part of the disease seems to be more especially confined to the periosteum; later, the apophyses and epiphyses become affected; next, the crests, tuberosities, and eminences enlarge and grow in the direction of the muscular action. The tendons are often found in deep grooves or bony canals, and the foramina for the nutrient arteries are enlarged.

Osteophytes may be found in the joints, especially over the wrist- and ankle-joints, and the cartilages show bone developments.

The spongy ends of the long bones now become more compact, the architecture changing, the bone-cells increasing, and eburnation taking place. The ends of the bones in Sarbo's case showed condensing osteitis. As Arnold showed, the long bones may apparently lengthen by the laying on of bone at the extremities, while the shaft is not at all affected; and von Recklinghausen has suggested that the giant appearance of some cases of acromegaly could be due to the late union of the epiphysis with the shaft, the epiphysis becoming widely separated from the shaft by the new bone, thus causing a pronounced lengthening.

Before turning to a more careful survey of the various bones, it must not be forgotten that the duration of the disease must be considered when examining any particular skeleton, as widely different conditions of the bones are found at different stages.

The bones of the cranium are often found thickened (Thomson's case had thickening of the cranial bones varying from 6 to 12 mm.) and hardened, true bone developing in the diploë, as well as the external and internal plates becoming hypertrophied. The ridges and crests for the attachment of muscles and fasciæ are more prominent, while the occipital protuberance has been found as a spicula-like outgrowth, an exostosis. The parietal eminences are sometimes abnormally prominent, as are always the superciliary ridges, the latter being due not only to the dilatation of the frontal sinuses (Broca), but also to the thickening of the plates of the frontal bone in this region (Thomson). The sphenoidal sinuses have been found dilated (Broca), and also the antrum of Highmore.

The lengthening of the face is largely due to the increase in the vertical diameters of the superior and inferior maxillæ. The malar bones are almost always prominent and projecting, the ridges for muscle attachment being pronounced. The orbital cavities are large, widened transversely, with the borders prominent, especially at the external angle. Some of the sutures of the bones may be obliterated, as in the articulations of the superior maxillæ and malar bones in Thomson's case. The external auditory canal may be increased in length by the growth of the cartilages and the formation of new bone. These canals may also be found narrowed by

exostoses. The glenoid cavities are increased in size, probably due, as Thomson suggests, to the large size of the condyles of the lower jaw. The eminentia articularis may disappear, giving an opportunity for the condyle to come forward, thus adding to the prognathism caused by the growth of the lower jaw.

The lower jaw is described as massive, the chief growth being in the body, which is found lengthened and widened, especially at the symphysis, with the mental process prominent and projecting. The alveolar process is widened and thickened, and the rami also may partake of this growth, while the angle of junction between the body and rami becomes more obtuse. In Thomson's case the coronoid processes extended upward more than one-third higher than normal. The growth of the alveolar process is rarely participated in by the teeth (except Cènas's case), they remaining normal in size, so that, the alveolar cavities enlarging, we frequently have spontaneous falling out of the teeth.

The projecting lower jaw and lengthening of the chin, it must be remembered, are not always found in acromegaly, as undoubted cases have occurred in which these conditions were absent. This growth of the lower jaw being present, on the other hand, with enlargement of the hands and feet, is, I believe, pathognomonic. Thomson found the margin of the foramen magnum surrounded by irregular protuberances of spongy bone.

Whenever an enlarged pituitary body has been found the sella Turcica has been found deepened and enlarged in all directions, due to the bone wasting from pressure.

The hyoid bone may be enlarged and its ridges very prominent.

Changes are always found in the spine, the degree being due to the age of the disease. The bodies of the vertebræ are enlarged, and especially from the laying-on of bone on the anterior part. In the cervical and dorsal regions the increase in bone is often restricted to the upper part of the inter-articular cartilages, while in the lumbar region the increase of the bone is more general. The spinous processes are enlarged, and the transverse processes may be. The irregular thickening of the inter-vertebral cartilages, with the irregular growth of the bodies of the vertebræ, sooner or later causes deformities of the spine, viz., kyphosis, lordosis, or scoliosis (Virchow-Fraentzel case showed alternate right and left scoliosis in the dorsal region). Anteriorly the spine may appear as one bone, due to the growth of spongy bone in the anterior ligament, forming bridges of bone connecting the vertebræ together (Virchow-Fraentzel's, Thomson's).

The sternum is enlarged and thickened, and the ensiform cartilage is ossified, generally projecting outward. Often very large transverse ridges are found on the sternum, also a hollow or depression may be seen at the upper part, due to to the manubrium not enlarging relatively to the body of the sternum.

The costal cartilages are large, with more or less bone-formation, and with prominent cartilaginous or bony nodes at the junction with the ribs, simulating the rachitic rosary. The bone-growth in the costal cartilages may give an apparent great widening of the sternum. The ribs are wide and thick, and by the faster growth of the costal cartilages become abnormally oblique.

Small bony tumors have been found on some of the ribs (O'Connor's case).

The clavicles are always found enlarged at their extremities, but more especially at the sternal end. A sharp, inward projecting spicula of bone, exostosis, was found in O'Connor's case.

The scapulæ are generally found enlarged, and more especially is the spine large and thickened. Thomson found the glenoid articular surface enlarged, due to the ossification of the glenoid ligaments.

The articular surfaces of all the long bones may be roughened (Broca, Thomson), and there may be exostoses, spongy growths, and osteophytes in and around the joints. The humerus may be thus affected, but is infrequently enlarged. The radius and ulna, if the case is of long standing, are found enlarged at the lower extremities, and, perhaps, at the lower third of the shafts. As before stated, the ridges and protuberances are enlarged on all of the long bones, if the disease is at all advanced. The enlarged lower extremities of the radius and ulna, with the widened and thickened carpal bones, give the large wrist and hand. The metacarpal bones and phalanges are widened and thickened, the former especially at the head, and the latter at each extremity, causing the prominent joints. The phalanges are generally equally affected, but one set may be more affected than the other.

The pelvis is almost always enlarged, especially the pubic bones. The symphysis is thick and deep, and the crests of the ilia are wide and prominent. Thomson found the ileo-pectineal line on the right side raised into a prominent crest, and the acetabula enlarged by partial ossification of the cotyloid ligaments.

The femurs are only enlarged at the lower extremities, viz., the condyles, as are also the heads of the tibiæ and fibulæ and the patellæ.

The malleoli are frequently found enlarged. Of the tarsus the os calcis is the most affected, growing backward into a prominent projection. The metatarsal bones and the phalanges are all enlarged similarly to those of the hands. Thomson found several of the phalanges of the toes ossified together.

Etiology.—Thus far there has been no positive cause found for the occurrence of this disease. Various theories have been offered, one of the most interesting of which is that by Freund. He suggested the probability that acromegaly was a disease of puberty or thereabouts, *i.e.*, a disease of development, a possible returning to type, the large hands and feet, projecting jaw, and retreating forehead being certainly very suggestive.

Klebs partially supported this theory, but laid great stress on the enlargement of the thymus gland. Virchow, however, does not support this theory of Freund at all. Professor Freund said that this anomaly of development had some relation to the condition of the developmental organs, to sexual development, and that the early cessation of menstruation or early loss of sexual power caused acromegaly.

This theory is not supported by facts.

The ages at which forty-six cases were discovered and reported are as follows:

2 cases in second decade of life (10 to 20 years). Cènas's case and Mennig's daughter (Virchow-Fraentzel).
6 cases in third decade of life (20 to 30 years).
8 cases in fourth decade of life (30 to 40 years).
20 cases in fifth decade of life (40 to 50 years).
8 cases in sixth decade of life (50 to 60 years).
2 cases in seventh decade of life (60 to 70 years).

It is here seen that two and one-half times as many cases first come for treatment, or are discovered, between forty and fifty as at any other decade of life. Fourteen of the 20 cases which first came in the fifth decade (from forty to fifty), were between forty and forty-five years old.

Of 39 cases giving data of more or less successfully estimated age at which the disease started:

2 are congenital (Cènas' case and Mennig's daughter).
4 began in the second decade (10 to 20 years).
16 began in the third decade (20 to 30 years).
12 began in the fourth decade (30 to 40 years).
5 began in the fifth decade (40 to 50 years).

This shows nearly three-fourths of these cases to have begun between the ages of twenty and forty, and 33 of the 39 cases after twenty years of age.

By the above facts I fail to see how the Freund theory is tenable.

Sex does not seem to bear any special relation to the disease. Out of 50 cases, 27 were women and 23 men.

Of 13 women who were at an age at which menstruation does not normally cease, 9 had cessation of menstruation as a first symptom, while 4 menstruated for a time after the beginning of the disease, but soon stopped.

One case, a woman aged fifty-three (Harris's case), had had acromegaly for twenty years, but had a child at forty-three years of age.

Of 12 cases of men in which it is mentioned, 10 had diminished or lost sexual power, while 2 were normal in this respect.

I believe these phenomena are only symptoms, and cannot attribute to them, as does Freund, a causative relation to this disease.

While the cessation of menstruation is unquestionably an early and a very frequent symptom, it is not constant, and is only a symptom.

The loss of sexual power in the male is a gradual loss, diminishing with the progress of the disease. Virchow and Verstraeten both find no causative relation between the generative organs and acromegaly.

Klebs and Fritsche found an enlarged thymus gland in their case, while Erb found, in three cases, a dulness at the upper part of the sternum which he attributed to an enlarged thymus. Klebs at first thought that this gland, being enlarged or persistent, might have something to do with the increased growth of blood-vessels and tissue. Later autopsies, however, have proved this gland to be generally absent, and Arnold has shown, as before mentioned, that the thickening of the sternum in the region of the manubrium could give the dull percussion note sometimes heard. These facts preclude the enlarged thymus from the position of an important factor in the etiology of this disease.

Of 19 cases giving data on this point, 15 are recorded as having no dulness at the top of the sternum, while in 4 cases dulness was found.

The thyroid also has come in for a share in the etiological interest of this disease, but its condition is found to be so varied that it is only of symptomatic importance. Out of 32 cases making record of the condition of this gland, it was atrophied 14 times, enlarged 8 times, and normal 10 times.

On the other hand, of more than ordinary interest is the pituitary body, which has so many times been found enlarged in autopsies of this disease, and so frequently can be diagnosed as being in that condition in living cases. Of 33 cases of acromegaly reporting the condition of the eyes, 18 had eye-changes, more or less severe, and 15 at the time of reporting had no eye-changes, while 4 had ear-trouble. Headache, sometimes violent, is a very frequent and almost constant (23 times out of 27 cases) symptom. Though acromegaly can surely occur without enlargement of the pituitary body, still we must acknowledge that it stands very close to some etiological factor (angiomatosis, or neurotic origin).

Nativity does not play any important part in the causation of acromegaly, although a number of the cases reported in America have been Germans. One case (Berkley's) occurred in a negress; hence the colored race is not exempt.

As to the hereditary history in 46 cases, rheumatism was stated as present in the families of 2 of them, 3 had tuberculosis in the family, and 2 had a neurotic family history.

The Hagner brothers, atypical cases of acromegaly combined with elephantiasis of the legs, were similarly affected.

The daughter of Mennig (Fraentzel's case of acromegaly, whose skeleton was exhibited by Virchow) had the disease; and Fratrich says that the father of his case had large hands like the patient.

As to the personal history of 46 cases, rheumatism was stated to have been present 5 times, 1 had had asthma, 1 pleurisy, 1 a winter bronchitis, 1 pneumonia, 1 abscesses of each hip, and 2 had had a severe typhoid fever, from which the disease could be dated, while 1 case (Massalongo's), when twenty-two years old, had "loss of consciousness and delirium, which lasted forty days, called cerebral fever."

Klebs is inclined to refer this disease to the vascular system, regarding it as an angiomatosis, and Gauthier agrees with him. We certainly frequently find varicose veins, sometimes hemorrhoids, and occasionally varicocele and epistaxis, but we do not find blood-vessel growths, and von Recklinghausen could not find indications of actual growth of new vessels. There is frequently a burning and flushing of the affected parts, showing an increased blood-supply, due to the dilatation of the blood-vessels, probably of vaso-motor origin. The blood, though many times examined, has shown nothing of moment.

Von Recklinghausen believes that this disease is of neurotic origin. He says that acromegaly may be caused by vaso-motor disturbances which may cause neurotic hyperæmia, going on even to inflammation of the nerves. This would explain the condition of a few of the nerves found at some of the autopsies. The widening of the blood-vessels and the thinning of their walls, especially of the veins, can well be the result of such abnormal innervation of the vessels. He also thinks that the disturbance of menstruation can be explained by this general angioneurosis. It is also known that disturbed nervous conditions can cause hypertrophies of both bones and soft parts.

On the other hand, except the conditions in the brain due to direct pressure from an enlarging pituitary body, but few signs or symptoms referable to the nervous system are found. In forty-six cases some mild paræsthesiæ were stated as present sixteen times, such as numbness, prickling or formications, generally in the hands, sometimes in the feet or ears. The "shot-feel" was twice mentioned, once vertigo, and twice fainting attacks. Sensibility and electrical conditions were always normal. Six times it was stated that the patellar reflexes were diminished or absent. Hence, in these forty-six cases there was no serious lesion of the nervous system, except the trouble caused by the pituitary body. Holschewnikoff's case of syringomyelia, with enlargement of the bones (acromegaly ?), was probably a mere concidence. Although, then, acknowledging that we have not yet discovered the origin of this disease which affects nerves, blood-vessels, glands, bones, cartilages, tendons, muscles, skin, and nails, I believe that the spinal cord, especially the vaso-motor centre, and the sympathetic system furnish the most promising field for future research.

Diagnosis.—This disease must be diagnosed from myxœdema, gigantism, erythromelalgia, elephantiasis, leontiasis ossea, chronic rheumatism, syringomyelia, rachitis, osteitis deformans, arthritis deformans, *osteoarthropathie hypertrophiante pneumique*, local hypertrophies, and adiposis dolorosa.

More than one case of acromegaly has been described under the name of *myxœdema*. Myxœdema is an affection associated with an increase of the subcutaneous fat and connective tissue, and is characterized by a mucoid deposit in the skin and some of the internal organs, with marked changes in the thyroid gland and in the sympathetic nerves. There is swelling of all parts of the face, tongue, throat, and larynx, but generally there is no pitting. The hands become large and clumsy, and there may be pain in the joints and head. There may be loss of hearing, choked disk, and impaired mental faculties, even to dementia in the last stages.

The principal clinical differences between these two diseases are as follows:

Myxœdema.	*Acromegaly.*
1. About eighty per cent. of all cases are women.	1. Both sexes are about equally affected.
2. Occurs most frequently between the ages of forty and fifty.	2. Begins most frequently between the ages of twenty and forty.
3. Bones are never enlarged.	3. Bones are always enlarged.
4. Face has the appearance of a "full moon" (Sir William Gull).	4. Face is oval or elliptical.
5. The ends of the fingers are swollen and clubbed.	5. The ends of the fingers are the same size as the bases, *i.e.*, "sausage-shaped."
6. The skin is pale, waxy, puffy, boggy, and shiny.	6. The skin is yellowish, wrinkled, and hairy.

Gigantism, or giant growth, is distinguished from acromegaly by the fact that in the former there is symmetrical and general growth all over the body; the cranium grows as much as the facial bones, and the face does not look too large for the head, nor the head too large for the body, as is the case in acromegaly.

In gigantism the ends of the bones are not enlarged out of proportion to the size of the shaft, and the hands and feet are not enlarged out of proportion to the arms and legs. The bones increase in length as well as in width and thickness, and that symmetrically, and the whole growth of the body is in proportion, as in a normal individual, all of which is quite the contrary in acromegaly.

In gigantism there is no projection of the lower jaw, there are no nervous phenomena, there are no eye and ear symptoms. The nose, ears, lips and tongue are not increased in size out of proportion to the size of the head, face, and mouth. The foot in giant growth is in normal relation to, or even too small for the length of the body, according to Virchow. He says, normally, the foot is one-sixth the body's length, and in gigantism the height is more than six times the length of the foot, while in acromegaly the height is always less than six times the length of the foot.

In acromegaly the bone-growth and hypertrophy are always at the ends or extremities of the long bones, and never is the shaft lengthened, although an apparent lengthening may take place due to a laying-on of bone at the ends, producing an actual increase in measurement, but without growth of the shaft.

In *erythromelalgia*, a vaso-motor neurosis of the extremities, there may be some increase in the size of the hands or feet. There may be, according to Weir Mitchell, severe pain of the part, and there is always an impaired blood-flow, giving burning sensations, local redness, and even cyanosis, often in patches or spots. Cènas's case, with its peculiar pigmentation, is the only case of acromegaly that has markedly simulated erythromelalgia. In the latter disease, however, there is no enlargement of the bones or soft parts of the face, no eye symptoms, no marked change in the speech, and the hand itself is unlike the acromegalic hand, the fingers are not sausage-shaped, but smaller at the tip than at the base.

Elephantiasis arabum is a hypertrophic disease of the skin and subcutaneous tissue, located generally in one, occasionally in two extremities of the body. There is generally a history of several attacks of local inflammation of the part affected, followed by a continuous growth and hypertrophy of the skin, until an enormous size is reached. The hypertrophied skin falls in great folds, fissures form, and the part becomes one immense, homogeneous mass, without form or shape, and sections show a fibrous tissue without nerves or blood-vessels.

How different is this picture from that of acromegaly, where all of the extremities are enlarged, or at least one after the other, and the parts never lose the normal curves, prominences and hollows, and, though large, preserve their normal contours.

Again, in elephantiasis the bones are not enlarged, the skeleton is not affected, and the nervous, facial, and cerebral phenomena are not present.

Leontiasis ossea is the name given by Virchow to the condition where osteophytes, or bony tumors, are formed on the face and cranium. These bony tumors are of irregular distribution, and produce great deformity and asymmetry. There is no hypertrophy of the limbs. Though this disease has been several times mentioned in the diagnosis of acromegaly, I fail to so see how it could be confounded with the general constitutional disease of acromegaly with its manifold signs and symptoms.

During the first stages of acromegaly one of the frequent symptoms, and often a prominent one, is joint-pain, which at this stage might confuse the diagnosis with that of *chronic rheumatism*. The joints at this time are tender to the touch, but are not reddened or swollen. The pain is not permanent in any one or two joints, and ankylosis does not take place, although later crepitations are often present, and some contractures of the fingers may be found, as in Cènas's case, due to the flexor tendons not growing as rapidly as the bones. As soon as the hands, feet, or face begin to enlarge, the diagnosis from chronic rheumatism becomes plain.

Syringomyelia is a disease of the nervous system, characterized by a "gliomatous new formation about the central canal of the spinal cord, with cavity formation" (Osler).

This disease generally begins before twenty, or in early adult life, and in its slow development and long duration simulates acromegaly. After the complete development of either disease, however, "the amyotrophic paralysis, with retention of tactile and loss of thermic and painful sensation" (Osler), on the part of the syringo-myelia, and the enlarged extremities, the formation of the face and chest, to say nothing of the pituitary enlargement, on the part of the acromegaly, render the diagnosis easy.

Holschewnikoff has reported a case of syringomyelia, with the formation of gliomata in the spinal cord, together with degeneration of some of the peripheral nerves, in which there was decided bone-growth of the extremities, in fact an acromegalic condition.

Rachitis is a disease of childhood, or rather babyhood, occurring most frequently in children under three years of age. This alone would exclude the possibility of confusion with acromegaly, except in congenital cases. Rickets is pre-eminently a disease of impaired bone-formation, as instance slow development or entire absence of the teeth, and impaired growth or softening of the bones, while acromegaly, on the other hand, is pre-eminently a disease of increased bone-formation.

The ends of the bones, especially the epiphyses of the wrist, unquestionably are enlarged in rickets, while the hands and feet may be flattened and apparently widened, but there is no increase in the thickness of the hands or feet. The bones of the head show no malformation, except flattening and lengthening of the cranium with projection of the occiput, and the softened spots. This causes the cranium in rickets to appear too large for the face, while in acromegaly the face appears too large for the cranium.

Also in rickets we find deformation of the pelvis, and if the child creeps, deformities of the arm-bones, and if he walks, bending of the leg-bones. This is quite different from acromegaly, where we have widening, hardening, and general growth of the bones. Softening of the ribs causes a sinking in just before the junction with the cartilages, giving the formation of the rachitic rosary, which from another cause we find in acromegaly. Kyphosis, when it occurs in rachitis, is in the dorsal region, while in acromegaly it is almost invariably in the cervico-dorsal region. It is thus seen that it is hardly possible to confound the one disease with the other.

The diagnosis between the *osteitis deformans* of Paget and acromegaly is generally not difficult.

The following schedule will show some of the marked differences:

Osteitis Deformans.	*Acromegaly.*
1. Rarely occurs before fifty, never before forty years of age.	1. Very generally begins before forty years of age.
2. The long bones are the ones primarily affected, rarely are the hands or feet affected.	2. Hands and feet are enormous, rarely are long bones much affected.
3. Long bones are often curved, giving great deformity.	3. Long bones are normal in shape, possibly thickened at the extremities, but are never curved.
4. Often one limb or one bone is affected long before another limb or bone.	4. Hands, feet, arms, and legs generally nearly symmetrical.
5. The cranial bones are affected, rarely the facial.	5. The facial bones are affected, rarely the cranial.
6. Lower part of face is narrow, giving a triangular appearance to the face.	6. Lower part of face is broad, giving an elliptical appearance to the face.

The above gross, to say nothing of more minute differences, will generally readily make the diagnosis of osteitis deformans from acromegaly.

Arthritis deformans, perhaps, approaches more nearly than any other bone disease to the external conditions found in acromegaly. In arthritis deformans decided changes take place in the articular tissues, accompanied by pain, with sooner or later great deformity and ankylosis of the joints. Tender nodules may appear in the muscles, while the muscles themselves become atrophied.

The disease is apt to attack the same joints on both sides of the body symmetrically, but soon spreads to all of the joints. The hands are thin from the wasting of the fat and muscles, but the ends of the phalanges and metacarpal bones may be enlarged and nodular. The fingers are more or less flexed and turned toward the ulnar side of the arm, while the joints of the hand are all stiff and more or less completely ankylosed. How different is this condition from the acromegalic hand!

Within the joints bony or cartilaginous protuberances are found on the outer surface of the epiphyses in arthritis deformans, while in acromegaly we may find osteophytes at the ends of the bones, as in the Virchow's skeleton, or the bony growths found in the joints of Thomson's case. Outside of this similarity in the joints between these two diseases there is no agreement of symptoms or appearances. The hypertrophy of the soft parts of the hands and face, with the enlargement of the bones of the face, with the cervico-dorsal kyphosis, enlarged tongue, changed voice and eye changes, if present, will all or any of them make the diagnosis from arthritis deformans. Schulz has reported a case of acromegaly associated with arthritis deformans.

In January of 1890, in the *Revue de Médicine*, appeared an article by Marie in which he described a new disease, and which he named *osteo-arthropathie hypertrophiante pneumique*. This disease, as its name implies, is characterized by a disease of the lungs with an enlargement of the extremities, and therefore simulates acromegaly. The affection of the lungs may be an empyema, a bronchitis, or neoplastic formations, and, according to Mosler, there is present a micro-parasite, the absorption of the products of which into the blood and the deposit of these in the joints produces a hypertrophic inflammation. The hands are enlarged, but principally in the joints and the ends of the fingers, the middle of the hand not being attacked. The elbow-, shoulder-, and knee-joints are all affected, and there is always more or less impaired motion. The wrist-joint is large, the hand proper not much enlarged, while the fingers are increased in size, especially the last phalanx, but the soft parts are not hypertrophied. The appearance of the finger-nails is also quite characteristic of this disease. They appear too large for the fingers, spreading out at the sides, and even curving over the ends of the fingers, often giving the appearance of the beak of a bird, while the enlarged ends of the fingers have caused them to be likened to drumsticks. Turning to the acromegalic hand, with its immense thickening of the hand proper, hypertrophy of the soft parts, equally enlarged phalanges, sausage-shaped fingers, small nails, much too small for the fingers, one might make the diagnosis by the hand alone. The bones in osteo-arthropathie pneumique are enlarged, but not the soft parts, while in acromegaly both are enlarged. In the former disease dorso-lumbar kyphosis may be present, while in acromegaly the kyphosis is cervico-dorsal. In Packard's case of osteo-arthropathie pneumique, however, the kyphosis was cervico-dorsal (*Am. Jour. of the Med. Sciences*, June, 1892).

The feet and toes in this disease are affected similarly to the hands. The face presents a different appearance from that of acromegaly; it is more rounded, the lower jaw is very rarely enlarged (occurred in Packard's case), prognathism does not occur, the face appears small, the soft parts are not hypertrophied, and the lips and tongue are normal in size.

Virchow proposes to call the *local hypertrophies* which are occasionally met with, where one hand, or one foot, or one finger or toe, or several fingers or toes, are involved, "partial acromegaly." Marie and Mosler do not accept this classification of these local hypertrophies, even if the bone of the part is enlarged, and I agree with them that these simple hypertrophies should not be confounded with the distinct disease of acromegaly. Marie says: "Let established names as macrodactylia and macropodia and unilateral macrosomia, etc., be preserved, as the names for these peculiar localized hypertrophies."

These local enlargements of one extremity, or one finger, or one toe, are generally congenital, though they may increase in growth at the time of puberty, and the part is generally increased in length. One side of the face may be affected, involving bones and soft parts, including the tongue, tonsil, and palate on that side, but whatever the enlargement there is no symmetry.

One more disease remains to be diagnosed from acromegaly, viz., the disease recently described and named by Dr. F. X. Dercum, *adiposis dolorosa* (*American Journal of the Medical Sciences*, November, 1892). In this article he reports three cases, all women, where there was an enormous growth of fat. In the first case it was especially marked on the arms and body, where the fat fell in great folds. The second case showed an immense development of fat all over the body, but unevenly distributed in lumps and in folds; she had headache, great weakness, and cardiac dyspnœa, but no mental impairment, and sight and voice were not affected. The autopsy of this case showed an indurated thyroid gland, with some deposit of calcareous matter, and there was œdema of the lungs.

The third case showed great development of fat on the upper arms, and especially on the abdomen, where the fat lay in great folds or tumors. She was somewhat deaf, apathetic, and had headache. This case also came to autopsy. The thyroid gland was larger than normal and somewhat calcified, but nothing else of moment was found. Dr. Dercum says that the nodules of soft tissue are at first deposited in one location, or, perhaps, in corresponding places on the upper or lower extremities. Then other parts are attacked, though some portions of the body are left without much fat development, and soon pain and other nervous symptoms appear. In the first of these cases of adiposis dolorosa the thenar and hypothenar groups of muscles showed the reaction of degeneration. Electrical changes are never present in acromegaly. Also the absence of any marked enlargement of the hands, feet, and face, as well as no bone-growth, excludes confusion with acromegaly.

Prognosis.—Marie estimates the duration of this disease to be from ten to twenty years. Of twenty-five cases giving the estimated duration only three have died, but the average duration of the disease in the twenty-two living cases is twelve and one-half years.

Fifteen of the twenty-five cases are over ten years in duration, and six over twenty years, while the range is from three years to thirty-four years (Bury's, and Graham's second case, both dead).

This disease is one of continuous progression, especially in the growth of the bones. Under treatment, or without treatment, periods of apparent quiescence, or periods of cessation of symptoms occur, and the soft parts of the hypertrophied portions of the body not only may not enlarge but actually appear diminished in size. Yet even in such cases the bones continue to grow.

These periods, when the patient may say he feels well, are, sooner or later, followed by marked exacerbations of all the symptoms, often coming on suddenly, even precipitately. These symptoms, all of which may be ameliorated by treatment, are severe headache, often dizziness, great constipation, troublesome dyspepsia, aggravated eye or ear symptoms, great temporary loss of strength, and melancholia, with more or less pain referred to various parts of the body. At this time the soft parts on the hypertrophied portions of the body appear larger, although œdema cannot be found.

A more or less complete recovery from these exacerbations, or severe symptoms, generally occurs, but the patient is not quite as well in all respects as he was before. Thus the disease proceeds, with some symptoms more or less constant, until there is hardly a tissue or organ of the body that is not affected in greater or less degree.

Finally, little by little, the patient falls into a condition of progressive cachexia, with partial or nearly complete loss of muscular power, due to atrophy of the muscles, so that he may be compelled to remain in bed. This condition may last for several years, and then death occurs unexpectedly, with the appearance of syncope. It

is possible that an enlarged pituitary body may cause coma and death. Most cases of acromegaly, however, die of some intercurrent affection.

The headache may become so severe as to cause suicidal tendencies, and temporary insanity may occur, probably caused by pressure from an enlarged pituitary body.

TREATMENT.—This disease is incurable, but in any given case we can safely expect to ameliorate many of the nervous symptoms. Of all treatment rest is the most important, under which all the phenomena, except those produced by actual lesions, will improve. Pain, the most frequent cause of complaint, has been treated by antipyrine, acetanilide, phenacetin, exalgine, caffeine, and codeia. Dulles gave salol and phenacetin for the headache, while in Ruttle's case it was helped by exalgine in three-grain doses every eight hours. Phenacetin, occasionally, and codeia, in small doses, continued for one or two weeks, have given good results in the writer's case.

The constipation should be treated, while dyspepsia, when present, can be best helped by a diet that requires but little mastication, as prognathism, which is so frequently present, is generally the cause of the dyspepsia. The bromide of potassium is often of service in relieving the headache and the feeling of pressure in the head.

Positive impairment of sight or hearing cannot be improved, and if the sight is affected at all the loss of vision will probably increase. Tinnitus aurium, if due to this disease, can probably be but little, if at all, helped.

Arsenic in some form, given for a long time, has done good service. Denti used the arseniate of iron. Mosler used baths and the faradic current to the back.

But, as before stated, any tonic or bracing treatment, combined with rest, will generally cause a cessation of the acute symptoms and a pause in the disease, except in the last stages. A theoretically good treatment, owing to the condition of the blood-vessels, dilated and with weakened walls, and of practical value in Mosler's and the writer's cases, is ergot. Ergot or ergotine should be given continuously for a long period, the exact length of time being governed by the results.

If there is atrophy of the muscles and great loss of muscular power strychnia, by the mouth or hypodermically, is of value.

Phosphorus has been used in acromegaly, also the Oertel treatment, and the milk diet.

Where glycosuria has been present the diabetic diet has been used.

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Oliver T. Osborne.

ADIPOSIS DOLOROSA. At a meeting of the American Neurological Association, held in New York in June, 1892, the writer presented the histories and photographs of three cases of an affection which up to that time had not been recognized. The first of these cases had been under the writer's care since 1887, and is still living. The second and third were discovered in the wards of the Philadelphia Hospital in 1891, and both cases dying, autopsies were held in each instance.

The histories of these cases are briefly as follows:

Case I.—M. G——, aged fifty-one, female, widow, a native of Ireland, and a domestic. Her father had died at forty-five of erysipelas. Her mother, who had had eighteen children, died at forty of some affection incident to the menopause. Of her brothers and sisters, seven died in childhood, one in adult life of pleurisy, one sister in childbirth, a brother and two sisters of phthisis, while the remaining five are living and apparently in good health. None of the patient's relatives have ever suffered, as far as she knew, from symptoms similar to her own, nor had any of them ever had any nervous or mental affection.

As a child she had had measles, whooping-cough, and scarlet fever. Menstruation began normally at fifteen. At eighteen she married. Some years later she had an attack of pneumonia but made a good recovery. She had in all seven children and one miscarriage. Five children died in early childhood, one from cholera infantum, two from measles, one from "congestion of the brain," and the fifth from spasms. The menopause set in abruptly at thirty-five. From this time up to within two or three years her health had continued good. She had undergone some increase in weight, but beyond this nothing worthy of mention could be elicited. Syphilis was denied, as was also alcoholic excess. However, the condition of the patient on several occasions upon her return to the hospital after furlough was such as to throw more than doubt upon her denial of alcoholic abuse.

When forty-eight or forty-nine years of age she noticed that her arms were becoming very large. The upper arms and shoulders appeared swollen. The swelling continued steadily to increase and was for about a year unattended by any other symptom.

In November, 1886, she was admitted to the surgical wards of the Philadelphia Hospital for the rupture of a varicose vein of the leg. In the following February she was transferred to the medical wards for a severe attack of bronchitis. Later she had an attack of severe pain and swelling in the right knee, attended by chill and fever. She was treated for rheumatism and promptly relieved. Two weeks after this she complained of a sharp darting pain in the right arm. It begun on the outer aspect above the elbow and gradually increased in severity and extent, spreading upward to the shoulder and neck, and downward to the forearm and hand. It was shooting and burning in character. She felt at times as though hot water were being poured upon the arm, and again as though the hands and fingers were being torn apart. No rise in temperature was noted. The pain was often paroxysmal, but it was never absent. On June 4, 1887, she was transferred to the nervous wards of the hospital and came under the care of the writer.

Her appearance at this time was striking. She was a tall, large-framed woman who looked as though she had at one time presented a fine physical development, but she seemed unnaturally broad across the back and shoulders. On removing the clothing an enormous enlargement of these parts was disclosed. The enlargement affected both shoulders, the arms, the back and the sides of the chest. It was most marked in the upper arms and back, forming here huge and somewhat pendulous masses. It was elastic and yet comparatively firm to the touch, and it was impossible to produce pitting. In some situations it felt as though finely lobulated, and in others, especially on the insides of the arms, as though the flesh were filled with bundles of worms.

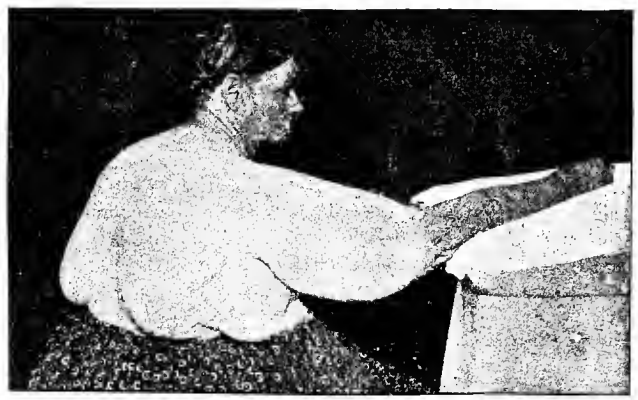

Fig. 4.—Author's First Case, Showing Large Masses of Fat on Back and Upper Arm.

The skin was not thickened; it did not take part in the swelling, and it was not adherent to the subjacent tissues.

In addition the swelling was very painful to pressure. Pronounced pressure appeared to be absolutely unbearable. The nerve-trunks also were exquisitely sensitive, but this painful condition was not by any means limited to them, but permeated the swollen tissue as a whole.

The muscles were not involved in the swelling. The affected parts were, however, quite weak. Examined electrically the muscles of the shoulders and arms yielded a negative result, partly because of the great resistance caused by the intervening tissue. Slight qualitative and quantitative changes were noted in the muscles of the forearms, while in the hands distinct reaction of degeneration was noted in the thenar and hypothenar groups, more evident on the right side.

Cutaneous sensibility was much diminished. On the right arm various areas existed in which no response whatever was given to the æsthesiometer. They were large and irregular in shape, and very sharply defined, and were present on both the inner and outer aspects. In the finger-tips the points could not be at all separated. In the left arm, some impairment of sensation was detected on the outer aspect of the forearm, and in the finger-tips sensation was decidedly below normal. Sensibility to heat and cold appeared also to have been lessened.

On examining the legs it was found that cutaneous sensibility was distinctly lessened on the right, while showing little or no impairment on the left.

No enlargement was noted at this time in any part of the body save in the arms and shoulders. The face was pale, as were also the mucous membranes. There was, however, a little color in the cheeks, more noticeable at times. Her features were well formed and intelligent. Her hair was dark and fine. Her mind was unimpaired, except that at times she was much abstracted. Sometimes she gave conflicting answers to questions, so that the latter had often to be repeated.

Ten days after her admission to the nervous wards she had a chill, followed by fever and a painful herpetic eruption over the upper portion of the left arm, and anterior portion of the left side of the chest. Some five or six days later another crop of vesicles made its appearance on the back and on the front of the chest.

Nothing further worthy of note occurred until October 13th, when the patient had another severe attack of bronchitis, which was accompanied by much dyspnœa.

Fig. 5.—Another View of Author's First Case.

In the latter part of the following December it was noted that during one of her paroxysms of pain the swelling of the right arm became more decidedly lobulated. The arm became more sensitive than ever, and on examination hard, cake-like masses were felt, resembling, as the resident physician expressed it, the caking of milk in a breast. This caking or increased lobulated feel was subsequently repeatedly noticed during paroxysms of pain. At this time also she suffered from an attack of pain in the right knee, and in the popliteal space a diffused swelling was felt which exhibited the same nodulated feel as did the swelling elsewhere. It was also very painful.

At various times subsequently paroxysms recurred, during one of which swelling was noticed in the posterior triangles of the neck. The latter seemed later to be permanently fuller than normal. Bronchitis also recurred, accompanied by dyspnœa, and at one time with free expectoration of bloody mucus.

In the following April she experienced an attack of pain of unusual severity. The latter, which involved the right arm and shoulder, right side of trunk and back of neck, now for the first time spread to the face and head. The right side of the face became distinctly swollen, and presented to the touch the same nodulated feel so characteristic of the swelling in other portions. At the same time the tongue and pharyngeal tissues appeared to become swollen. Her tongue, she said, felt much too large for her mouth. In addition her voice was very hoarse, and she spoke with great difficulty. This condition persisted for upward of a week, and then slowly subsided. For some time, subsequently, she spat blood, the source of which was not determined, though it appeared to come from the throat. The reddish color in the cheeks also became more pronounced, until it covered the entire forehead like an intense blush. This blush was afterward observed to occur with other paroxysms of pain.

During the summer of 1888 the patient's condition underwent some change. The paroxysms became less frequent and less severe. Hand in hand with this improvement, sweating became much more marked. However, paroxysms occurred from time to time, and upon one occasion a thick welt-like swelling, exquisitely painful, was observed extending from the upper and inner angle of the scapula, perpendicularly down the back to very nearly the lumbar region. Upon another occasion swelling again made its appearance in the right popliteal space, as well as on the inner aspect of the knee. In the latter locality the swelling became permanent, and the tissues presented the same peculiarities as noted elsewhere. Pain also occasionally appeared in the left arm. Prolonged attacks of cardiac dyspnœa occurred every week or two, and apparently independently of bronchitis.

An examination of the eyes by Dr. de Schweinitz revealed contraction of the fields of vision for form and colors, most marked in the left eye. The other special senses, hearing, taste, and smell, appeared to be somewhat obliterated. An analysis of the urine yielded a negative result. A blood-count failed to reveal an increase of white blood-corpuscles.

Upon a number of occasions the patient during paroxysms of pain vomited blood; upon several occasions this was observed by the writer himself. The quantity could not be accurately estimated, but while it was never large at a single emesis it was constantly brought up in repeated vomiting during an entire night or day.

Measurements were made of this patient at various times, and these have shown a steady increase in the bulk of the enlarged parts.

Of late the patient has not suffered as intense pain as formerly. Cardiac dyspnœa, however, is a frequent and distressing symptom. The face is still flushed. Recently, shooting pains have appeared in the abdominal region, and examination discloses in this region an extensive deposit of tissue to which the pain is referred. A large longitudinal wheal, especially sensitive, is found in the left lumbar region.

Swelling has also made its appearance over the left hip, and to some extent over the right. The thighs and buttocks do not seem enlarged in proportion, but soft masses are now found on the inner sides of both knees, the right larger than the left, the former more painful to pressure. A small nodule to the right of the scrobiculus is especially painful.

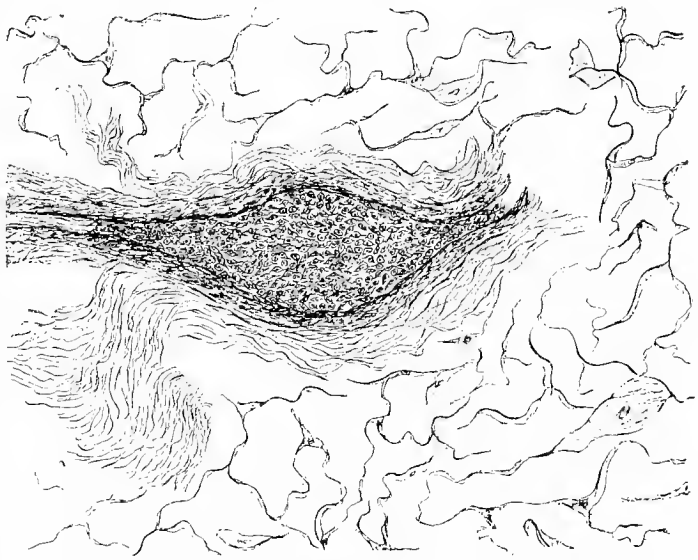

Fig. 6.—Microscopic Drawing from Portion Excised from Left Arm, Middle Third, Showing Embryonal Connective-tissue Cells (Carmine). (Drawn by Allen J. Smith.)

At various times, by means of a Duchenne trocar, fragments for microscopic examination were removed from either arm. They revealed connective tissue and fat-cells present in varying degree. It was observed that the former was decidedly embryonal in type, the

cells being large and fusiform, and their nuclei correspondingly large and prominent. The fat-cells for the most part were associated with these connective tissue-cells, and occasionally individual fat-cells were seen in which the fatty metamorphosis had not been complete. These appearances are well illustrated by Figs. 6 and 7.

In one of the fragments removed the writer was fortunate enough to find nerve-elements. These had

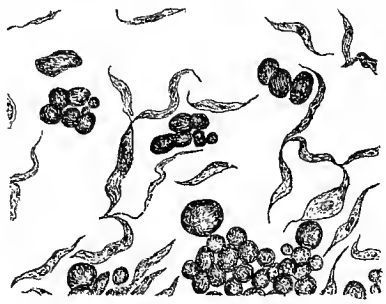

FIG. 7.—Another Portion of the same Specimen, Showing Fat Cells and Oil Drops. (Drawn by Allen J. Smith.)

probably been included in the grasp of the trocar by the latter grazing a blood-vessel, as the fibres were non-medullated. The latter revealed decided changes, their connective tissue was denser than normal, and they presented an unusual number of nuclei, which here and there were aggregated in clusters (see Fig. 8). The most interesting finding, however, was a more or less complete ganglion of relatively large size (see Fig. 6). The capsule of the ganglion was evidently sclerosed. Certainly it appeared very dense and excessively thick.

CASE II.—E. W——, female, aged sixty-four, married, a native of England. Her father had died of alcoholism at middle life; her mother of œdema of the brain (verified post mortem). Has living an elder brother and sister, and one younger brother. The younger brother, when a child, was peculiar, he would run to people in a fright and say that he was drowning, and the like. He is now in average health, but drinks heavily. He has a contracture of the ring finger. Has nine children, all of whom appear to be well. The older brother suffers periodically from violent headache; also, since a young man, he has suffered from constantly cold feet, this so severe as to disturb sleep, and cause great distress. He has had five sons and two daughters. One son died of tetanus (traumatic), the others are well. One daughter has a contracted middle finger of the right hand; has never suffered pain in the finger. Patient's sister is living, sixty-five years old; no children.

The patient herself does not remember having had the ordinary diseases of childhood. In early infancy she had convulsions, which recurred with great frequency for a time. On her being relieved of lumbricoid worms, however, the convulsions ceased.

At seventeen she was married. She had two sons, the older of whom is now forty, and who has seven healthy children. The younger son died at two years of age, of hemorrhagic diarrhœa. The patient had no miscarriages and no still-births. Left her husband because of venereal disease, contracted by the latter. She was told by a doctor that she had escaped infection. A year later, however, she had sore throat, with white patches. For many years she was an immoderate drinker. For weeks at a time she was intoxicated every night.

Menstruation began at eleven and ceased abruptly at thirty-five. She lost habitually an unusual quantity of blood, but never suffered any discomfort.

Her present malady began about fifteen years ago, when she was forty-nine years old. At that time she was living in California. The first thing noticed was a constant feeling of coldness about the knees, followed by swelling, which gradually increased. At first she thought that the swelling was due to her growing fat, but later was astonished to see that there was a localized mass on the inner aspect of each knee. At the time there was dull aching pain in the affected parts. Later, the right arm became involved, a mass making its appearance on the outer aspect. Her body she now noticed also became larger, as her stays were too small for her. During this time, while still in California, inability to perspire freely, except at the Turkish bath, was marked, and was part of her reason for coming East. Since she has been in Philadelphia the lack of perspiration has not been as marked as before. Various plans of treatment were tried, but did not influence the progress of the disease, *i.e.*, the growth of the swelling. Five or six years ago, injections of chloroform were made into the swellings on the inner sides of the knees, but no good was accomplished. Painful ulcerations were the result, and scars of considerable size mark their location.

About five years ago a slight swelling appeared in the epigastrium. This gradually increased in size until it resembled the breasts in shape, and afterward spread so as to involve nearly the whole abdomen.

From the knees the process extended to the thighs, and gave rise to large masses on their outer side and about the hips.

At various times she had suffered with pains apparently situated in the enlarged tissues, or running down the limbs. Sometimes these attacks were fairly well localized in one limb, in one side, or about a joint.

Five years ago her attention was called to a peculiar condition of the right hand. The last phalanx of the second finger began to be fixed in a flexed position, while the end of the finger appeared to be growing somewhat smaller. Later the remaining fingers of this hand became involved, and all the phalanges deformed. The deformity, as seen now, is flexion of the first phalanx, marked over-extension of the second, and half-flexion of the third. The thumb is also stiff, but all of its joints are flexed. For some time she has noticed the thumb of the left hand becoming like that of the right.

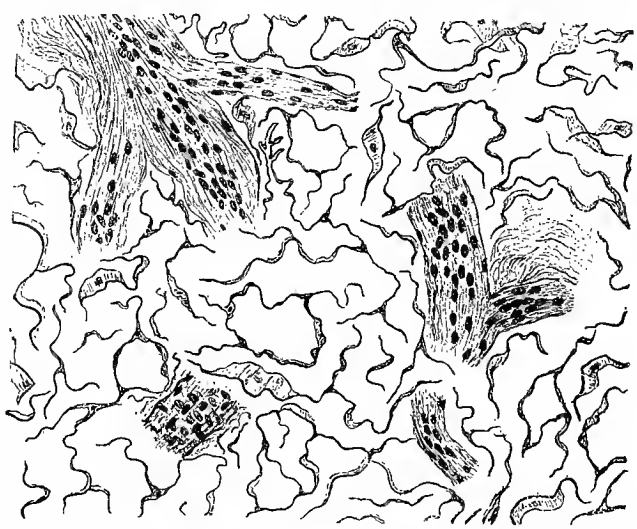

FIG. 8.—Microscopic Drawing from Portion Excised from Left Arm, Lower Third, Showing Inflammation of Non-medullated Nerves (Carmine). (Drawn by Allen J. Smith.)

A year ago the patient had a quasi-rheumatic attack affecting the deformed hand and the arm. The pains seemed to run up and down in the arm rather than about

the joints. Some months ago she had pneumonia of the right lung, and made a good recovery.

For several months past she has had slight uterine hemorrhages at times, associated with which were dull,

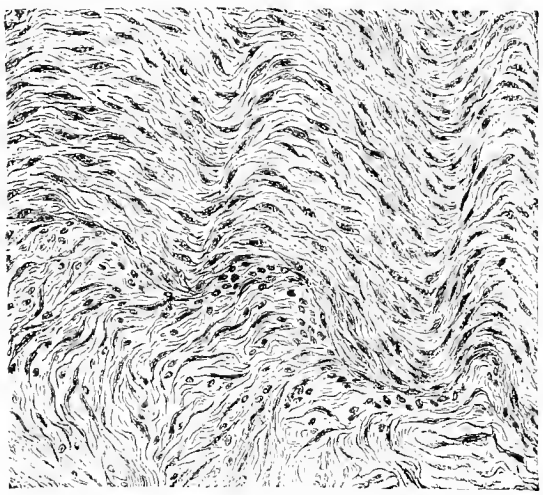

FIG. 9.—Another View from the Same Portion of Tissue Removed from the Left Arm. (Drawn by Allen J. Smith.)

aching pains, resembling those formerly felt before menstruation.

In addition, she stated that the swelling had spread up from the knees over the thighs unequally; that the left thigh and buttock had been earlier and more conspicuously enlarged than the corresponding parts on the right side. Gradually, however, the latter became enlarged to an almost equal degree. Later, swelling appeared over the left arm, and later still on the back and sides of the trunk, and wherever appearing, it gradually became diffused, and finally reached very great proportions. The patient further volunteered the statement that she had formerly been very slight in build.

To ordinary observation she merely presented the ap-

FIG. 10.—Author's Second Case.

pearance of an excessively obese person. However, examination soon revealed that the enlarged tissue was very unevenly distributed. In the region of the knees, where it had first made its appearance, it was excessively irregular and lumpy. To the fingers it resembled in a remarkable degree the swollen tissues of Case I. It gave the same nodular feel, and could not be made to pit on pressure. At the time of the examination no tenderness existed in the swellings, but shooting pains were referred to them in various situations. This was particularly the case in the mass over the right hypochondrium. In addition, she complained of scalding sensations on the inside of the right cheek and the right side of the tongue. Nothing abnormal could be discovered in the mucous membrane of these parts. No tenderness could be discovered in any of the nerve-trunks at the time of the examination. The patient was excessively weak, and could move about her bed or sit up only with great difficulty. Her grip was almost *nil*. No tendon-jerks could be elicited, probably because of purely mechanical difficulties. For the same reason an electrical examination could not be made.

Slight diminution of tactile sensibility and of the temperature sense and also some analgesia were present. An area of absolute anæsthesia existed on the back of the left arm, extending thence over the posterior aspect of the left shoulder. A marked increase in the swelling had taken place during the last year, measurements showing, for instance, that the left forearm had increased one inch and seven-eighths, and the right forearm one inch and three-eighths; the left arm one and a half, and the right arm two inches. This increase appeared to be maintained throughout.

FIG. 11.—Rear View of Author's Second Case.

Subjectively the patient complained much of headache. Her face was very much flushed, and she suffered greatly from cardiac dyspnœa. It was a persistent and distressing symptom. Examination of the eyes proved negative, as did also that of the urine. Perspiration, according to the patient's statement, was scant. Face not involved in the enlargement; no subnormal temperature; hair thin, but not excessively so; no difficulty in speech; no mental impairment.

The patient remained very much in the same condition for some two weeks following her admission to the nervous wards, when her dyspnœa greatly increased. Her pulse, already soft and compressible, became irregular and intermittent. This condition, though relieved from time to time, persisted until hands and feet became puffy, the face cyanotic, and the lungs œdematous and congested. Death occurred on December 22, 1891.

Autopsy, December 23d.—Body that of a very large woman. Weight estimated at about three hundred pounds. Face dark from venous congestion. Some discoloration on under surface of body and thighs. A number of large white scars on either side over the knees. Legs and feet œdematous. Body distorted and flattened, as though by its own weight.

Scalp and calvarium revealed nothing abnormal. Veins of dura and longitudinal sinus full. Venous congestion of the pia. Cortex a little darker than normal. Puncta vasculosa prominent. Brain otherwise normal. Spinal cord appeared normal. Skin of thorax appears normal. The subcutaneous tissue is fatty and moist.

Thyroid gland small, indurated, and infiltrated by calcareous matter in both lobes.

Right lung œdematous and tightly adherent to chest-wall. Left lung œdematous, with hypostatic congestion posteriorly. Both pleural cavities contain a large excess of fluid.

Pericardium contained some six or eight ounces of fluid, in which was suspended some flocculent lymph. Weight of heart twenty-seven ounces; the right side dilated, the moderator band much thickened. Walls of left side also much thickened, marked hypertrophy of the columnæ carneæ and papillary muscles. Some fatty change, especially in the walls of the right ventricle.

Over the abdomen the subcutaneous fatty tissue was three inches thick. About a pint of ascitic fluid in abdomen. Stomach much dilated. Intestines normal. Liver showed some fatty infiltration; otherwise normal. Spleen apparently normal, though somewhat dark. Kidneys both reveal, excepting slight adhesion of the capsules, nothing specially abnormal.

In the pelvis an ovarian cyst, containing some six ounces, and a hydrosalpinx were found on the left side. Uterus seemed a trifle larger than normal. Bladder normal.

Brain, cord, some of the nerve-trunks, pieces of skin and subcutaneous tissue, pieces of the liver, kidneys, spleen, a fragment of muscle, and the whole of the thyroid gland, were removed for microscopic examination. The specimens were left in the care of Dr. H. W. Cattell, assistant to the pathologist of the hospital. Unfortunately, Dr. Cattell fell ill with scarlet fever, and during his absence the specimens, together with those of Case III., were thrown away by an attendant.

Case III.—M. M——, aged sixty years, widow, a tailoress by occupation, and a native of Germany, but a resident of America for twenty-six years, was admitted to the nervous wards of the Philadelphia Hospital, October 7, 1891. Memory very poor. History obtained in part from relatives.

Her father and mother healthy, though her mother died of heart disease. She had seven brothers and sisters, all apparently well. She had no children; had never been pregnant.

Many years ago a lump appeared at the back of the neck, for which she consulted Dr. Gross at the Jefferson Medical College, but for some reason no operation was performed. At various times thereafter swellings made their appearance in various situations. Further, she lost more blood at her menstrual periods than normal. Occasionally she suffered from hæmatemesis and epistaxis.

Fig. 12.—Author's Third Case.

The climacteric occurred at forty-six. No history of any intercurrent affections. Mental impairment had been noticed for about two years.

On examination the patient was found to be excessively feeble. For some two weeks she had been unable to walk. She lay, for the most part, in a quiet, apathetic state, though when aroused she answered questions slowly, but intelligently. She was also somewhat deaf.

Examination further revealed, soft, fat-like masses or swellings in various situations. Thus, a large, soft mass was found over either biceps, and others, somewhat smaller, over the outer and posterior aspect of either upper arm. Two large masses were found over the belly, separated above the umbilicus by a deep, transverse crease. Another gave excessive prominence to the mons Veneris. From the back of the neck, at its lower part, sprang a big mass like a hump, while a diffuse swelling gave a

Fig. 13.—Rear View of Author's Third Case.

cushion-like coating to either half of the back, and extensive deposits gave unnatural prominence to either hip. In marked contrast, the deposit was absent from the forearms and hands, from the face, from the thighs and legs, and from the buttocks. The gluteal regions, in fact, seemed flattened and sloping.

The deposit over the back seemed tolerably firm and resistant; over other portions it was quite soft, though elastic, and exhibited the same nodular feel noted in the previous cases. Further, it was discovered at once that these masses were painful to the touch, the patient complaining very much when only moderate pressure was exercised. This was especially true of the deposits over the arms and back of the neck. In addition, the patient complained of stabbing pains in the deposits, more marked in the regions just mentioned. There was no tenderness over the nerve-trunks. She complained also of headache.

In making the examination it was also further noted that the left radius was rough and nodular for about two and a half inches in its middle third; also, that there was a large discolored area on the outer aspect of the left forearm resembling a syphilitic scar. Both tibiæ were somewhat nodular, though no scars were discovered on the legs. A few white scars were seen on the forehead. Finally, quite a number of purpuric spots were observed on the forearms, thighs, legs, and back.

The skin of the forearms and hands, and that of the legs and feet to a less extent, was dry, dark, and much roughened.

Cutaneous sensibility was found generally diminished, while a few patches of anæsthesia were noted. One of these was an area diffused over the right side of the trunk and the right shoulder. They appeared to be constant, and were confirmed at various examinations.

Owing to the extreme weakness of the patient, the study of the eyes could not be made satisfactorily, but, as far as it went, was negative. The urine contained albumin, though no casts were found.

In answer to questions the patient said that she had not been sweating freely for years, but owing to her mental condition no importance was given to this statement. She at no time presented any change in temperature. Her hair was well preserved.

The patient seemed to fail slowly and steadily, although liberal diet and stimulants were freely used. Her dementia gradually deepened, and for some days before death she voided urine and fæces involuntarily. She finally died in a comatose state on November 5, 1891.

Autopsy, November 6th.—Body that of a large woman with irregularly distributed fat-like masses. Some discolorations on the back. Small bed-sores beginning on the buttocks.

Scalp and calvarium normal. Dura normal. Pia very œdematous. Brain very soft and œdematous. Cord revealed nothing abnormal.

On incising the skin of the chest and abdomen it was found to be normal in appearance, but the subcutaneous tissue, which looked like very white fat, was excessively thick, attaining below the umbilicus a depth of seven inches.

The thyroid gland was larger than normal, harder to the feel, and much calcified, especially the right lobe.

The heart weighed eight and a half ounces. Both aortic and mitral valves were slightly thickened. Heart substance evidently fatty. Lungs emphysematous.

The mucous membrane of the stomach revealed a chronic gastritis. The liver weighed forty-four ounces, and, beyond some fatty infiltration, was practically normal. Spleen normal. The kidneys, however, showed decided shrinking and loss of cortical substance, with somewhat adherent capsules. Nothing noteworthy was seen in the pelvic organs.

As in Case II., brain, cord, nerve-trunks, skin and subcutaneous tissue, thyroid gland, and portions of other viscera were removed for microscopic examination, but, as already mentioned, the specimens were subsequently lost.

It was not without some hesitation that these cases were presented together. The writer was well aware that without a microscopic examination to supplement the autopsies their study was incomplete, and yet the cases are in themselves so interesting, and appear to be so unusual, that their publication in a group, with such data as are at hand, was more than warranted. Case I. had originally been published in the *University Medical Magazine* for December, 1888, under the title, "A Subcutaneous Connective Tissue Dystrophy of the Arms and Back, Associated with Symptoms Resembling Myxœdema." Case II. had been discovered in the medical wards of the Philadelphia Hospital by Dr. Frederick P. Henry, in 1890, and was published by him in the *Journal of Nervous and Mental Diseases* for March, 1891, as a "Case of Myxœdematoid Dystrophy." Dr. Henry fully recognized the relation existing between this case and that previously described by the writer, and he adopted the term dystrophy in order to bring the cases "into the same category." In November, 1891, this case (Case II.) having been transferred to the nervous wards of the Philadelphia Hospital, came under the care of the writer, and was studied again. The account here given is abstracted partly from the notes of Dr. Henry, and partly from those of the writer.

Case III. was discovered in the nervous wards in October, 1891.

Certainly these cases differ radically from ordinary cases of lipomatosis, and certainly the nervous symptoms present must have a special significance. To begin, the enlarged tissue makes its appearance in a very irregular way. Nodules of soft tissue are, at first, deposited in some one situation, or perhaps in corresponding places in both arms or in both legs. For a time the deposit is limited to these original areas, but subsequently it makes its appearance elsewhere, and may become very extensive. Regions, however, may exist which remain permanently uninvaded. In Case I. the enlargement was first noticed in both upper arms, and later in the back. Subsequently a swelling made its appearance on the inner aspect of the right knee, to be followed months after by a similar swelling in a corresponding position over the left knee. Later still, swellings made their appearance in various other situations. However, the legs, with the exception of the knees, have remained free from involvement, while the thighs and buttocks have only recently shown a doubtful change. In Case II. the enlargement began on the inner aspect of either knee, and then gradually spread unequally over the thighs and buttocks. Later, the left arm became involved; next the sides and back, and, finally, the entire trunk. In Case III. the enlargement began in the back of the neck, and then at various times appeared in other situations. It remained absent from the face, the forearms, the legs, the thighs, and the buttocks. It is a peculiarity of this case, also, that the enlargement tended to produce distinct segregated masses.

Not only is the development of the enlargement irregular and even capricious in these cases, but there is, in addition, another important fact to be remembered, and that is: that at some time or other the enlargement is accompanied by pain or other nervous symptom. Thus in Case II. pain, shooting in character, and a sensation of coldness preceded the appearance of the nodules on the insides of the knees. In Case I. shooting and burning pains made their appearance about a year after the swelling had appeared in the arms, while similar pains, very great in intensity, preceded the appearance of the swelling on the inner aspect of right knee and in other situations. Case I., it should be remembered, was observed by the writer for a number of years, and was therefore studied in great detail, and pain was noted as a marked feature of the case, especially in the early course of the disease. Occasionally it was observed in old areas of enlargement, and again in regions free from the swelling, but in which the latter subsequently appeared. In Case III. stabbing pains were complained of and were referred to the deposits, and the latter were very painful to examination.

We may say, therefore, that pains, shooting, burning, or stabbing in character, were present in all cases at various times in their history.

Some of the paroxysms observed in Case I. were particularly suggestive. Sometimes a welt-like swelling suddenly made its appearance, evidently following the course of a cutaneous nerve-trunk and at the same time being exquisitely painful. After a time the swelling would become slightly less, but would never wholly disappear. Several such "welts" are still demonstrable in Case I. If the paroxysm of pain made its appearance in an area of old enlargement, that is, reappeared or recurred, a decided and sudden increase would take part in the swelling; and it would become for the time being firmer and more resistant and occasionally more nodulated than before, and generally a permanent increase in the swelling could be demonstrated. Further, it should be remembered that at one time some of the nerve-trunks of the right arm were very sensitive to pressure, that some of the muscles, those of the thenar and hypothenar groups of either hand, revealed reaction of degeneration, and finally that the patient suffered on two occasions from herpes zoster.

In Cases II. and III. tenderness over the nerve-trunks was not present at the time of the examination. In Case I., however, this symptom is also no longer present, its absence having been noted for some time past. This and other circumstances justify the assumption that Cases II. and III. were further advanced than Case I., and that the latter was really observed during a developmental period and while more active changes were going on.

Among the nervous symptoms must also be placed the diminished cutaneous sensibility and the patches of anæsthesia as well as perhaps the excessive weakness. It is probable also that the absence and the diminution of sweating belong to this category. It will be remembered that this symptom was undoubtedly present in Cases I. and II. and doubtfully in Case III. Lastly, headache was noted in all the cases.

Among other symptoms present in these cases should be noted hæmatemesis in Case I., hæmatemesis and epistaxis in Case III., and a recurrence of uterine flow many years after the cessation of menstruation in Case II. In Cases I. and II. the menopause occurred unusually early, namely, at thirty-five, and in Case II. menstruation was unusually free. In Case III. the menopause occurred at forty-six, and menstruation was likewise said to have been excessive. Finally Case III. presented a well-marked purpura. What significance these symptoms may have, it is impossible to say. It may not, however, be out of place to recall the not infrequent occurrence of uterine hemorrhages in women who subsequently suffer from myxœdema.

Bronchitis is a most frequent and persistent symptom in Case I., while both Case I. and Case II. suffered mark-

edly from cardiac dyspnœa. But these symptoms were absent in Case III.

As already stated, fragments of the enlarged tissue were removed from Case I. by the Duchenne trocar, as also from Case II. In both instances fat-cells and connective tissue were found in varying proportions. At times the connective tissue appeared decidedly embryonal in type (see Fig. 4). This was especially so in Case I., in the fragments removed from the upper third of the right arm. It would seem further that in the more recent formations the fat-cells are less perfectly developed, while in the older areas a fully formed adult fatty tissue is present. It is especially to be regretted that the loss of the specimens from the autopsies of Cases II. and III. prevented a confirmation of these results.

The fact that in both cases the thyroid gland was found indurated and much infiltrated by calcareous deposit is not only very interesting but exceedingly suggestive. Without microscopic studies, however, and without a more extended series of cases it is impossible to draw a conclusion. The part, if any, played by the thyroid in this curious affection can only be determined by future autopsies. It goes without saying, also, that the thyroid should be studied in every case of obesity, whether typical or otherwise, that reaches the post-mortem table.

With the above data before us, it is impossible to classify these cases under any well-established disease. Evidently the affection is not simple obesity. If so, how are we to dispose of the nervous elements present? It is equally certain that we have not myxœdema to deal with. All of these cases lack the peculiar physiognomy, the spade-like hands, the infiltrated skin, the peculiar slowing of speech, and the host of other symptoms found in myxœdema. It would seem, then, that we have here to deal with a connective-tissue dystrophy, a fatty metamorphosis of various stages of completeness, occurring in separate regions, or at best unevenly distributed and associated with symptoms suggestive of an irregular and fugitive irritation of the nerve-trunks—possibly a neuritis. This, however, does not embrace the whole truth, and it remains for future research to determine to what this neuritis is due, whether it is a cause of the fatty metamorphosis or only concomitant, and whether the thyroid gland does not play some mysterious part in its causation.

Inasmuch as fatty swelling and pain are the two most prominent features of the disease, the writer has proposed for it the name *Adiposis* Dolorosa.*

F. X. Dercum.

ÆTIOLOGY (now often less authoritatively written Etiology; from Lat., *ætiologia;* Gr., **αιτία**, cause, **λόγος**, discourse) is the general science of causation. In a narrower sense it forms one of the grand divisions of Biology—the science of living things—the others being Morphology, Physiology, and Distribution. Ætiology deals with the causes and the explanations of the phenomena of biology, and with the whole subject of origins. Darwin's classical work, the "Origin of Species," is a good example of a monograph in ætiology. Examples in medical literature will occur to everyone. Professor Huxley has defined ætiology in biology as that science which has for its object "the explanation of biological phenomena by showing that they constitute particular cases of general physical laws."

If we keep this definition in mind we shall immediately discover the place of ætiology among the medical sciences. The phenomena of disease are quite as truly biological phenomena as are those of health, for pathology is simply the morphology, physiology, and ætiology of the morbid organism. In this case, therefore, ætiology has for its special province *the explanation of the phenomena of disease by showing that they constitute particular cases of general physical laws.* The importance of a science which seeks to do this can be appreciated only by those familiar with the history of medicine from the time of its gradual emancipation from priestcraft and dæmonism, through the humoral pathology, methodism, pneumatism, and the like, to the dawn of the cellular pathology in the middle of the present century. It means nothing less than the search of modern science for the causes of disease.

The word ætiology is used in the medical sciences in two distinct senses, which may be described as the proximate and the ultimate, or the practical and the theoretical. The term is known most widely in connection with the proximate causation of diseases, and to observe the difference in its application it is only necessary to take an example from any well-known disease, for instance, typhoid fever. By the ætiology of this disease is usually meant the mechanism of infection; how the specific germ (if this be now allowed to exist) is distributed in a community, how it finally arrives in the alimentary canal and by what vehicles, namely, polluted milk, water, or other food materials, secondary infection, climatic or "pythogenic" influences, broken drains, miasmata, the level of the local ground-water, etc. This aspect of the subject may be called the proximate, immediate, or practical side of ætiology. But after the specific *materies morbi* of typhoid fever has arrived in the body it has still to do its work. It must somehow derange the normal structure or function, or both, of some part or parts, or of the whole body. It must unduly disturb the living stuff. It is the doing of this act which constitutes true ætiology; this is the real causation of typhoid fever. The ætiology of the disease is the ultimate action upon the normal organism, the reaction to which is seen in the chain of phenomena called the disease. Obviously, practical ætiology becomes the foundation-stone of sanitary science and preventive medicine; while theoretical ætiology is the goal of pathology.

We may conceive of the living organism as a living machine, having, in health, certain normal structure and functions. Disease will then be manifested by abnormal structure or function. This might be due, conceivably, to inherent defects in the constitution or construction of the machine,—as when a watch breaks down or keeps time badly owing to poor construction or poor constituent materials; or to some interference with the machine by something proceeding from without,—as when dirt or injury interferes with the running of the watch. Diseases due to defective structure or poor materials of the machine may be called *intrinsic*, diseases coming from the environment may be called *extrinsic*. The former are strictly constitutional, the latter strictly environmental in their origin. But organisms can never be free from the influence of their environment to which they must constantly be adjusting and readjusting themselves. So fundamental is this phenomenon that Mr. Herbert Spencer has seized upon it as the main phenomenon of life itself, which he defines as "the continuous adjustment of internal to external relations;" or, in other words, adjustment of a changing organism to its changing environment. There can be no question that for the student of ætiology this is the most important feature of normal life, and that it furnishes a sound basis for his definition of disease. From this point of view life is a long series of departures from the normal, each followed by a return or readjustment. Adopting the definition and applying it to disease (abnormal life) we may define the latter as *partial failure in the adjustment of internal to external relations*—a total failure being death, either local or general.

Physiology teaches that the function of functions is metabolism, and the continuous adjustment just referred to is based upon the hypothesis of a flexible metabolism, itself in constant change and also capable of responding to changes in the environment. In the language of physiology, metabolism is here co-ordinated with irritability. In less technical language the living machine differs from an ordinary lifeless machine in the remarkable

* Adiposis, as is well known, would be etymologically more correct if it were written adipositas, but adiposis has been so long in use that it must be regarded as established. Adiposis Dolorosa has also perhaps a less formidable sound than has its Greek equivalent "Lipomatosis Algera."

extent of its power of repairing itself and adapting itself to the varying demands made upon it. But we must immediately qualify this statement. It is only the well-built living machine that can do this, and even the best of such machines can do it only to a limited extent. Here, then, lies the true conception of disease. Given a poorly made machine, or one of poor materials, and in time, no matter how favorable the environment, break-down (or disease) is certain to occur. Or, on the other hand, given a good machine, but an environment to which it is unable fully to adjust itself, and again disease and disaster ensue.

Disease, then, like ordinary life, is a condition; if the organism is well-made and capable, and adjusts itself without undue strain to its environment, health, or at least freedom from constitutional disease, is assured to it. But if it be poorly built, or of poor materials, it will ultimately fail to do its work well and disease will appear; or, it will fail utterly and death will supervene. Again, given a good living machine, its environment may change beyond its power of adaptation to it, as when a strong man is poisoned or falls into molten metal. In physiological language disease is to be conceived of as either imperfect metabolism or excessive (irreparable) interference with metabolism.

That nosology is the simplest, and also the most scientific, which regards diseases as either intrinsic or extrinsic, constitutional or environmental, and places diseased life in the same general category with normal life. If we accept this view and hold that disease is disturbance or abnormality, due either to defects in the living machine itself, or to environmental conditions or influences with which the machine cannot deal without exceeding its ordinary powers of adjustment and suffering thereby, we shall arrive at the fundamental conception of ætiology. We shall see that the causes of disease may be many, but that all causes, in the last analysis, must be either constitutional or environmental, or both.

At the present time there is remarkable activity in the domain of ætiology. The proximate causes of disease, the mechanism of infection, the distribution of specific germs, the sanitary effect of particular occupations or trades, such as stone-cutting and match-making, the influence of climate, diet, urban and suburban life, and the like, are being eagerly studied. Preventive medicine, working with the invaluable clews supplied to it by the germ theory of disease, is making progress that may fairly be described as immense, and is enriching almost daily our knowledge of proximate and practical ætiology. But it is in the field of ultimate or theoretical ætiology that the most remarkable achievements are now being made. In the course of the hot pursuit of immunity, which is one of the features of the day, much has come to light concerning the facts of cellular irritation, defence, and disease. It appears that in acute infectious disease—and at present our knowledge is largely restricted to the environmental diseases—there is first an invasion of the organism by something proceeding from without, it may be lifeless substances (poisons) or living organisms (germs, parasites, etc.). These act upon some or all of the living cells of the body, which in turn, by the exercise of their ordinary functions of adjustment, react upon the foreign matters. The extent of their reaction will depend upon the emergency and upon their own powers. The nature of the reaction will depend upon the particular irritation applied. The success of the reaction will depend upon its victory or failure. The reaction itself may make its appearance as functional disease or disturbance, such as fever, or as lesion, discoverable by structural changes in tissues or organs.

Ætiology here becomes the history of a battle in which the living machine struggles with an unfavorable environment. If it struggles easily, naturally, and successfully, the phenomenon is called ordinary life. If violently, and with fever, delirium, and slow convalescence, we must think of disease, but not necessarily of permanent lesion. If with obvious injury, and sequelæ such as indicate lesion, we must suppose that the machine has suffered beyond complete repair, though it may still continue to work. If death ends the struggle, it means that, however heroic may have been the effort, the mechanism proved inadequate to cope with its environment—unable to adjust its internal to its external relations.

Turning to the intrinsic or constitutional diseases we find ourselves dealing with a much more difficult phase of the subject. The special structure of the vital apparatus depends chiefly upon heredity, though its powers are influenced by environmental conditions, such as food, temperature, electricity, and moisture. What it is, precisely, that distinguishes the protoplasm of A from that of B we cannot say; why the one forms biliary or urinary calculi, while the other does not, though living under apparently similar conditions, we do not know. The microscope fails to reveal the important differences of molecular structure which must exist. Yet there can be no doubt that, if these could be seen, differences might be detected as great as those between any two machines intended to serve precisely the same purpose—for example, two clocks of different manufacture.

Enough has now been said to show that while we are yet very much in the dark concerning the ætiology of disease, we are certainly making headway in "the explanation of biological phenomena by showing that they constitute particular [and usually extreme] cases of general physical laws." The "general physical laws" prevailing in disease are the general laws of biology; the "particular cases" which diseases constitute are those of poorly built organisms struggling with ordinary environments, or, perhaps, as often, well-made organisms struggling with unfavorable environments; *i.e.*, normal organisms with abnormal conditions, or else abnormal organisms with good conditions. For a recent and suggestive treatment of the ætiology of disease see the Lumleian Lectures by P. H. Pye-Smith, delivered at the Royal College of Physicians, London, in *The Lancet*, 1892, Vol. I., p. 847 *et seq.* The debate now going on concerning *Immunity* (which see) should also be carefully followed.

William T. Sedgwick.

AGARICIN, AGARIC ACID.—The active principle of Boletus Laricis, Linn., White or Purging Agaric.

It occurs in white crystalline needles, soluble in alcohol, ether, and chloroform; boiling with water forms a gelatinous solution.

The use of this drug has been revived as a remedy for profuse sweating, especially the colliquative sweats of phthisis. Its effect is produced by its action on the glands themselves and not by any action on the nerve-centres. It is superior to white agaric on account of a more prompt and certain action and by not producing as much irritation of the digestive organs.

The dose is from $\frac{1}{12}$ to $\frac{1}{4}$ gr., increased to 1 gr.; it should be administered five or six hours before the expected sweating. It is given in pill or powder, combined with small doses of Dover's powder to counteract any tendency to diarrhœa. It may be administered by hypodermic injection. The following solution is recommended: Agaricin, $\frac{3}{4}$ gr.; alcohol, absolute, 80 ℥.; glycerine, 1 drachm. *Beaumont Small.*

AIX-LA-CHAPELLE (Ger., Aachen). Although the beneficial action of the thermal waters of Aix-la-Chapelle on a great variety of morbid processes has already been set forth (see art. Aachen, Vol. I. of this HANDBOOK), the chief *éclat* of this resort is undoubtedly due to the successful treatment there of syphilis. Many physicians have questioned whether the waters of Aix-la-Chapelle were possessed of curative properties unassisted by ordinary antisyphilitic treatment. Be this as it may, there is no doubt that better results are obtained at this spa, in all syphilitic diseases, than at any other watering-place in Europe.

It seems worth while to examine somewhat more closely the management of syphilis at Aix-la-Chapelle, for there is no theoretical reason why similarly good results should not be attainable at some of our own hot sulphur springs.

At Aix-la-Chapelle, mercury, properly given, is recognized as the true antidote to the poison of syphilis. And in agreement with the dictum of Sigmund, not only is the manifestation of mercurial poisoning held to be not needed, but syphilis is thought to be the more certainly cured in proportion as the body is protected from the toxic effects of mercury.

The Aix method of treating syphilis consists in the ancient practice of inunction, assisted by thermal baths and the drinking of mineral water.

The writer has closely followed the reasoning and rules given by Dr. Brandis, one of the most experienced physicians of the spa, as laid down in a series of articles published in the *Medical Press*. For more detailed information the reader is referred to "Aachen als Kurort," edited by Dr. Beissel, in association with the leading practitioners of the town, and published at Aix in 1889.

Dr. Brandis insists on three points:

1. The body must always be adequately prepared for the absorption of the mercury, and the gray ointment must always be used carefully and in sufficient quantity. The patients are directed to take a warm bath of half an hour's duration, and at a temperature of 95° F., so as to be prepared for the subsequent inunction. From this rule it may be necessary to deviate for various reasons. A very frequent cause which compels us to allow another treatment to precede the specific treatment is mercurialism, the result of previous incautiously applied mercurial treatment. If we are to undertake the inunction cure it is necessary to pay attention to the state of the skin. The Aix baths possess in a high degree the property of making the skin soft and absorbent. After the bath the patient must be most carefully dried, and immediately, in the bath-room, rubbed with gray ointment.

During the entire treatment it is advisable to allow the patients to drink the warm waters; two or three glasses should be drunk in the morning, and now and then in the evening also. In winter and cold weather they should be taken in bed; during the summer and on warm days, while walking about. Nevertheless, we must carefully notice if the internal employment of the waters disturbs the digestion, if it take away the appetite and thus interfere with the fulfilment of a very weighty indication, namely, the good nourishment of the body.

For removing the debility of the patients Dr. Brandis relies not on the use of the waters, but on the abundant drinking of warm milk, a measure the merits of which are not sufficiently appreciated.

Vapor-baths, followed by copious sweating, are indicated where the mercury no longer exercises its action on the healing process, and later on, in spite of continuous employment of co-operating remedies, appears not merely to remain inactive, but to give place to a new outbreak of the disease. As a rule, therefore, patients are directed, possibly after the twentieth inunction, to take a vapor-bath on three consecutive days, and after that to take the baths after each tenth inunction. During these days the rubbings must be discontinued.

As to the method of performing the inunctions, Sigmund's instructions are observed. But it is essential that competent rubbers do the work.

The ointment must be rubbed in with the entire surface of the hand, and with both hands conjointly, so that when, for example, the legs are subjected to the rubbing, the surfaces of the hands glide up and down simultaneously.

The use of gloves and pads is prohibited, as absorbing too much of the ointment. Mercurial poisoning in the rubbers is not observed. Every rubbing is to last fully twenty minutes, ten minutes for each half of the dose.

The instructions of Sigmund are as follows

On the first day rub both legs; on the second, both thighs; on the third, abdomen and breast; on the fourth, the back; and on the fifth, both arms.

Many patients, however, cannot endure the rubbing of the breast and abdomen; in such cases the sides of the body and the nates are employed. The daily dose varies with the body-weight and the susceptibility of the patients—between four and five grammes for adults, and from one to two grammes for children.

2. During a course of treatment the body must be maintained in good condition; exercise in the open air, spacious bedrooms, personal hygiene, good food in plenty are all to be thought of in this connection.

The treatment of the mucous membrane of the mouth is of great importance, for through its local treatment we must strive against the commencement of mercurial stomatitis.

Dr. Brandis employs a preparation made according to the following recipe:

℞. Pulveris aluminis,
Plumbi acetatis.....āā 30.0
Aquæ destillatæ..... 300.0
Misce et filtra.

This solution may be used diluted with pure water, or some aromatic water, about two dessertspoonfuls in a glass of water. The mouth must be regularly rinsed out, from the beginning of treatment, ten or twelve times a day, or even oftener; even when taking walks the patients must carry a small bottle of the liquid; and in urgent cases they must even use it repeatedly at night. After each meal the teeth must be brushed with a mixture of prepared chalk and camphor.

The author states that by most carefully carrying out these measures, we generally succeed in averting salivation; but occasionally it may happen that we may be obliged to suspend the inunction for a time. One thing more is to be observed—namely, we may accustom even highly sensitive patients to tolerate mercury. If we know beforehand that we have to deal with such, we begin with small doses of the mercurial ointment, and gradually increase to larger. Or if we have the misfortune to induce stomatitis, and are obliged to suspend the remedy, we postpone resuming it until all these symptoms have disappeared; we then begin again with small doses, and gradually rise to larger. A practical suggestion relates to ulcerative processes, so frequently observed in the course of syphilis. It is not always quite simple to distinguish mercurial from syphilitic ulcerations; they both occur in the most different parts of the mucous membrane of the mouth, and may look very like one another. Before all, this holds good of those mercurial ulcerations which occasionally appear on the tonsils and on the soft palate. Here frequently only long-continued observation can decide the matter; if, however, we are still in doubt, the inunctions must be suspended; the mercurial ulcers will then heal, whereas the syphilitic ulcers will be aggravated. They also behave differently when cauterized with nitrate of silver. The mercurial sore stands an energetic cauterization very well; in fact, its healing is furthered by it; whereas the opposite is generally the case with the venereal ulcers. Increased secretion of saliva may also occasion doubt, for at times syphilitic disorders which affect the cavity of the mouth directly produce salivation. Another disagreeable result of the inunction treatment is mercurial diarrhœa. This symptom sets in suddenly, the evacuations follow one another rapidly, there is pain and tenesmus, the stools are scanty and show mucus and blood. Treatment by opiates is indicated, but the inunctions must be at once interrupted.

Healthy persons lose in weight if subjected to mercurialization. In contradistinction to this, syphilitic patients gain in body-weight as soon as they enter the stage of convalescence. This applies to recent cases, as well as to those of old standing.

The inunctions must be employed for a sufficiently long time. As our task consists in healing the symptoms of the disease, and, as much as possible, in averting relapses, the earlier the syphilitically infected person is brought under mercurial treatment, the milder is the course of the illness.

3. Above all things, Brandis insists that we must not too soon dismiss the patient from treatment; indeed, never, until all symptoms have disappeared, up to the last vestige; and also, that even the slightest attacks must be

energetically treated from the outset. If experience shows us on the one hand that an inadequate treatment either fails to remove completely the existing symptoms, or, where complete recovery is achieved for the time, cannot avert later relapses, on the other hand we find that the desired result will be obtained in both directions, in those difficult and obstinate cases in which a long and energetic mercurial treatment must perforce be carried through.

In all ordinary cases the inunctions are prolonged eight or ten days beyond the time of healing of visible lesions, and the thermal baths need not be given for a longer period.

It is probable that Dr. Brandis goes a little too far when he claims that there are absolutely no contra-indications to anti-syphilitic treatment, as practised at Aix-la-Chapelle. The writer has visited Aix on several occasions, and he is convinced of the great efficacy of its waters, when used in conjunction with other remedies. But the very aged and extremely debilitated, as also the very young, should be judiciously treated at home, rather than incur the risks of a long and tedious journey to the ancient spa of Aix-la-Chapelle. Although it is an "all the year round" watering-place, the warm season should be given the preference. In the fall and winter months, the town is cold, dreary, and depressing, a circumstance worth remembering in sending patients there.

Edmund C. Wendt.

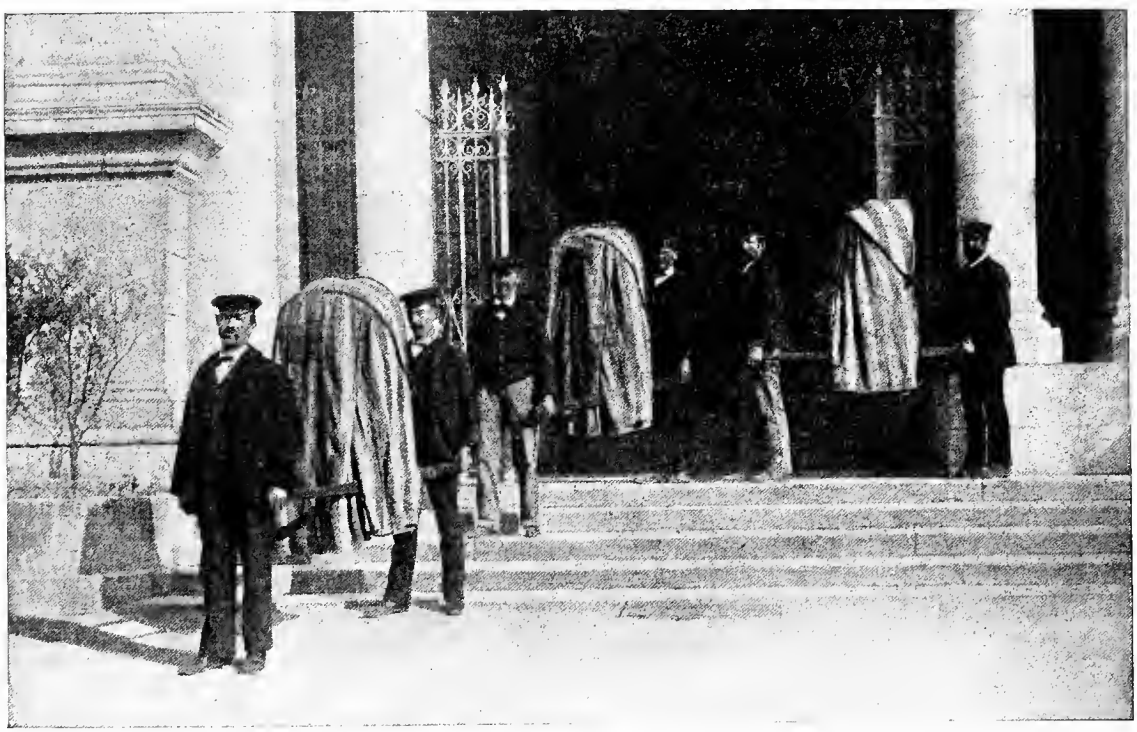

Fig. 14.—Method of Conveying Patients to and from the Thermal Establishment at Aix-les-Bains. (The Patients are Wrapped in Blankets only.)

AIX-LES-BAINS. In addition to the information already published (see Vol. I. of Handbook) concerning Aix, it may be well to give a supplementary description of certain features of this popular spa. It is not to be forgotten that no other resort in France is so largely frequented in the summer months by English and Americans as Aix-les-Bains. Dr. Linn (*The Climatologist*, June 15, 1892) has given a *résumé* of Aix in its modern development as a fashionable resort, from which the following account is taken:

The thermal establishment is one of the finest in France, and contains over fifty douche-rooms—general and local vapor-baths, swimming baths, and a large number of other baths, as well as the throat, eye, and ear douches, inhalation- and spray-rooms. Two thousand douches and one thousand baths can be, and often are, given daily.

The principal application of the Aix waters is by what is now called the "douche massage" (Forestier). The patient is taken into one of the large douche-rooms, where he is met by two of the attendants, male or female as the case may be. They seat the patient on a wooden stool, and, one taking the lower extremities and the other the back, they shampoo, knead, or rub according to the directions previously given by the patient's medical adviser. This is the "massage," in which all the attendants are skilled at Aix, it having been handed down to them from father to son, and from mother to daughter for many years past. The masseurs each have a hose under their arms from which they direct the water over the bather. It is this massage under the hot sulphur water that constitutes the principal treatment at Aix. The temperature of the water is varied by the physician's orders. As a rule, ten to fifteen minutes is the duration of this operation, when the patient is rubbed dry and enveloped in a blanket, put into a bath-chair and carried home by porters, who not only take him to his hotel, but also to his room, and place him in bed. This specialty of Aix is most important, as a rheumatic person seems to obtain more harm than good by having to dress after a douche or bath, and walk home afterward.

The waters of Aix-les-Bains are so abundant that they are allowed to flow away from an ugly public fountain. They act energetically by a stimulation of the cutaneous surface. It is, as it were, a purgation of the skin, making it eliminate whatever excrementitious matters may have been retained in the system, and relieving congestions of the deeper parts or organs, while giving a stimulus to the circulation in general. To this may be added the effects of the mineral elements in the waters taken into the system and blood both by drinking them and inhaling them during the douche and baths.

Dr. Linn accepts the usual indications for treatment, such as gout, rheumatism, skin diseases, syphilis, catarrhal affections of the respiratory passages, etc. But he has this to say as to contra-indications:

"It is easy to understand that all *acute* diseases would be better without the stimulation of the Aix treatment, and that its province is in *chronic troubles only*. Degeneration of the muscular fibre of the heart is a contra-indication, but valvular affections coming from a rheumatic cause improve at Aix, unless there be a tendency to syncope. Under this heading we think that patients should be warned against taking these powerful massage douches without medical advice, as they are apt to do great harm by an injudicious use of them. Many people insist on the masseurs giving them a vigorous treatment, when they have no proper power of reaction, and simply exhaust themselves, producing a state of feverish debility and weakness. Others, again, when the baths are crowded, get up at a very early hour to secure a douche or to have their morning free. We are of opinion that in many cases it will be found best to have a light breakfast and take the douche, as we do a sea-bath, at nine or ten in the morning or even later, and not attempt to turn out delicate people at five or six o'clock on a cool or wet day. As to the best time of the year to take this treatment, as a rule it should be during the summer months, *June to the end of September*, when the external warmth and greater equability of temperature, less risk of chill and its consequences, will allow patients who have rheumatic trouble, especially, to get the best results. It is remarked that July and August are the crowded months at the hydropathic stations, and many volumes have been written to try and persuade the good public that they would do better to come at other times; but the great mass are right, for very delicate people the *hot months are the best for bath treatment.*

"The establishment is, however, open all the year round, and those who like bracing air and want more reasonable rates can come at any time. The duration of the treatment has been rather arbitrarily fixed at three weeks or twenty-one days, but this depends on the case, as almost every patient demands a careful study by a physician, who alone can fix the time. It may be said, though, that many people get saturated with strong mineral waters in about three to four weeks."

Aix now has two *casinos*, the "*Cercle*" and the "*Villa des Fleurs.*" Good music and operas, reading-rooms, a race-course, pigeon-shooting, tennis, and other "distractions" are always provided at Aix. There are excellent opportunities for pleasant walks and excursions. The hotel and boarding-house accommodations are ample and highly satisfactory.

Concerning *Marlioz*, which is almost now a part of Aix, the same author gives the following information:

"Marlioz, an important sulpho-sodiac and bromo-iodurated water, is in the suburbs of Aix, and now forms part of it. It is a pleasant walk down the Avenue de Marlioz of about fifteen minutes, and the omnibus or tram runs there in less time. There are three springs, which are compared to the sulphur waters of the Pyrenees, like *Eaux Bonnes*. These springs are much richer in mineral elements than the hot waters of Aix itself. Patients live in Aix, but some rooms can be had close to the pretty little establishment in Marlioz. The specialty here is throat troubles. Its pulverizing or spray arrangements and inhaling-rooms are excellent and complete in every particular; there is also a good bathing department. The waters are highly efficacious in all chronic affections of the respiratory passages, chronic catarrhs, etc.; and form with the Challes water, which is also given in Aix, drawn from fountains in the chemists' or druggists' places like soda-water, a valuable adjunct to the other courses of treatment given in Aix-les-Bains."

Altogether the spa of Aix-les-Bains deserves the popularity which has been so liberally bestowed upon it by the exacting Anglo-American public.

Edmund C. Wendt.

AKINESIA ALGERA. Moebius[1] has given this name to an array of symptoms, among which the most characteristic is loss of power of movement as the result of accompanying pain, while no sufficient cause for the latter symptom has yet been found.

The cases which he reports were persons of neurotic inheritance, so-called *déséquilibrés*, in whom the disease manifested itself after mental over-exertion. In the one case neurasthenia, in the other hysteria, was present. In both cases the disease was quite protracted. The first case reported by him occurred in a man, a teacher in the gymnasium, thirty-three years old. The father suffered from paranoia. The patient during his youth was very excitable and extremely ambitious. No history of sexual perversion. In 1887 he suffered from headache and insomnia. In the spring of 1888 he was unable to carry on his work, and was sent to an institute. Subsequent to this there occurred a loss of memory for three or four weeks. After every movement the patient experienced a heaviness of the limbs and pains in the muscles. Improvement took place under prolonged rest, or the Weir Mitchell treatment. Following this a relapse occurred, during which the patient abstained from all movement of the limbs. The skin- and tendon-reflexes were present; the patellar reflex was quite marked. On the right side the ankle reflex was weak; on the left it was marked. There was found hyperæsthesia in the hands and forearms; no points of pain, however, were discovered. Organs of special sense normal. Every voluntary movement of the limbs and trunk was accompanied by severe pain, lasting for hours. These pains were most marked in the forearms. The head was free from pain, and there was no difficulty in moving it. There was a very slight muscular atrophy of the left hand, which was possibly caused by the pressure of pasteboard splints.

In the way of treatment, bromide of potassium, given in the evening in doses of from three to four grains, produced rest. Hypnotic suggestion was without result. Improvement followed after several months' rest. The tendon reflexes became weaker and finally normal, there remaining a weak ankle clonus on the left side. Subsequent to this, and following a considerable excitement, a relapse occurred, with subsequent improvement. The hands, however, remained quite painful.

The second case occurred in a woman, forty-three years of age, by occupation a teacher of music. A neurotic family history was given. From her twentieth year onward the patient had suffered from tremors, with semi-unconsciousness. The hands were painful, and were held in a flexed position. She also suffered from insomnia, and was incapable of mental work. The feet were painful, and walking was impossible. After suffering in this way for ten years, improvement set in, and the patient was comparatively well for a subsequent period of ten years. In the summer of 1889, probably as the result of over-work and excitement, a relapse occurred, from which she had not recovered up to the time of the report. There were found, extreme irritability, a forced position of the hands, and pain in the legs. The latter could be moved, but they soon became tired, and suffered from quite severe after-pains. Auditory and visual functions were normal. Hypnotic treatment without result. The patient twice attempted suicide, and finally gave evidence of mental trouble, with hallucinations of persecution. She subsequently died in an insane asylum.

In a subsequent publication[2] Moebius reports another case in which, in addition to the absence of motion resulting from pain, and really superseding it in importance, there was present an extreme degree of photophobia. We have here a condition very similar to that which has occurred in regard to motion, a condition in which the patient will not see because of the attending pain.

Moebius seeks to widen the term by calling it "Apraxia algera," or abeyance of the function of any or all organs because of the pain attending their functional activity.

In the last case this was very well illustrated by the very severe pain in the head attending any mental effort whatever. The case has a further interest in that the

report is taken from the "Autonosography" of the distinguished psycho-physicist, Gustav Theodor Fechner.

Longard[3] reports a case occurring in a young lady, aged twenty-nine. Her mother had suffered from arthritis deformans; her father, in 1874, became afflicted with paranoia. The patient had for years previously suffered from pelvic troubles (pelvic inflammation, uterine fibroids, metritis, etc.). The symptoms observed in this case were mental excitement and peculiar pains over the entire body, which later became so severe as to compel the patient to abstain from all motion. The psychical excitement also increased. During the later period of observation, retention of urine, marked constipation, and very obstinate insomnia showed themselves. Objectively, an increase of the tendon reflexes was found. The course of the disease was not materially altered during six months' treatment in the hospital. Improvement occurred later as the result of improved surroundings.

Longard calls attention to the fact that these cases of akinesia algera give the same clinical picture as was formerly described under the name of spinal irritation.

According to Moebius the affection is a functional or psychic one, and is not due to organic disease. The pains he regards as hysterical, or pain-hallucinations. The disease itself is not, however, a pure hysteria, but may be regarded as an analogue of the general anæsthesia described by Krukenberg, Heyne, and von Ziemssen. The cases reported by W. Neftell in 1883, and called by that author Atremia, are regarded by Moebius as similar to his cases.

The prognosis is not very favorable. In the matter of treatment the best thing to do is to accede to the wishes of the patient for rest.

S. P. Kramer.

[1] Deut. Zeit. fur Nervenheilkunde, 1891, vol. i.
[2] Ibid., vol. ii., 431.
[3] Ibid., vol. ii., 455.

ALASSIO. A winter health-resort on the Italian Riviera, which is lately claiming an increased share of attention. It is prettily situated, but owing to its comparative newness the accommodations for invalids are far from perfect. The only reliable meteorological data available are those of Dr. Schneer ("Alassio and its Climate," Turin, 1878) and a synopsis published by Dr. M. G. Foster (*British Medical Journal*, November 7, 1891). Dr. Foster, who is now practising at San Remo, informed the writer that the authorities of Alassio appeared to lack energy in effecting reforms, more particularly from a sanitary point of view. Dr. Foster spent two winters at Alassio, and did not observe any typhoid fever there; but it is said to occur there every summer. There is no system of drainage, the excreta being collected in cesspools. The drinking-water is hard, but as to organic impurities reliable data are not at hand to justify its condemnation or acceptance. Sparks ("The Riviera," London, 1879), claims that the water is good and potable.

Alassio is on the north shore of the Mediterranean, about equidistant from Nice and Genoa. It lies at the head of a curving bay, which is some five miles wide. The town has about 6,500 inhabitants. Its latitude is about the same as that of San Remo. Dr. Foster's description is here reproduced, as it is accurate and devoid of local bias:

"Without the gates of the city proper at either end stretches a suburb composed of dwellings of the Italian population mingled with a few villas. Each of these suburbs contains a hotel situated facing the sea, while a third is placed about a hundred yards behind the main street of the town. The villas of the English residents are dotted over the lowermost spurs of the encircling hills. The hills form an unbroken semicircle round the town. Their greatest elevation is on the north (1,963 feet). Numerous valleys run up among the lower spurs of these hills, but none pierce them.

"Alassio thus secures good protection from the north, west, and southwest. The seashore is generally windy, but in the valleys running up among the hills the wind is rarely severely felt, and on most days the air in these situations is almost entirely still."

The records of temperature (as given by Foster) are as follows:

"October has a	mean	temperature of	61.9°	Fahr.
November	"	"	54.3°	"
December	"	"	49.7°	"
January	"	"	47.3°	"
February	"	"	48.2°	"
March	"	"	52.3°	"
April	"	"	56.4°	"
May	"	"	64.3°	"

"The mean temperature of the three winter months is therefore 48.4° F."

Turning now to the rainfall observations, the records give the following results:

"October shows an average of 7 days on which rain fell, an average rainfall of 93.1 millimetres, and a mean relative humidity of 55.2.

"November shows an average of 8.6 days on which rain fell, an average rainfall of 163.7 millimetres, and a mean relative humidity of 58.

"December shows an average of 5.6 days on which rain fell, an average rainfall of 43.3 millimetres, and a mean relative humidity of 55.4.

"January shows an average of 4.3 days on which rain fell, an average rainfall of 60 millimetres, and a mean relative humidity of 52.9.

"February shows an average number of 4.8 days on which rain fell, an average rainfall of 70.9 millimetres, and a mean relative humidity of 55.7.

"March shows an average of 6.6 days on which rain fell, an average rainfall of 50.7 millimetres, and a mean relative humidity of 57.9.

"April shows an average of 10.8 days on which rain fell, an average rainfall of 111.9 millimetres, and a mean relative humidity of 62.8.

"May shows an average of 5 days on which rain fell, an average rainfall of 46.4 millimetres, and a mean relative humidity of 63.1.

"Fog has been recorded on 14 days in the six winters."

In his summary of what class of cases are likely to derive benefit from a winter residence at Alassio, Dr. Foster expresses the following opinions:

"The climate of Alassio possesses those advantages which a tolerably high and fairly equable temperature, abundance of sunshine, and freedom from fog can give. Cases of gout and chronic rheumatism do well there. Cases of heart disease certainly appear to do well; they eat and sleep better, and, with ordinary precautions, attacks of secondary bronchitis can be prevented. Cases of bronchitis and emphysema, with care, keep very free from winter cough. Cases of phthisis require very careful selection. Early cases, with limited consolidation and only slight fever, generally do well. Later cases with cavities seem to show improvement, the cough and expectoration diminish, and, since the patients can generally pass a fair amount of time in the open air, the appetite and sleep are both improved. Cases characterized by frequent hemorrhage, with only slight physical signs, seem generally to do well. Owing to the proximity of the principal hotels to the sea, the effect of the climate varies in different cases; some patients sleep badly by the sea, and thus lose much of the benefits; others again sleep better there than elsewhere. Weakly and strumous children certainly show great improvement, as they can pass a large amount of time on the seashore. Finally, with regard to that numerous class of cases which are sent to the Riviera under the generic title of nervous breakdown, some cases seem to show great improvement and regain their lost health, while in other cases all the symptoms appear to become aggravated."

Alassio is a somewhat cheaper place to live in than many of the other Riviera stations.

Edmund C. Wendt.

ALEXANDER-ADAMS OPERATION. The operation of shortening the round ligaments for the cure of prolapsus uteri was proposed by Alquié, as applicable to the cure of retroflexion. Aran, according to Tillaux, suggested this operation. The same thought occurring to Freund he performed the operation on the cadaver. It was first performed on the living subject by Alexander, of Liverpool, in 1881. Adams, of Glasgow, performed it in 1882, without a knowledge of Alexander's operation. During the past ten years the operation has been done hundreds of times, and principally in America. This operation has been severely criticised by many, both here and abroad, but on carefully looking up these criticisms it was found that they were wholly based on theoretical grounds, or had been brought forward by those who had not done the operation sufficiently often to be familiar with it or its results. Those who have done the operation the most times and have seen the excellent results that follow in properly chosen cases, are its most enthusiastic advocates. Hysterorrhaphy is advocated by some, *especially* by operators on the Continent, in preference to the Alexander-Adams operation. I have had considerable experience with hysterorrhaphy for the relief of retroversions and flexions, both with and without adhesions, attended both with and without prolapsed and adherent ovaries. My results have been excellent, there having been but one failure and one death in quite a considerable number of cases.

As far as I can ascertain we have no data relative to the effect of pregnancy on the adhesions produced between the parietal peritoneum and the peritoneum covering the uterus. With the other operations inside the abdominal cavity that secure the forward position of the fundus uteri I have had no experience. But opening the abdominal cavity is not wholly without danger, consequently the Alexander-Adams operation is preferable, especially as it will accomplish, in just as satisfactory a manner, everything that an intra-abdominal operation will do, and it is practically free from danger.

Indications for the Operation.—1. For the cure of uncomplicated retroversions and retroflexions where the patient is desirous of getting rid of wearing a pessary which necessitates her consulting a physician at stated intervals and makes her feel that she is still on the invalid list. Patients often choose this operation to avoid wearing a pessary.

2. For the cure of retroversions and retroflexions where a prolapsed ovary or ovaries prevents the wearing of a pessary, either by mechanically diminishing the transverse pelvic space, thus causing a pessary to ride obliquely instead of horizontally, or where, through sensitiveness of one or both ovaries, a pessary cannot be tolerated.

3. For the cure of retroversions and retroflexions with prolapse in the second degree, and for all cases of procidentia; it being understood that whatever plastic operation on the vaginal walls or perineum is called for, shall be done at the same sitting. As this operation diminishes a rectocele, but increases a cystocele, I advise doing the Alexander-Adams operation before operating on the vaginal walls. All operations on the vaginal walls can be done without bringing any strain on the round ligaments, just fastened in their new relations. If a trachelorrhaphy is called for it should be done at the same sitting with the Alexander-Adams, but prior to it, as all dragging down on the round ligaments should be avoided.

4. For the relief of lateral displacements, retroversions, and retroflexions with adhesions. Often, after packing faithfully for weeks, sometimes for months, in the Sims position, we are unable to relieve this class of cases, the more or less fixed position of the uterus and our inability to keep it forward in anteversion being due to adhesions between ovary and tube, or ovaries and tubes, and peritoneum covering uterus, broad ligaments, rectum, or intestine. In my experience these cases give a history of septic peritonitis following labor, abortion, or salpingitis. In opening the abdominal cavity in cases where there has been for months or years retroposition with adhesions—often cases of pyosalpinx with a history of repeated attacks of peritonitis—I have over and over again been surprised at the ease with which the uterus could be anteverted by the intra-abdominal fingers, and in a good proportion of the cases the fundus would stay forward without being supported. This led me in 1889 to make attempts, under ether, through the rectum, to replace uteri retroverted or retroflexed and adherent, after the packing had been thoroughly tried. The index finger of the left hand is passed up the rectum, the patient being *thoroughly* etherized, flat on the back on an even hard surface, with the knees well separated and the thighs drawn *forward* to an angle of forty-five degrees with the table. The index finger is passed up until, with the aid of counter-pressure by the right-hand fingers through the abdomen, it feels the whole of the posterior surface of the uterus, the posterior surface of the broad ligaments, the fundus, the ovaries, and the tubes. In this way all the pelvic structures can be actually examined and their relations to each other, changes in size, etc., can be more accurately determined. Then gently, but slowly, the uterus is anteverted. At times the adhesions are overcome with difficulty. Dr. Conant and myself worked over one hour in breaking up the adhesions in one case, and half an hour is no unusual time to be consumed in replacing the uterus. Then, while the uterus is held in position by a Kingman's or Emmet's uterine repositor, the cervix being pushed well back into the post cul-de-sac, an Alexander-Adams operation is done. The uterus is thus held upward, non-flexed, and forward while the raw surfaces of the peritoneum are becoming adherent to each other.

In some cases it is impossible to correct the retrodisplacement, owing to the quantity, quality, or location of the adhesions, without using more force than would be safe. In such cases, if the condition of the patient demands interference, or if she is sterile and willing to run the risk, cœliotomy should be done, all adhesions broken up, and the uterus fastened in anteversion by hysterorrhaphy. This combination has worked admirably in cases where it was impossible to satisfactorily replace the uterus through the vagina or rectum.

When, the patient being under ether,—and a diagnosis not made when the patient is thoroughly anæsthetized should not be accepted as final,—the tubes are found to contain fluid or are much enlarged, I think it advisable not to interfere with adhesions, for fear of rupturing the tube or tearing away the fimbriated extremity, thus allowing septic material to escape into the peritoneal cavity.

5. While witnessing Dr. Conant make several dissections for the round ligaments, I was surprised to see how securely and evenly the internal abdominal rings were closed when the round ligaments were drawn out, and it occurred to me that the Alexander-Adams operation might be done for the radical cure of hernia.

Dr. Conant wrote me the following, under date of August 24, 1892: "I have had one case for radical cure of hernia by the Alexander operation. The case was one of double inguinal hernia in a young girl of nineteen. I practically did the regular Alexander, except that I was somewhat puzzled to find the round ligament on the right side, owing to the size of the sac. The result of the operation was very gratifying. Previous to the operation, which was done last spring, she was unable to work, but since the operation she has been at work for the last three months. She is in good health, although she has some pain at times in her left side. I have examined the case within a week and found a firm cicatrix about the pillars of the rings on both sides. She never wore a truss." In October, 1892, I did an Alexander-Adams operation for procidentia of six months' standing, and left inguinal hernia. At the present time (January, 1893) the uterus is in perfect position, there is complete relief of all symptoms, and there has been no symptom of a return of the hernia.

6. In two cases I have done the Alexander-Adams operation to prevent incarceration of a fibroid which threatened to take place at any time, the growth of the tumor being very rapid. In both cases severe symptoms from pressure were present. In both cases the fibroid, which

was interstitial, in the posterior uterine wall, was got out of the hollow of the sacrum with great difficulty. In both cases, one a woman who had borne five children, the other not married, the ligaments were as large as a No. 2 Faber lead-pencil. The first case was operated on in March, 1891 (reported in list of cases). Examination one year later revealed the uterus to be in perfect position, with a marked diminution in the size of the fibroid. (Treatment with the idea of arresting the growth of the fibroid had been continued throughout the year.) The second case was operated on in June, 1892. At present (October, 1892) the uterus with its large fibroid is up out of the pelvis, and there is relief from all former distressing symptoms.

Those opposed to this operation bring forward the following objections:

1st. That the ligaments are often absent.

2d. That there is great difficulty in finding the ligaments.

3d. That it is a dangerous operation.

4th. That it prevents the usual course of pregnancy, causing it to terminate in abortion.

5th. That after pregnancy the uterus returns to its former malposition.

6th. That it may give rise to serious secondary symptoms or conditions.

7th. That it is limited in its application.

8th. That it will soon become obsolete.

1. In my experience with over one hundred and twenty-five cases, I have never failed to find the ligaments except in one case. This was among the very first operated on. No doubt the ligaments were present and of good size, but I failed to find them. Since then I have operated successfully on a case where the operation had been attempted, but abandoned on account of the inability of the operator to find the ligaments. The patient was told that she had no round ligaments. I agree with Dr. W. M. Conant in his statement, that "The ligaments are never wanting provided there is a uterus." They may be very small, but they are there and are of a good size nine times out of ten after they are drawn out.

2. The difficulty in finding the ligaments depends entirely on the experience of the operator. The description of the operation given in many text-books is misleading. The beginner is led to think that he is about to do an operation the success of which depends on his ability to recognize each layer of tissue and every vessel and nerve from the skin down until he has reached the aponeurosis of the external oblique muscle. Now this is at times difficult to do with thin abdominal walls, and often so in a fat patient, and it is no wonder that the beginner gets wound up with a round turn just at the time when it would mean success for him to have some fixed and easily recognized landmarks. Many descriptions of the modus operandi of the Alexander-Adams operation remind me of the old way in which an abdominal section was described—where layer by layer the tissues were cut through on a grooved director with a dull knife down to the peritoneum, more time being used up in getting inside the peritoneum than is now often consumed in getting in, doing what is necessary, and getting out. If the operator will mark, read, learn, and inwardly digest Alexander's excellent article, fully describing the operation, in the "Transactions of the International Medical Congress," 1887, vol. xi., p. 742, and Mundé's admirable article in the *American Journal of Obstetrics*, 1888, he will have no difficulty in finding the ligaments.

3. Alexander has operated eighty-four times and has never had a death, and in the article above referred to he says, "I no more expect a death from it than I expect a death from an amputation of the finger."

Mundé has operated thirty-seven times and has never had a death nor any unpleasant results.

Reid has operated thirteen times with no death.

Edebohls has operated twenty-nine times with no unpleasant results.

Newman, in 1888, read a paper on this subject, and estimated there had been up to that time three hundred cases operated on. Of this number he knew of three deaths.

W. M. Conant has operated over thirty times with no death.

F. B. Harrington has operated twenty-five times with no death.

Kingman has operated over twelve times with no death.

Burrage has operated over sixteen times with no death.

J. G. Blake has operated twenty-five times with no death.

J. B. Swift has operated thirteen times with no death.

I have operated over one hundred and twenty-five times with two deaths. The first was due to acute sepsis. The abdominal cavity was opened while drawing out one of the ligaments. This was among my first operations and before the rigid asepsis now employed was used. The second was due to pneumonia and occurred six days after the operation. The wounds had healed by first intention throughout. The various journals for the past few years have contained abundant testimony like the above.

In over two hundred and forty-six cases operated on in Boston, most of the cases having been operated on since 1888, I have been able to learn of only three deaths, two mentioned above and a third, due to sepsis, the bladder having been opened on the left side, either by the knife or a deep stitch. On this followed infiltration of urine with pelvic abscess, to which the death was to be directly attributed. In nearly a thousand cases collected by Dr. W. M. Conant he found a record of only seven deaths.

4 and 5. These can best be answered in one. That it does not prevent the usual course of pregnancy can, as Dr. Conant has shown, be best determined by a reference to the cases reported. He collected twenty cases; seven by Alexander, five by Mundé, two by Conant, two by Johnson, and four unknown. Alexander claims that pregnancy is favored by this operation and that there is little danger of the return of the former malposition. Dr. Mundé wrote Dr. Conant as follows: "In four the uterus remained in its normal position after confinement. One, done for prolapse, became pregnant soon after the operation and after the confinement the prolapse returned. This is the *only* case where the displacement, retroversion or prolapse, returned after the operation, so far as I know."

Dr. Conant's first case was the first one he operated on; about a year after the operation she was married and was unwell only twice, when she became pregnant. She has been delivered at term. My two I will report here at some length.

Case I.—Diagnosis under ether: Ruptured perineum; retroflexion; bilateral laceration of the cervix; left ovary prolapsed and adherent at a point close to the uterus at the base of the left ligament. By packing, the uterus was got into normal position, but a pessary could not be worn on account of the prolapsed and adherent ovary. She was advised to have the lacerated cervix operated on and to have an Alexander-Adams operation to relieve the sagging and dragging down. *She had aborted four times since her last confinement five years ago.* The operations were done in February, 1890, and perfect results were obtained. In a few months she became pregnant and was delivered at term. The family attendant answered the following questions.

Length of labor? "About one and three-quarters hours."

Sex and weight of child? "Boy; nine and one-half pounds."

Character of labor? "She had good pains, better than ever before."

Puerperium? "She remained in bed fourteen days. She flowed a good deal—not post-partum hemorrhage,—but during her stay in bed she lost considerable blood, although there was good and permanent contraction of uterus. She was weak on getting up, but nothing of interest occurred. She nursed the baby." One year after pregnancy took place she was examined at my office. The symptoms for which the operations had been done had never returned. The uterus was in per-

fect position. Cavity measured two and one-half inches. No discharge from vagina or cervix.

Case II.—Sterility. Diagnosis under ether; Retroversion with adhesions; left ovary prolapsed and adherent; chronic endometritis.

She had been married five years. Never pregnant. Sought relief for the sterility and for back-ache and pain in the left ovarian region. January, 1891, the uterus was forcibly restored to its normal position and the round ligaments were shortened. Both sides suppurated, but the result was perfect, except that the uterus was drawn over toward the right side. She became pregnant two months after the operation and was delivered at term. Examined at my office one year after confinement. Uterus was in the same position that it was directly after the operation. Left ovary could not be found. Since the operation there has been complete relief of all back-ache and pain in left ovarian region.

6. I have had four cases in which pneumonia followed this operation, but I could see no connection between the operation and the lung trouble. All four occurred in hospital practice, during the winter, and at a time when the grippe was very prevalent. One case, noted above, died. I have had several cases in which pneumonia followed cœliotomy and in no way, so far as I could see, was it connected with the operation.

Cases of cystitis have been reported, but I have seen but one such case, and I attributed it to washing out the bladder. For the relief of frequent and painful micturition the nurse in my absence was ordered to wash out the bladder, and a violent cystitis followed, lasting two weeks. In quite a large proportion of the cases operated on by myself there has been bladder-trouble, showing itself in frequent and painful micturition with scalding referred to the meatus and urethra, and suprapubic distress or dull pain. In some cases there has been tenesmus with the forcing out of a few drops of blood at the end of micturition. In these cases the urine has been of a high color, high specific gravity, and loaded with mucus and urates.

Unfortunately, in almost every case after this operation there is inability to empty the bladder for the first twenty-four hours, and sometimes it is three or four days before the catheter can be dispensed with. But in some of my cases the above symptoms occurred when no catheter was used, and whenever the catheter *was* employed the greatest vigilance was exerted to secure cleanliness. In the cases where no catheter was used, the symptoms were usually less severe, lasted a short time, and were more amenable to treatment. Still, the severest cases got well after a time. One class of these cases is peculiar, and points to the fact that the operation is directly the cause of the bladder trouble. In this class there had been no previous bladder trouble, no retention, and no catheter had been used. The bladder symptoms appeared, but not for eight or ten days, and in one case they did not appear for three weeks after the operation. I have gone thus extensively into the bladder trouble following this operation, as it is a strong point with the opponents of the Alexander-Adams operation. For twelve years I have seen a great deal of gynecological surgery, both hospital and private, and at the hands of the very best men, and have known the above-mentioned bladder symptoms to be present, even severe attacks of cystitis, over and over again, after perineorrhaphy where the catheter was used, after trachelorrhaphy and operations on the vaginal walls where no catheter was used, and after cœliotomy both where the catheter was and where it was not used.

I have known of one case of double phlegmasia alba dolens. It followed an attempt to do an Alexander-Adams operation, but the ligaments were not found. Drainage was used and was probably the cause of the trouble. In almost all of my cases where the nerve was broken or injured in drawing out the ligaments there was more or less neuralgic pain in the neighborhood of the incision. At times the pain would extend upward as high as the floating ribs, at times it would reach over the thigh and down the sciatic nerve and its branches. These pains were complained of usually after the patients were up and about, or after they had got home. In these cases an attack was pretty sure to come on at menstrual periods. These attacks of pain come on every day or two, lasting from a few minutes up to an hour or two, but in the severest cases give no trouble after a few weeks. A burning feeling in the incision, with numbness in the mons veneris lasting from a few days up to a week or ten days, was not uncommon. It occurred in at least ten cases. Hæmaturia occurred in three cases. They were cases of retrodisplacement with extensive adhesions, and the forcible breaking up of these adhesions, as pointed out by Dr. Conant, may have injured the ureters. The hemorrhage was small and occurred only during the first twelve hours after the operation.

The liability to hernia has been brought forward as an objection to the operation. If the operation is properly and successfully done no hernia can occur, as the internal abdominal rings are completely and securely covered over by the anterior surface of the broad ligaments.

Unfortunately, sloughing of the wound is not uncommon in the experience of all. Whether the fault is in the ligament, its vitality being poor, whether the fault lies in the poorly vitalized aponeurosis to which we fasten the ligaments, or whether the damage is due to the bruising and stretching of the ligaments during extraction, has not yet been settled. That this suppuration is not due to the operator or to the variety of suture material used, has been proved. After looking over the cases it was found that suppuration occurred in thin as often as in fat abdominal walls. In the first twenty-five cases done by Alexander, nearly one-third sloughed on one or both sides; in the remaining fifty-nine cases only two sloughed. Sloughing of the wound delays convalescence, and often sinuses remain until the sutures put in to hold the ligaments are discharged or removed. Sloughing of the wound does not interfere with a perfect result as far as the position of the uterus is concerned. Sloughing of the wound is not dangerous if the pus is let out as soon as formed. I have never known an instance where peritonitis or any intra-abdominal symptoms followed sloughing of the wound.

7. Enough has been said above to show that it is not limited in its application.

8. It certainly will be a long time here in Boston before this operation becomes obsolete. Those who see much of gynecological practice are doing the operation more and more. In proportion to its size I doubt if there is a city in this country where more men are doing this operation than in Boston.

A success surgically and a success therapeutically are two very different things. Those who are most pleased with the operation are those who know enough about gynecology to operate on proper cases.

Anatomy.— "The round ligaments are two fibro-muscular cords that arise from the upper end of the uterus anteriorly and run through the superior portion of the broad ligament to the internal ring and pass through the inguinal canal, and terminate in fibrous expansions over the symphysis, becoming lost in the mons. They can, therefore, be divided into three parts— the portion external to the canal, the portion in the canal, and the portion within the pelvic cavity. The pelvic portion is attached to the upper angle of the uterus, in front of and just below the origin of the Fallopian tubes. It runs in the anterior fold of the broad ligament, and comes upward, outward, then forward and inward to the internal ring. After it leaves the broad ligament it is covered with peritoneum and lies in the lateral wall of the pelvis, crossing the external iliac artery. At the ring the epigastric artery is to the inner side, and at the operation can be easily felt pulsating. At first the ligament is large, but in leaving the broad ligament it is smaller and rounded. In the canal it tapers gradually, and has the same relations as the spermatic cord. As it leaves the external ring, the ligament runs near the outer side of the pubic spine and then each breaks up over the symphysis into thin sets of fibres. A branch of the genito-crural nerve lies to the outer side of the ligament as it emerges from the ring.

The length of the ligament is about four inches. Besides areolar tissue and vessels, the ligaments contain, chiefly in their inner third, plain muscular fibres which are prolonged into them from the outer muscular layer of the uterine wall. Each ligament receives a covering from the peritoneum which projects into the internal ring as the canal of Nuck. When traction is made on the round ligaments the uterus is pulled forward and upward; the broad ligament resumes its normal position, and a prolapsed tube and ovary are lifted out of the posterior cul-de-sac. There seems also to be puckering up of the broad ligament." (W. M. Conant.)

Preparation of the Patient, Operator, Instruments, Ligatures, Sponges, etc.—Thirty-six hours before the operation one ounce of castor-oil is administered. After this nothing but gruel is allowed for nourishment, and the patient is kept in bed. The evening before the operation the patient takes a tub-bath, and the abdomen below the umbilicus and the pubes are thoroughly washed with soapsuds and all the hair shaved off; then the parts are washed with ether, then with a 1 to 1,000 solution of corrosive sublimate, and a corrosive sublimate pad (1 to 3,000) is fastened over the whole lower abdomen and pubes. This pad is not disturbed until the patient is on the table ready for the operation. Every six hours, beginning thirty-six hours before the operation, the vulva is washed with a 1 to 1,000 solution of corrosive sublimate and vaginal douches of the same strength are given. Two hours before the operation two ounces of whiskey are given by the rectum, and one hour before administering ether one one-hundredth grain of atropia is given by the mouth. In several years' experience with atropia, it has been found that when it is administered as above, seven-tenths of the patients do not vomit on coming out of the ether, and in part, or wholly, it prevents the filling up of the mouth and fauces with mucus. While the patient is being etherized, the instruments, ligatures, sponges, and towels are placed in an Arnold steam sterilizer. The room, table, and clothing has been prepared as if a cœliotomy was to be done. The operator and assistant remove their outside garments, substituting freshly washed cotton trousers, frock, and canvas shoes. The hands and forearms are scrubbed in soapsuds with constant rinsing for ten minutes by the watch, great care being taken to clean the finger-nails; then they are washed in a saturated solution of permanganate of potassium until of a dark mahogany color; then, finally, the permanganate stain is removed by peroxide of hydrogen or oxalic acid. If at any time after this the fingers touch anything or any part of the patient that is not aseptic, the hands are washed in running water with brush and soap. When the patient is etherized, the bladder is emptied and the vagina and vulva are vigorously washed with soap and water. Dr. W. L. Burrage's method of cleaning the vagina is a good one. He takes a piece of moderately soft soap as large as a French prune, introduces it with a little water into the vagina, and with the index and middle fingers of the right hand he thoroughly lathers the whole vaginal mucous membrane. After washing out the vagina and cleansing the vulva with a hot 1 to 1,000 solution of corrosive sublimate the uterus is put in extreme anteversion. If adhesions are present they are overcome as mentioned above. As it has been my experience, backed up by that of the pathologist, to find chronic hyperplastic endometritis in every case where an Alexander-Adams operation was called for, I dilate the cervix, thoroughly curette the endometrium with the sharp curette, and pack the uterine cavity with sterilized gauze, on which iodoform or dermatol, as recommended by Burrage, has been freely dusted. The gauze is allowed to stay in the uterus from a week to ten days. By using Burrage's uterine speculum no trouble is experienced in introducing the gauze.

All being ready for the Alexander-Adams, the corrosive sublimate pad is removed, a Kelley pad is put under the patient, and clean rubber sheets are put above and below to protect the patient and conduct the water into the pad. Between the thighs a Ferguson speculum is placed to conduct all wash water into the pad. The abdomen is thoroughly scrubbed with soapsuds and then washed off with hot water that has been boiled and filtered. From the time the first incision is made until the wound is closed the field of operation is very frequently flooded with hot water that has been boiled and filtered. The sterilizer is now brought into the operating-room, and hot steaming towels are placed around the field of operation. The instruments are taken out on trays, which are put in pans filled with hot water that has been boiled and filtered. The sponges, made of folded gauze, are taken from the sterilizer and put in covered pails containing hot water that has been boiled and filtered.

Operation.—Two, and only two, landmarks need be kept in mind. One only is really *necessary*, but as some operators get into the peritoneal cavity without apparently knowing the fact until they are there, the second landmark, the observance of which will surely keep them out, is given. First of all, locate the pubic spine. This is usually done with ease, and it is only exceptionally that the spine is not pointed enough to be readily recognized. When, either through fat in the abdominal walls or lack of development, the spine cannot be located with entire satisfaction, make an incision an inch long through the skin and subjacent tissues over where you think the spine should be, and the definite location of it will then be settled by the finger. I am thus particular about this because I have never seen anybody fail to find the ligaments when they kept the finger and their mind's eye on the pubic spine. The pubic spine located, cut down at once to the aponeurosis of the external oblique muscle (see that the lower end of the incision stops just over the pubic spine). This white glistening tissue cannot be missed. This is the second landmark, and if the operator keeps above this he will never unintentionally enter the abdominal cavity. Stop all bleeding as you go along, so that the aponeurosis may be kept white and clean. Use as few pressure-forceps as possible, as union by first intention is desirable. Clean up the aponeurosis for an inch and a half from the pubic spine, and then with the index finger on the spine the ligament will be found without any difficulty. Sometimes the external ring can be seen, usually it can be felt; now and then the intercolumnar fascia is so strong that no ring can be seen or felt. In this latter case if the fascia is cut through just in front of the pubic spine, a mass of fat will protrude, and this is the guide to the ligament. Grasp this fat with the tissue about it, unless the ligament is seen, in which case grasp the ligament, and tease it out of the ring, or slit up the aponeurosis a little way and tease the fat and tissue out of the canal. If one is careful to get hold of all the fat and tissue, the ligament will soon be seen after a little traction on these tissues. Separate the nerve from the ligament, being careful not to injure it by rough handling or by sewing it to the aponeurosis when fastening the ligaments. Draw out both ligaments until the uterus, by vaginal examination, is found to be in the desired position, then fasten them to the pillars of the ring or to the aponeurosis, if the canal has been slit up. (I have never seen the ligaments fastened to the pillars of the ring.) The slack of the ligament may be cut off near where it is fastened and entirely removed, or it may be folded into the wound and fastened there by the sutures that close the incision, or by separate sutures, or it may be tied in a hard knot to the slack of the opposite side, and both buried and sewed into the incisions that have been prolonged so as to meet. I prefer the second method, if the ligaments have not been crushed or bruised in getting them out. If I fear that their vitality has been impaired, the first method is employed. Attention to cleanliness should be the same as if cœliotomy was being done, as it may be necessary to free the ligaments from adhesions throughout the whole length of the canals, and the peritoneal cavity may be opened; then, too, healing by first intention is the desideratum. If a ligament should break, slit up the aponeurosis to the point where the ligament dips down to enter the internal ring, and at the internal ring search for it. If it cannot be found at the internal ring it will be necessary to do a cœliotomy to secure it.

Catgut, silk, and silkworm-gut may be used in suturing the ligaments. Silk, silkworm-gut, and wire may be used in closing the incisions. Wherever ligatures are needed I prefer silkworm-gut for three reasons: 1st, It can be made perfectly aseptic; 2d, it is never absorbed; 3d, it is less irritating than any other suture material. Whatever kind of suture material is used, four sutures are needed to securely fasten each ligament, two on each side. These sutures are cut short and buried. Care should be exercised not to tie these ligament-sutures too tight, neither should they catch up too much of the ligament for fear of strangulation with following suppuration.

Preparation of Ligatures.—Silk is soaked in ether for forty-eight hours, and it is then boiled for two hours in a 1 to 20 carbolic acid solution, or for the same length of time in filtered water. It is kept in absolute alcohol. Only as much as will be used at any one operation is taken from the alcohol and sterilized. If any of this is left over after having been handled, it is boiled again for two hours before being used.

Catgut is soaked in ether for several days in the coils as it is bought. Then it is wound on glass buttons, each button taking one coil. It is then boiled in alcohol in a jar with the cover on, in an Arnold sterilizer, for one hour on three consecutive days. It is then removed from this alcohol with sterilized forceps and put in absolute alcohol. Only one button is taken from the alcohol for an Alexander-Adams. This is again sterilized by boiling in alcohol in an Arnold sterilizer for half an hour previous to the operation.

Silkworm-gut is first thoroughly boiled for two hours in filtered water. Then it is put in absolute alcohol. Ten or twelve strands are put with the instruments in the sterilizer half an hour before the operation.

After closing the incisions, powdered boric acid and iodoform are thickly dusted over both lines and kept in place by square pieces of baked gauze secured in position by corrosive collodion. Over this the powdered boric acid and iodoform are thickly dusted. Then a thick pad of baked gauze is placed on the lower abdomen and pubes. The whole is kept in place by an abdominal binder, or adhesive plaster, and perineal straps. The patient is kept in bed two weeks. At the end of a week the sutures are removed, and the lines of incision are covered with powdered boric acid and iodoform, and sealed over with baked gauze held in place by corrosive collodion. If possible the catheter is dispensed with and the nurse is instructed to see that the patient passes her water every four or five hours. The moment any bladder trouble shows itself, saccharine, boric acid, and benzoate of ammonia are given. The bowels are moved on the third day by a large dose of magnesia, assisted by enema, so as to avoid straining. After this the bowels are moved every day. Slop diet is given until after the third day. If suppuration appears, a large opening is at once made down to the ligament; at times it is necessary to open up the whole incision. Then poultices are applied for twenty-four to thirty-six hours, then the suppurating cavity is cleaned two or three times a day with peroxide of hydrogen and filled with powdered dermatol, aristol, or iodoform. The occurrence of suppuration does not prolong the patient's stay in bed.

The following cases were operated on at the St. Elizabeth's and Carney Hospitals, Boston, during the two years following December, 1889:

TABULATED STATEMENT OF CASES ON WHICH THE ALEXANDER-ADAMS OPERATION WAS PERFORMED IN THE ST. ELIZABETH'S AND CARNEY HOSPITALS, BOSTON (1889-1891).

Number.	Date.	Name.	Age.	Married.	Single.	Children.	Abortions.	Indication for operation.	Operator.	Other operations.	Relief of symptoms.	Results.	Remarks.
1	Dec., '89...	A. H.	22		S.			Retroversion.	J.	Dilated; curetted.	Yes.	Perfect.	
2	Jan., '90...	M. C.	24		S.	..		Retroversion; prolapsed ovaries.	C.	....	....	Perfect.	
3	Feb., '90...	R. N.	25	M.	..	..	..	Retroversion.	J.	Cervix.	Yes.	Perfect.	Pessary for a few months.
4	April, '90 ..	H. C.	27	M.		2		Retroflexion; prolapsed ovaries.	J.	Cervix; perineum.	Yes.	Perfect.	
5	May, '90...	K. D.	18	..	S.	..		Retroversion with adhesions.	J.	....	No.	Perfect.	Pessary for a few months.
6	May, '90...	C. F.	29	M.	..	1		Retroversion with adhesions.	J.	Cervix.	Yes.	Perfect.	Pessary for a few months.
7	June, '90...	M. D.	21	..	S.	..	..	Retroversion with adhesions.	J.	Curetted.	....	.....	Died of acute sepsis.
8	June, '90...	L. K.	38	W.		2	1	Retroversion with adhesions.	J.	.....	Yes.	Perfect.	Had pneumonia.
9	Sept., '90 ..	W. P.	30	M.		2	1	Retroversion.	J.	Cervix.	Yes.	Perfect.	
10	Nov., '90...	M. T.	24	M.	..	..		Prolapse in second degree.	K.	.....	Yes.	Perfect.	
11	Nov., '90...	R. A.				...		Retroversion with adhesions.	J.	.....	....	....	Lig. on left side not found; operation abandoned.
12	Dec., '90...	N. W.	24	..	S.	..	..	Retroversion with adhesions.	J.	....	....	Perfect.	
13	Dec., '90...	B. C.	40		S.	..		Retroversion.	J.	.....	....	Perfect.	
14	Dec., '90...	J. C.	25		S.	1		Retroversion with adhesions.	J.	Cervix.	No.	Perfect.	Abscess on both sides.
15	Dec., '90 ..	F. D.	23		S.	..		Retroversion.	J.	Curetted.	Yes.	Perfect.	
16	Jan., '91...	T. R.	21	..	S.	..		Retroversion with adhesions.	J.	Curetted.	Yes.	Perfect.	
17	Jan., '91...	M. G.	27	M.	..			Retroversion with adhesions.	J.	Curetted.	Yes.	Perfect.	Abscess on both sides; Confined at term.
18	Jan., '91...	F. B.	28	W.		2	..	Retroversion.	J.	Curetted; cervix.	Yes.	Perfect.	Pregnant in a few months; aborted.
19	Jan., '91...	F. B.	34	W.	..	5	..	Retroversion.	J.	Curetted; cervix.	Yes.	Perfect.	Abscess on right side.
20	Jan., '91...	E. L.	26	..	S.	..		Retroversion.	J.	Curetted.	....	Perfect.	Abscess on both sides.
21	Feb., '91...	A. C.	25		S.	..		Retroversion; prolapsed ovaries.	J.	Curetted.	....	Perfect.	
22	Feb., '91...	K. C.	28	M.	..	..		Retroversion.	J.	Cervix.	...	Perfect.	Abscess on right side.
23	March, '91.	E. P.	30		S.	..		Retroversion; fibroid in posterior wall.	J.	.....	Yes.	Perfect.	Fibroid in posterior uterine wall.
24	March, '91.	S. L.	32	M.	..	2	2	Retroversion with adhesions.	C.	Cervix; perineum.	....	Perfect.	
25	April, '91...	T. M.	28	M.	..	..	..	Retroversion.	C.	Cervix.	....	Perfect.	
26	April, '91 ..	N. D.	24		S.	..	..	Retroversion with adhesions.	C.	.....	Yes.	Perfect.	Abscess on right side.
27	April, '91 ..	J. T.	41		S.	..		Retroversion; multiple fibroids	J.	Curetted.	No.	Not perfect.	Uterus retroverted.
28	April, '91 ..	M. B.	31	..	S.	..		Retroversion with adhesions.	J.	Curetted.	Yes.	Perfect.	
29	April, '91 ..	H. S.	..	..	..	..	..	Retroversion.	J.	Curetting.	Yes.	Perfect.	Full history of case lost.
30	April, '91 ..	M. B.	31	..	S.	..		Retroversion with adhesions.	J.	Curetted.	Yes.	Perfect.	
31	April, '91 ..	A. M.	26	..	S.	..	..	Retroversion with adhesions.	C.	Curetting.	....	Not perfect.	
32	April, '91 ..	M. E.	46	M.	..	4	2	Retroversion with adhesions.	J.	Perineum.	...	.....	Died of pneumonia on the eighth day.
33	May, '91 ...	A. J.	30	M.	..	1	8	Retroversion with adhesions; left ovary prolapsed.	C.	.....	....	Perfect.	
34	May, '91 ...	M. D.	35	..	S.			Retroversion with adhesions.	C.	.....	...	Perfect.	
35	May, '91 ...	A. F.	21	M.	.	..		Retroflexion with adhesions; ovaries prolapsed.	J.	Curetted.	Yes.	Perfect.	Delivered at term.

TABULATED STATEMENT OF CASES ON WHICH THE ALEXANDER-ADAMS OPERATION WAS PERFORMED.—(*Continued.*)

Number.	Date.	Name.	Age.	Married.	Single.	Children.	Abortions.	Indication for operation.	Operator.	Other operations.	Relief of symptoms.	Results.	Remarks.
36	June, '91..	M. K.	32	..	S.	.	..	Retroversion with adhesions.	K.	.....	....	Perfect.	
37	June, '91 ..	E. H.	31	M.	..	..	..	Retroversion with adhesions.	K.	.....	....	Perfect.	
38	June, '91 ..	M. B.	23	..	S.	..	..	Retroversion with adhesions; left ovary prolap-ed	J.	Curetted.	....	Perfect.	
39	July, '91...	R. H.	25	..	S.	..	..	Retroversion with adhesions.	J.	Curetted.	....	Perfect.	Abscess on right side.
40	Aug., '91...	P. M.	..	..	..	..		Retroversion with adhesions; prolapsed right ovary.	Bl.	....	....	Perfect.	
41	Sept., '91 ..	K. W.	27	..	S.		..	Retroversion.	Bl.	.....	....	Perfect.	
42	Sept., '91 ..	M. D.	25	..	S.	..	..	Retroversion; ovaries prolapsed.	J.	Curetted.	....	Perfect.	
43	Oct., '91 ...	J. D.	30	M.	..	5	..	Retroversion.	J.	Cystocele.	Yes.	Perfect.	
44	Oct., '91 ...	F. M.	33	M.		1	..	Retroversion with adhesions.	K.	Curetted.	....	Not perfect.	
45	Oct., '91 ...	M. C.	31	M.	..	2	..	Retroversion with adhesions.	K.	.....	....	Perfect.	Abscess on both sides.
46	Oct., '91 ...	M. T.	21		S.	..	..	Retroversion; ovaries prolapsed.	C.	Curetted.	...	Perfect.	
47	Nov., '91...	A. S.	35	..	S.	..	.	Retroversion with adhesions.	K.	Curetted.	....	Perfect.	Abscess on right side.
48	Nov., '91...	M. B.	25	M.	..	..		Retroversion; prolapsed ovaries.	K.	Curetted; cervix.	....	Perfect.	
49	Dec., '91...	A. M.	30	..	S.	..	..	Retroversion.	C.	Curetted.	....	Perfect.	Acute articular rheumatism.
50	Jan., '92...	N. C.	23	M.		..	.	Retroversion; left ovary prolapsed.	C.	....	....	Perfect.	Abscess on right side.
51	Jan., '92...	E. O.	32	M.	..	..	..	Retroversion; left ovary and tube prolapsed.	J.	Curetted.	Yes.	Perfect.	
52	Jan., '92...	L. M.	23		S.	..	..	Retroversion.	C.	Curetted.	....	Perfect.	
53	Jan.. '92...	M. C.	38	..	S.	..	..	Retroversion with prolapse.	C.	Curetted.	...	Perfect.	Abscess on right side.
54	Jan., '92...	M. M	34	M.	..	..	..	Retroversion with adhesions.	J.	Curetted.	....	Perfect.	
55	Jan., '92...	J. O.	23	..	S.	..	..	Retroflexion with adhesions.	J.	Curetted.	....	Not perfect.	
56	Jan.. '92...	A. S.	30	..	S.	..	..	Retroversion with adhesions.	C.	Curetted.	....	Perfect.	
57	Feb., '92...	L. W.	42	M.		..	..	Retroversion with adhesions; ovaries prolapsed.	J.	Curetted.	....	Perfect.	
58	Feb., '92...	M. F.	40	M.		2	..	Retroversion with adhesions.	J.	Curetted.	....	Perfect.	
59	Feb., '92...	J. H.	29	M.		..	3	Retroversion with adhesions.	C.	Curetted.	....	Perfect.	
60	Feb., '92...	L. S.	19	..	S.	..	..	Retroversion with adhesions; double inguinal hernia.	C.	Curetted.	....	Perfect.	Alexander-Adams for the radical cure of the hernia.
61	Feb., '92..	J. D.	33	M.		..	..	Retroversion with adhesions.	J.	Curetted.	....	Perfect.	
62	March, '92	A. M.	28	M.		..	2	Retroversion.	J.	Curetted.	No.	Perfect.	
63	March, '92.	J. D.	26	M.	..	..		Retroversion with adhesions.	J.	Curetted.	Yes.	Not perfect.	Has had two attacks of gonorrhœal peritonitis.
64	March, '92.	E. S.	29	..	S.	..		Retroversion with adhesions.	J.	Curetted.	Yes.	Perfect.	Abscess on both sides.
65	March, '92.	M. H.	30	M.	..	..		Retroversion.	B.	Curetted.	....	Not perfect.	Abscess on left side.
66	March, '92.	K. O.	32	M.	..	1		Retroversion; right ovary prolapsed.	B.	Curetted.	....	Perfect.	Abscess on both sides.
67	March, '92.	J. H.	22	..	S.	..	..	Retroversion.	J.	Curetted.	Yes.	Perfect.	Abscess on both sides.
68	April, '92 ..	H. S.	34	M.	.	1	.	Retroversion.	B.	Curetted; perineum.	....	Perfect.	Abscess on both sides.
69	April, '92 ..	A. D.	27	..	S.	..	.	Retroversion with adhesions.	K.	Curetted.	...	Not perfect.	
70	April. '92 ..	M. M.	24	M.	..			Retroversion with adhesions.	J.	Curetted.	Yes.	Not perfect.	Abscess on left side; wearing pessary.
71	May, '92 ...	L. B.	24	M.	..	1		Retroversion.	J.	Curetted; perineum.	Yes.	Perfect.	
72	May, '92 ...	A. D.	41	M.	..	3	1	Retroversion with adhesions.	J.	Curetted.	....	Perfect.	Abscess on both sides; both ligaments broke and retracted.
73	June, '92..	N. Q.	25	..	S.	..	..	Retroversion with adhesions.	J.	Curetted.	....	Perfect.	Abscess on both sides.
74	June, '92..	A. L.	20		S.	..	..	Retroversion with adhesions.	B.	Curetted.	....	Perfect.	Abscess on both sides.
75	June, '92..	A. C.	32		S.	..		Retroversion.	B.	Curetted.	....	Perfect.	Abscess on left side.
76	July, '92...	M. S.	23	..	S.	..		Retroversion.	B.	Curetted.	....	Perfect.	Abscess on both sides.
77	July, '92...	M. N.	24	..	S.	..		Retroversion.	J.	Curetted.	....	Perfect.	Abscess on both sides.
78	Aug., '92 ..	M. C.	26	M.	..	..		Retroversion.	Bl.	Curetted.	....	Perfect.	
79	Aug., '92...	M. K.	23	..	S.	..	.	Retroversion with adhesions.	B.	Curetted.	...	Perfect.	Abscess on both sides.
80	Aug., '92...	M. O.	23	..	S.		.	Retroversion with adhesions.	B.	Curetted.	....	Not perfect.	
81	Aug., '92...	K. S.	30	M.	..	..	..	Retroversion.	B.	Curetted.	....	Perfect.	Abscess on both sides.
82	Sept., '92 .	M. K.	20	..	S.	..		Retroversion.	S.	Curetted.	....	Not perfect.	
83	Sept., '92 ..	M. M.	22	M.	..	..	..	Retroversion.	K.	.....	....	Perfect.	
84	Oct., '92 ...	F. M.	30	..	S.	..	..	Retroversion with adhesions; ovaries prolapsed.	J.	Curetted.	....	Not perfect.	Left ligament broke and was lost.
85	Feb., '90 .	E. K.	30	M.		1	4	Retroversion; left ovary prolapsed.	J.	Cervix.	....	Perfect.	Delivered at term, subsequently.
86	March, '90.	R. G.	23	M.		..	..	Retroversion with adhesions.	J.	.....	....	Perfect.	Abscess on left side.
87	April, '90 ..	O. G.	42	M.	..	11	2	Retroversion.	J.	Cervix.		Perfect.	Abscess on left side.
88	May, '90...	E. H.	35	M.		4	1	Retroversion with adhesions.	J.	Cervix; perineum.	....	Perfect.	
89	May, '90...	M. M.	29	M.			..	Retroversion; ovaries prolapsed.	J.	Dilated.	Yes.	Perfect.	
90	May, '90...	M. R.	35	..	S.		..	Retroflexion; left ovary prolapsed.	J.	....	....	Perfect.	Abscess on left side.
91	July, '90...	K. G.	24	M.	..	.	..	Retroversion with adhesions.	J.	.....	....	Perfect.	
92	Sept., '90 ..	C. B.	35	M.	..	1	..	Retroversion with adhesions; left ovary prolapsed.	J.	Cervix.	Yes.	Perfect.	
93	Sept., '90 ..	C. K.	34	M.	..	.	..	Retroversion.	J.	.....	....	Perfect.	
94	April, '91 ..	M. S.	26	..	S.	..		Retroversion with adhesions.	J.	Dilated.	....	Perfect.	Abscess on right side.
95	May, '91...	M. B.	31	..	S.	..	..	Retroversion with adhesions.	S.	....	....	Perfect.	
96	May, '91...	M. S.	38	M.	..	3	2	Retroversion with adhesions.	S.	.....	....	Not perfect.	
97	July, '91...	A. C.	32	M.	..	1		Retroversion.	J.	.....	Yes.	Perfect.	Tired of wearing a pessary.
98	July, '91. .	E. G.	39	M.	..	2	..	Retroversion.	J.	Curetted.	Yes.	Perfect.	
99	Aug., '91...	L. G.	31	M.	..	5	..	Retroversion.	J.	Cervix; perineum; hæmorrhoids.	Yes.	Perfect.	
100	Aug., '91...	J. F.	40	..	S.	..		Retroversion with adhesions.	J.	Curetted.	No.	Perfect.	
101	Sept., '91 ..	E. M.	28	..	S.	..	..	Retroversion with adhesions.	J.	.....	Yes.	Perfect.	Abscess on right side.
102	Oct., '91 ...	B. O.	35	M.	..	2	5	Retroversion; left ovary prolapsed.	J.	....	....	Perfect.	

TABULATED STATEMENT OF CASES ON WHICH THE ALEXANDER-ADAMS OPERATION WAS PERFORMED.—(*Continued.*)

Number.	Date.	Name.	Age.	Married.	Single.	Children.	Abortions.	Indication for operation.	Operator.	Other operations.	Relief of symptoms.	Results.	Remarks.
103	Nov., '91...	N. S.	26	..	S.	..	..	Retroversion with adhesions.	J.	Curetted.	Yes.	Perfect.	Ligament on right side broke and was lost.
104	Nov., '91...	M. R.	20	M.		1	..	Retroversion with adhesions.	J.	.....	Yes.	Perfect.	Ligament on left side broke and was lost.
105	Nov., '91 ..	E. S.	19	M.	..		..	Retroversion with adhesions; left ovary prolapsed.	J.	Curetted.	Yes.	Perfect.	Abscess on both sides.
106	Nov., '91...	K. O.	33	M.	..	2		Retroflexion; right ovary prolapsed.	J.	Curetted.	Yes.	Perfect.	Pneumonia.
107	Nov., '91...	B. K.	27	M.	.		..	Retroversion.	J.	Cervix; perineum.	Yes.	Perfect.	Pneumonia.
108	Nov., '91...	N. D.	21	..	S.	..	..	Retroversion with adhesions.	J.	Curetted.	....	Perfect.	
109	Dec., '91...	N. H.	27	M.	..		..	Retroversion.	J.	Curetted.	....	Perfect.	
110	Dec., '91...	K. G.	22	..	S.		..	Retroflexion; ovaries prolapsed.	J.	Curetted.	....	Not perfect.	
111	Dec., '91...	C. L.	34	..	S.	..	..	Retroversion.	J.	Curetted.	Yes.	Perfect.	
112	Dec., '91...	M. W.	44	M.	..	4	2	Retroversion.	J.	Curetted.	....	Perfect.	
113	Jan., '92...	M. P.	29	..	S.	..	..	Retroversion.	S.	.....	Yes.	Perfect.	Fibroid on posterior uterine wall.
114	Jan., '92...	M. R.	41	M.	.	1	..	Retroversion; ovaries prolapsed.	J.	Curetted.	Yes.	Perfect.	
115	Jan., '92...	M. C.	30	M.		..		Retroversion with adhesions; salpingitis.	J.	Curetted.	No.	Perfect.	Abscess on left side.
116	Jan., '92...	S. L.	43	M.	..	7		Retroversion.	J.	.....	No.	Perfect.	
117	Feb., '92...	A. P.	35	..	S.	..		Retroversion.	S.	.....	....	Perfect.	
118	Feb., '92 ..	A. W.	23	M.	..	1	..	Retroversion with adhesions.	S.	.....	....	Perfect.	
119	Feb., '92...	K. M.	33		S.		..	Retroversion; left ovary prolapsed.	J.	Curetted.	Yes.	Perfect.	
120	March, '92.	M. B.	35	M.		..		Retroverted.	S.	.....	....	Perfect.	Abscess on left side.
121	March, '92.	H. C.	27	M			..	Retroversions with adhesions.	J.	Curetted.	Yes.	Not at all a success.	Abscess on both sides
122	April, '92 ..	K. C.	19	..	S.	.	..	Retroversion with adhesions.	S.	... .	....	Perfect.	
123	April, '92 ..	M. S.	36	M.		5	2	Retroversion.	S.	Curetted.	...	Perfect.	Abscess on left side.
124	April, '92 ..	M. K.	29	M.		..	..	Retroversion.	S.	.....	....	Perfect.	
125	April, '92 ..	M. D.	42	M.		3	6	Retroversion.	S.	Cervix; perineum.	....	Perfect.	
126	April, '92 ..	A. F.	28	M.	..	..		Retroversion with adhesions.	S.	....	....	Perfect.	Abscess on right side.
127	April, '92 ..	M. B.	25	M.		1	..	Retroversion with adhesions; left ovary prolapsed.	J.	Cervix.	Yes.	Perfect.	
128	May, '92...	M. D.	33	M.		1	1	Retroversion with adhesions; left ovary prolapsed.	J.	Curetted.	....	Perfect.	
129	May, '92...	S. B.	30	M.		1	1	Retroversion; left ovary prolapsed.	J.	Cervix.	Yes.	Perfect.	
130	May, '92...	E. B.	56	M.		3		Procidentia.	J.	Curetted.	Yes.	Perfect.	Abscess on both sides.
131	May, '92...	S. O.	34	M.	..	..	..	Retroversion.	J.	Curetted.	Yes.	Perfect.	
132	May, '92...	F. S.	27	M.		..	..	Retroversion.	S.	Curetted.	....	Perfect.	Abscess on left side.
133	May, '92...	A. M.	39	M.		..	..	Retroversion with adhesions.	K.	.....	....	Not perfect.	
134	May, '92...	C. M.	32	M.		2	3	Retroversion; left ovary prolapsed.	J.	Curetted.	....	Not perfect.	Pessary now keeps uterus in place.
135	May, '92...	M. B.	27		S.	..	..	Retroversion; ovaries prolapsed.	K.	.....	....	Not perfect.	Abscess on left side.
136	May, '92...	E. K.	29	..	S.	..		Retroversion; left ovary prolapsed.	J.	Curetted.	Yes.	Perfect.	
137	May, '92...	J. H.	27	..	S.	..	..	Retroversions with adhesions.	K.	.....	....	Perfect.	
138	May, '92...	L. M.	19	.	S.	..	.	Retroversion; left ovary prolapsed.	B.	.....	....	Perfect.	Abscess on left side.
139	June, '92...	M. C.	26	M.	..	..	..	Retroversion; left ovary prolapsed.	J.	Curetted.	Yes.	Perfect.	Pregnant.
140	June, '92...	L. P.	32	M.	..	3	..	Retroversion.	J.	Curetted.	Yes.	Perfect.	Fibroid in post-uterine wall.
141	June, '92...	J. M.	27	M.	..	2	2	Retroversion.	J.	Cervix.	Yes.	Perfect.	
142	Aug., '92 ..	J. S.	27	M.	..		..	Retroversion.	B.	Curetted.	....	Not perfect.	Wearing pessary.
143	Sept., '92 ..	L. C.	30	..	S.	..	..	Retroversion with adhesions.	J.	Curetted.	....	Not perfect.	Abscess on right side.
144	Sept., '92 ..	N. S.	49	M.	..	3	..	Procidentia, five years' standing.	J.	Perineum.	Yes.	Perfect.	
145	Oct., '92...	H. W.	47	M.	..	5	1	Procidentia, one year.	J.	Cervix; perineum.	....	Perfect.	
146	Oct., '92...	A. B.	49	M.	.	2	..	Procidentia, two years.	J.	Perineum.	....	Perfect.	
147	Oct., '92...	F. G.	42	M.		10	2	Retroversion.	S.	Curetted.	....	Perfect.	Abscess on both sides.
148	Oct., '92...	O. N.	40	M.		7	1	Procidentia, six months; left inguinal hernia.	J.	.....	....	Perfect.	Radical cure of hernia by the Alexander.
149	Oct., '92...	K. D.	34	M.		3	..	Retroversion with adhesions.	J.	.....	....	Not perfect.	Both ligaments broke and were lost.
150	Oct., '92...	L. W.	32	M.	..	2	..	Retroversion with adhesions.	J.	Curetted; cervix; perineum.	....	.....	Acute pleurisy with effusion; phthisis.
151	Oct., '92...	A. W.	20	..	S.			Retroversion with adhesions; ovaries prolapsed.	J.	Curetted.	....	Not perfect.	
152	Oct, '92...	G. K.	14	..	S.	..	..	Retroversion with adhesions; ovaries prolapsed.	J.	Curetted.	...	Perfect.	

F. W. Johnson.

ALVELOS. The milky, resinous juice of Euphorbia heterodoxa, Müller, belonging to the order Euphorbiaceæ, indigenous to Brazil. It is obtained by expression, is yellowish-white, of syrupy consistence, resembling vaseline, insoluble in water and alcohol, soluble in ether, miscible with fixed oils.

It possesses powerful escharotic properties, together with a solvent action on organic tissues. It combines the effects of a caustic with that of papaine. It is recommended for the treatment of syphilitic and cancerous growths. The part is painted with the drug once a day; before the application the part is washed with carbolic acid or other antiseptic solution. The operation is repeated until the disease is removed. It is said the purity of the drug may be known by its imparting a pronounced color and odor to the urine due to its absorption. This effect has to be watched during its use as it exerts a decided irritant action in the renal tissue. *Beaumont Small.*

AMPUTATION AT THE HIP-JOINT. The mortality which until recently followed amputation at the hip-joint rendered this operation the most formidable in surgery. Within the last ten years this mortality has been greatly reduced. No great war has occurred within these years, so that it is difficult to estimate the present death-rate of traumatic cases. The reduction for such cases ought, however, to be proportionate with that of amputation for disease. For this latter class of cases, a dozen years ago, the mortality was estimated at over forty per cent. Now it varies from fifteen to twenty per cent. Formerly it was only on comparatively robust patients that the operation was performed; now it can be done on delicate, sickly children with a fair chance of a successful issue. The reasons for these better results are, 1st, the antiseptic treatment of the wound; and 2d, the improved methods for the control of hemorrhage. The first cause has brought about an immense improvement in all operations, and the improvement is in almost direct proportion to the extent of the wound, and therefore the difference between the present results and those of the pre-antiseptic times is more marked in this operation than perhaps in any other. The second cause has very much added to the safety of the operation. It cannot be said that any one method is pre-eminent for the control of hemorrhage, but there are several admirable plans for the arrest of bleeding, which, in different hands, give almost equally good results. Shock continues to be the source of the greatest danger, but this has been very much lessened since the loss of blood has been diminished. Following the removal of so large a part of the human frame, there must always result considerable shock. In this connection it is well to correct an erroneous statement which has been handed down from text-book to text-book for scores of years. It is very commonly stated that amputation at the hip-joint removes about one-fourth of the body. This is incorrect. Recent observations estimate the loss of tissue as equal to about one-tenth or one-twelfth of the weight of the entire body.

Methods. More than forty-five methods of amputation at this point have been described. Many of them are entirely obsolete. A very judicious choice has been made of the best methods in the original article on this subject, in Vol. I. Of the plans there described, several continue to be used with great success. The shape and position of the flaps are of less importance than the means for control of hemorrhage. In many patients the flaps must be adapted to each case, and especially is this true in amputations for injury. Some modification of the method known as Furneaux Jordan's is perhaps as generally useful as any other. The flaps are formed as follows: the soft parts are drawn upward with the left hand and a circular incision is made through skin and cellular tissue around the middle third of the thigh. The cuff of skin is raised for about two and a half inches, and this flap being drawn strongly upward, the muscles are severed by circular sweeps of the knife down to the bone. The vessels are then secured. A second incision is made along the outer side of the thigh, starting from the circular wound and ending midway between the iliac crest and the top of the great trochanter. This incision divides everything down to the bone. The soft parts are then peeled off the femur, and the head of the bone disarticulated. If the case is not suitable for this method an equally good stump can be obtained by one of the other methods.

Means of Arresting Hemorrhage.—While several new devices for this purpose have been introduced, yet some of the older methods still give very satisfactory results; of these may be mentioned control by means of the elastic bandage, according to the plan of Jordan Lloyd. In this method the Esmarch bandage is first applied, as far up the thigh as the tissues are healthy; a piece of strong rubber bandage is then passed between the thigh and trunk, its centre resting between the anus and tuberosity of ischium. A roller bandage is placed over the external iliac artery. The ends of the rubber bandage are drawn strongly upward and outward, one in front of the groin, and the other across the buttock, to a point above the crest of the ilium. They should be pulled until all pulsation in the femoral artery has ceased. The anterior band compresses by means of the roller bandage the external iliac, and the posterior the branches of the internal iliac artery. The ends of the bandage can either be held by an assistant, or crossed over to the opposite side and tied below the crest of the ilium. Another plan, which in the hands of its inventor, and of others, gives excellent results, is Davy's rectal lever. Ten cases have recently been reported treated by Davy, with eight recoveries. Trendelenburg's method of passing a steel rod between the vessels and femur, and

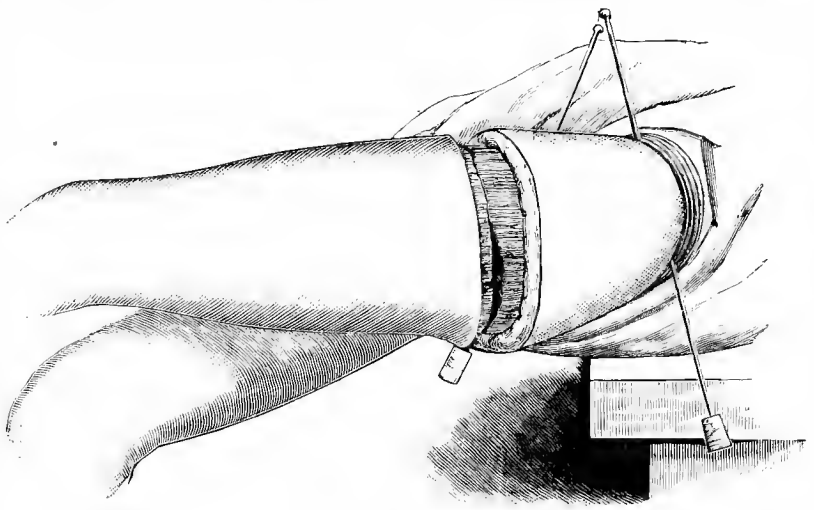

Fig. 15.

compressing the artery by a rubber cord, is also a very serviceable device. The most satisfactory method is the one recently proposed by Dr. Wyeth. The patient is placed with the hip well over the end of the table, and an Esmarch bandage applied. With the bandage still in position, his needles are inserted as follows: "Two steel mattress-needles, three-sixteenths of an inch in diameter and a foot long, are used. The point of one is inserted an inch and a half below the anterior superior spine of the ilium and slightly to the inner side of this prominence, and is made to traverse the muscles and deep fascia, passing about half-way between the great trochanter and the iliac spine, external to the neck of the femur and through the substance of the tensor vaginæ femoris, coming out just back of the trochanter. About four inches of the needle should be concealed by the tissues. The point of the second needle is entered an inch below the level of the crotch, internally to the saphenous opening, and passing through the adductors, comes out about an inch and a half in front of the tuber ischii. No vessels are endangered by these needles. The points are protected by corks to prevent injuries to the operator's hands. A piece of strong white rubber tube, half an inch in diameter, and long enough when tightened in position to go five or six times around the thigh, is now wound very tightly around and above the fixation-needles and

tied." The Esmarch bandage is then removed, and if the operation is to be completed according to Dr. Wyeth's plan, a circular incision is made, the skin-flap is turned up, the muscles are divided at the lesser trochanter, and the bone is sawn through. All vessels are then tied. The remaining portion of the femur is then removed by division of the attachments of the muscles. It is not, however, necessary to complete the operation in this manner. In one of my cases Wyeth's pins were applied and the flaps were formed according to Farneaux Jordan's method, and the bone disarticulated while the pins and tubing were still in position, and before a vessel had been secured. The arrest of hemorrhage was perfect, and not a drop of blood escaped from the upper ends of the cut vessels. I should add that in this case a roller bandage was placed over the iliac artery, but I do not know that it was necessary, as in another case no such compression was used, and no leakage occurred from the vessels. In both patients the complete arrest of hemorrhage was highly satisfactory, as has over and over again been testified to by the inventor of this admirable method, and by others who have made use of it.

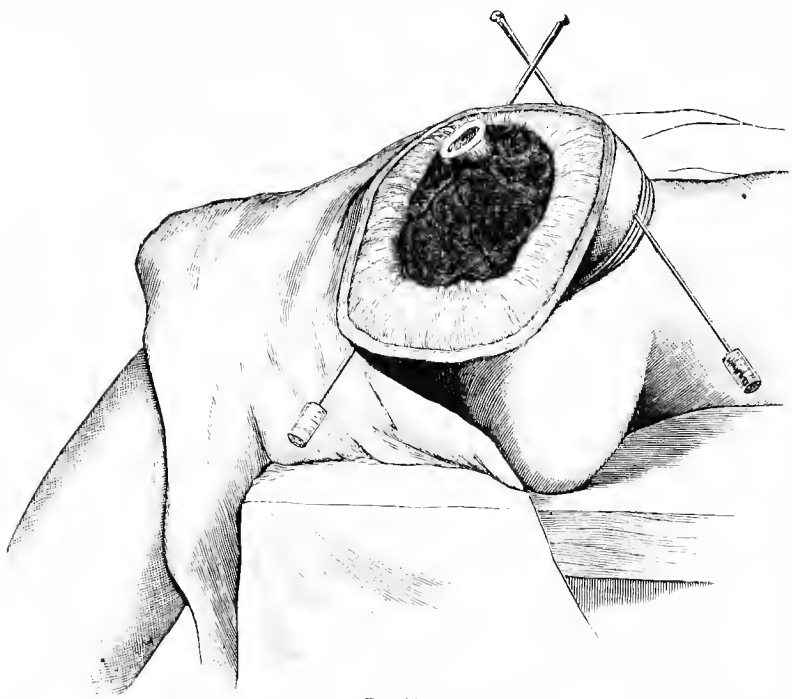

Fig. 15.

The accompanying diagrams, inserted with Dr. Wyeth's permission, illustrate the method of the introduction of the pins.

In one of my cases, a very large man, I found that needles fifteen inches long were more serviceable than would have been the shorter ones.*

Whatever method be adopted, the wound should be closed by suture and two or more drainage-tubes inserted. The entire operation should be carried out with the strictest antiseptic precautions. It is important that the patient should be enveloped in flannel, and that the room should be thoroughly warm. It is also useful, in weak patients, to adopt a modified Trendelenburg's position, with the pelvis elevated and the head low.

Andrew J. McCosh.

AMYLENE HYDRATE (*Dimethyl ethyl carbinol*). This is a clear, colorless, thin, neutral liquid, with a burning taste and an aromatic odor somewhat resembling camphor. It is soluble in eight parts of water and in alcohol, ether, glycerine, and oils; specific gravity .815. Recommended in 1888 by Professors Jolly and von Mering for its soporific properties. It is said to occupy a place between chloral and paraldehyde, two parts equalling one of the former and three of the latter. Its advantage over chloral is that it has no depressing effect on the heart; its smaller dose and less disagreeable odor make it preferable to paraldehyde in many cases. It produces a calm refreshing sleep, which lasts for six or eight hours, from which the patient awakens without any bad symptoms. It is used in insomnia due to nervousness, debility, mental excitement, and delirium tremens, and in fevers. It has not proved of much use when the sleeplessness is due to pain. It does not cause headache, nausea, or deranged digestion. In very large doses it produces a lowered temperature, shallow respiration, feeble pulse, loss of reflexes, paralysis of extremities. It is given in doses of thirty to forty-five minims. Its taste and odor often prove objectionable, and may be disguised by combining with extract of licorice, or some aromatic. It may also be used as an enema with mucilage of acacia, in doses of forty to ninety minims.

Beaumont Small.

ANÆSTHETICS. The period which has elapsed since the publication of the first volume of this work shows no addition of value to our agents for the production of general anæsthesia, no change in the principles which govern the process, nor has there been any decided change in the relative standing of the agents employed. Yet it has been a period of marked activity. The leading societies of the world have debated the subject, many papers of value have been published, while experimental study has been prosecuted to a degree greater than ever before. Few conclusions, however, have been reached which are universally accepted. On the contrary, there is wide diversity of views upon some of the most important points. Even experimental investigators have not agreed, and practical men have reached conclusions diametrically opposite.

The major part of the work done upon this subject during the last decade has had its origin in the contest between chloroform and ether. This contest, which began in the early years of anæsthesia, still continues, and without promise of early settlement. The advantages of each agent have been presented and urged sometimes with more warmth than judgment, and in more of a partisan than a scientific spirit. It needs but a glance through the literature of the period to show that this contest has been the inspiration of the work done, and that a record of the efforts of the advocates of the two great anæsthetics is a record of the progress of the subject.

A strong plea for chloroform has been made by Dr. Lombe Atthill, of Dublin.[1] At a debate held by the Medico-Chirurgical Society of Glasgow the weight of testimony was altogether on the side of this agent, both in the number of speakers and the amount of experience. Several men of high repute spoke in its favor. Dr. Hartley, of Leeds, stood almost alone as an advocate of ether.[2] In this country Dr. Chisholm has advocated chloroform as the best anæsthetic,[3] and Dr. Farrington has made a plea for it.[4] The claims of ether have been presented in valuable papers by Comte, by Julliard,[5] and

* The needles can be obtained from any large upholstering establishment.

by Fueter, of Switzerland,[6] and by Dr. Teale in the address on surgery before the British Medical Association in 1889, by Silex, of the Augenklinik of Berlin, based on two thousand five hundred administrations per annum,[7] and by Ormsby.[8] In this country ether has been advocated by Knapp,[4] an excellent and much-needed paper on administration has been published by Shrady,[9] and one on the time and amount of ether required to produce anæsthesia by Lovett.[10] Wood's address before the International Congress at Berlin, 1890, must be also considered as a plea for this agent.

The use of various mixtures of anæsthetics may be said to be on the increase. The administration of nitrous oxide first and then ether is confined to hospital practice from the necessity for complicated apparatus. It is resorted to a good deal in London. The plan of administering ether first and chloroform afterward, or *vice versa*, is followed to some extent in Europe, but statistics are wanting, as they also are as to several mixtures much used in Vienna. The A. C. E. mixture, which consists of alcohol one part, chloroform two parts, ether three parts, by measure, seems alone to deserve consideration. This preparation has certainly advanced very much in favor during the past few years. The increasing number of deaths from chloroform in England has excited alarm, and the A. C. E. has been chosen by those who would avoid the dangers of chloroform on one hand and the practical disadvantages of ether on the other. As preferable to chloroform, this mixture has had the powerful advocacy of the London *Lancet*, its merits have been recognized by Eastes,[10a] and the more recent authorities advise its use under many circumstances, as do Buxton,[11] and Hewitt, the author of the chapter on anæsthetics in "Treve's Operative Surgery." The experience of a lifetime with this mixture has been presented in a paper before the Ohio State Medical Society,[12] and the debate elicited upon it showed a very considerable use of it through at least one section of this country.

The attempt to determine the relative safety or danger of the different anæsthetics by statistics has continued, but without greater success than in the past. The factors cannot all be given. All deaths are not reported. In a single city the coroner investigated fifteen deaths from ether, only three of which had been reported.[13] No statement of the deaths from an anæsthetic in any city or country is of value in determining this question unless the number of administrations are also given. Again, the irregularity of occurrence of accident renders an immense array of numbers necessary. Thus, in the debate at Glasgow, while several speakers testified to many thousands of safe administrations of chloroform, one of the participants had met with four deaths. Bardeleben had no death in 30,000 administrations, then in one year he had four.[14] Kollock had two deaths from ether in giving it 200 times.[15] Richardson found in the records of eight hospitals 17,000 administrations of chloroform up to 1864, before there was a death; in the same hospitals during the five subsequent years there were six deaths in 7,500 administrations. Of two hospitals, under circumstances almost identical, there was in one 1,575 administrations without a death; in the other there occurred one death to every 525 administrations.[16]

The following statistics, taken from the records of institutions, may be accepted as accurate.

	Administrations.	Deaths.
Bristol Infirmary, seventeen years:[16a]		
Chloroform	5,902	3
Ether	704	1
St. Bartholomew's Hospital,[8a] 1878–87:		
Chloroform	12,368	10
Ether	5,509	2
Ether, preceded by NO_2	9,072	1

[Both the ether deaths were in patients very feeble from prolonged intestinal obstruction.]

Richardson,[16] 13 hospitals, 1848–69 inclusive:		
Chloroform	35,162	11

Recently, very large collections of administrations and deaths have been made, and are presumably reliable:

	Administrations.	Deaths.
Julliard:[8]		
Chloroform	524,507	161
Ether	314,738	21
Weir, New York Hospital:[9c]		
Ether	10,791	6
Gurlt[17] (XX. German Surgical Congress):		
Chloroform	22,656	6
Ether	470	0
Ether and Chloroform	1,055	0
Ether, Chloroform, and Alcohol	470	0
Gurlt[9b] (XXI. Congress, including above):		
Chloroform	94,123	36
Ether	8,431	1
Ether and Chloroform	2,891	1
Ether and Alcohol	1,380	0
Bromide ethyl	2,179	0

Gurlt presents the collective experience of German surgeons. The value of his first series is increased by stating the relative occurrence of dangerous symptoms, which was: Chloroform, 71; ether, 0; ether and chloroform, 5; ether, chloroform, and alcohol, 4. The latter mixture is not the A. C. E., but one in which the proportions are: Chloroform, 100 parts; alcohol and ether, each 30 parts.

By the study of such statistics the relative danger of the different anæsthetic agents may be approximatively reached. The latest German writer accepts the statistics of Andrews, of this country, which make the mortality for chloroform, 0.37, and ether, 0.04.[14] Wood gives the danger from chloroform as four or five times greater than that from ether,[13] and this agrees very nearly with the conclusion reached by all who have studied the subject statistically. Still, there are demurrers. A reviewer commenting upon the deaths reported in England, 1870–85, says that chloroform being used in so much larger a number of cases than ether, the deaths (chloroform, 184; ether, 28 deaths), do not show it to be the more dangerous agent. Macewen, commenting on like statistics, computes that chloroform is given in Great Britain ten times to ether once, and takes the same position.[2] Further, the advocates of chloroform maintain that deaths during the operation alone do not represent all the mortality from ether. They claim that this anæsthetic frequently causes death by inducing bronchial and pulmonary affections, especially in the old, and that such cases do not appear in the tables of comparative statistics. It must be admitted that the claim is just. Gerster saw three fatal cases of pneumonia after ether, and he reports two more and one serious attack. Five serious attacks of bronchitis followed the administration of ether in one institution.[9c]

Experiment upon animals as a means of determining the relative danger of the two great anæsthetics has been actively prosecuted during the last few years. The Hyderabad Commission (see under Chloroform) began this work. In the number and variety of experiments made, this commission surpassed all former efforts in this direction. But the observations they reported and the conclusions they arrived at differed so widely, so diametrically, from those of all other experimental physiologists that a revision and repetition of former work was absolutely necessary. The Commission, in their experiments, saw no deaths from failure of cardiac action. The conclusions they reached were: 1, That chloroform never causes death in dogs by affecting the heart; 2, that death always takes place by the respiratory organs and that disturbance of the function of respiration invariably gives warning of danger; 3, that when the action of the heart does fail it is the result of asphyxia, *i.e.*, of some interference with breathing, and is not a direct effect of the chloroform. These doctrines, but especially the application of these doctrines to the human subject, together with the deduction that safety could always be insured by the simple measure of watching the respiration, threat-

ened to revolutionize the clinical aspects of the subject. A number of experimental studies followed in rapid succession. Wood and Hare came first with a repetition of experiments and of new ones devised.[18] They arrived at the same conclusions as before, that chloroform is a powerful depressant poison, acting sometimes on the respiration, sometimes on cardiac action, and sometimes on both together; that it surely causes death by paralyzing the heart; that it sometimes does this at an early period of the administration when but a small quantity has been inhaled; and that the danger of cardiac arrest by this agent is in direct proportion to the concentration of the vapor and the rapidity of its administration.

Dr. MacWilliam reported to the British Medical Association an exceedingly interesting and important experimental study of the comparative effects of ether and chloroform.[1c] The results seem deserving of especial attention, because obtained by a method whereby the action of both ventricles and auricles were graphically recorded independent of, although with, tracings of the blood-pressure. Experiments showed, besides the usual fall of blood-pressure and marked diminution in force of the auricular and ventricular contractions, a decided dilatation of the organ. This dilatation was a constant feature; it affected all the cavities; they were imperfectly emptied. This change of form, too, was remarkable for the suddenness of its occurrence and the early period at which it occurred. It was often seen when but a small amount of chloroform had been given. Crucial experiments were made to determine that this change was not the result of changes in the systemic blood-pressure, nor effected through the vagi, and were not dependent upon asphyxia, or any interference with respiration, but that it was the direct effect of chloroform upon the heart itself. The conclusions were that "chloroform acts directly upon the heart, causes a marked depression of the cardiac muscle, a reduction of its tone, a relaxation of its walls, and an impairment of its functional activity." It was also proved that changes in the circulation frequently first gave warning of danger, and often before the respiration was affected. This had been clinically established before, but was denied by the Hyderabad Commission. A further important point of this report is the proof it gives that the rate and depth of respiration influence the effect of chloroform more than any other factor. By rapid or deep breathing an overdose may speedily be taken, and due dilution of the vapor with air is not, therefore, a guarantee against accident. The effect of ether upon the heart was concurrently studied by Dr. MacWilliam. It was shown to be in marked contrast with that of chloroform. Given less carefully and less gradually it caused but little change in the action or the form of the organ. Dilatation sometimes occurred, but then only in slight degree and when the ether was given in large amount and suddenly. As a rule it was absent and no effect upon the heart was manifested, while when chloroform was administered to the same animal in the same manner marked dilatation occurred and the force of the contractions was lessened.

Kappeler made a sphygmographic study of the various anæsthetics on patients and obtained results which correspond closely with those of Dr. MacWilliam, and which are more favorable to ether than those given in his work published in 1880.[19] He observed a noteworthy difference in the pulse-curves under ether and chloroform. The depression which always took place in greater or less degree with the latter, only occurred with the former in half the cases and then but in slight degree. With ether the curves showed any considerable change from the normal only when narcotism was pushed to complete abolition of reflex action and entire muscular relaxation. The observations showed that in its slight effect upon the pulse ether is an exception to all other anæsthetics. Yet in deep and prolonged administration similar changes occurred with both, so that "while death from syncope will occur less frequently under ether than under chloroform, such a death is, from the pulse-curve in ether narcosis, very possible."

All experiments, then, with the sole exception of those of the Hyderabad Commission, concur in supporting the conclusions reached by Wood, that "ether usually acts very much more powerfully upon the respiration than upon the circulation, but occasionally, and especially when the heart is feeble, ether is capable of acting as a cardiac paralysant, and may produce death by cardiac arrest at a time when the respirations are fully maintained; that chloroform is capable of causing death either by primarily arresting the respiration, or by primarily stopping the heart, but that commonly both respiratory and cardiac functions are abolished at or about the same time." Shore devised and executed a series of ingenious experiments wherein chloroform-carrying blood was restricted to the head of an animal, and in another to the body, the head receiving none. In the one case the fall of blood-pressure took place, in the other it did not; it was thereby proved that this fall was the effect of a direct action of chloroform on the heart and not on the vaso-motor centre.[1a]

By recent experimental study, then, we have gained much, but rather in confirmation of doctrines already accepted than in addition to our knowledge. The dilatation of the heart under chloroform, and the slight effect upon its action by ether had been observed by the first committee of the British Medical Association.[1c] But now an essential difference of action upon the heart by the two agents is accepted no longer as a matter of clinical deduction, but stands proved beyond question. The doctrine of Bernard, endorsed by the Hyderabad Commission, that ether and chloroform are similar in action and differ only in degree, is no longer tenable.

Notwithstanding the proof of an essential difference in mode of action between the two anæsthetics their relative standing has not much changed during the period under consideration. Chloroform still holds the leading position. Ether has gained considerably in England and still more in Switzerland. It has not made any advance in France; there, "chloroform reigns almost without a rival."[20] The A. C. E. mixture has advanced in favor, and is now largely used, especially in some sections of this country and in England. The estimate given at the Glasgow debate was that chloroform is given in Great Britain ten times to ether once. The statistics of the Twentieth German Surgical Congress showed 22,656 administrations of chloroform and 1,472 of mixtures to only 470 of ether.[14] The second series of Gurlt's statistics shows a great advance of ether. Chloroform is, then, still the leading anæsthetic of the world, despite its greater danger, proved by experiment and deduced from clinical experience.

The tendency of the practice of the present time is to a choice of anæsthetic, rather than to the banishment of either. The doctrine is gaining ground that each agent is better adapted to certain cases than the other, and that it is the duty of the surgeon to choose the anæsthetic according to the patient or to the operation to be performed. In this country Gerster and Hunter McGuire have ably supported this course. Dastre likens the adhesion to either chloroform or ether alone to the attempt made in the Academy of Medicine in 1833 to determine whether the treatment of pneumonia should be by venesection or by cathartics.[21]

The operation may determine the choice. For operations upon the nose, mouth, and pharynx chloroform is the best, and especially when the actual cautery is to be used. Tooth-drawing is an exception, however. Nearly ten per cent. of deaths under chloroform have occurred in dental practice, a proportion enormously high when the relative number of administrations for other purposes is considered. Nance says that chloroform should never, upon any consideration, be given for the extraction of teeth.[8b] Dastre emphasizes the different effect of the two agents upon the capillary circulation, chloroform restricting, ether increasing it. For operations after which much capillary hemorrhage may be expected he would therefore prefer the former. For protracted operations testimony differs as to which is the safer agent. The preceding administration of morphine, or morphine with atropine, by subcutaneous injection, best

promotes the prolongation of anæsthesia with a minimum of the agent. As to operations the success of which may be prevented by vomiting, there is a singular discrepancy of testimony. Thomas has seen such bad effects from this symptom after ether given for laparotomy that he thinks its abandonment for such cases worthy of serious consideration.[22] Cameron had the same experience in two out of four Cæsarean sections and would not use ether again in that operation.[2] On the contrary, one of the speakers at the same debate maintained that there was much less vomiting after ether than chloroform, an opinion also expressed by Zweifel.[7a] The influence of morphine and atropine is undoubtedly the best means of preventing vomiting and securing quiet after operations. Dastre is strongly in favor of this plan, supporting his opinion by the practical experience of Aubert of Lyons, and by citing the well-known influence of atropine upon the action of morphine as first shown by Brown-Séquard. So far as the experience of the writer goes it has not furnished a single case of severe vomiting after laparotomy for which anæsthesia had been effected by the A. C. E. mixture preceded by an injection of morphine and atropine.

Certain surrounding conditions may determine the anæsthetic. Artificial light, if in open flame, would banish ether on account of the inflammability of its vapor. Both McGuire and Gerster would prefer ether, and justly so, when obliged to entrust the anæsthetic to an unskilled assistant. The limits of safety are more easily passed through inattention, carelessness, or want of skill, with chloroform than with ether. When the patient cannot be fully anæsthetized with ether of course chloroform should be given. Gerster found 11 such cases in 125 administrations.

The state of the patient has an important bearing upon the choice of the anæsthetic. During pregnancy the injurious effect of coughing and vomiting should be considered. Hewitt makes obesity a contra-indication to ether.[23] Arterial sclerosis should also forbid ether on account of the greater increase of blood-pressure under this agent. Dr. Agnew's fatal case is an instructive example. Atheroma is also, for the same reason, a contra-indication to nitrous oxide.[13] When the patient is very feeble, or has suffered from severe hemorrhage, or when shock is present, ether should be preferred. The opinion prevails that chloroform is the safer anæsthetic for the extremes of age. For the old this is correct, on account of the liability of the aged to diseases of the respiratory organs. That chloroform is especially safe with young children is open to the gravest doubts. No precise statistics can be given, but numerous deaths have occurred while the number of administrations is comparatively small. Of 67 deaths reported in *The Lancet*, 1880–90 inclusive, more than twenty per cent. were of children under fifteen; some three, four, and five years old. Chloroform is better for young subjects on account of its manageability and promptness of effect, while its vapor is far less unpleasant and less irritating than that of ether; that it is safer remains unproven. There is great unanimity of opinion as to the administration of anæsthetics to patients suffering from heart disease. Valvular disease, compensation being maintained, is no bar to their administration. Fatty degeneration, if diagnosed, would contra-indicate chloroform. Richardson says he knows of but one condition of exceptional danger with chloroform, "a dilated and weakened right heart."[16] There is no question that a patient with valvular disease will go through the strain of an operation or of a severe labor better with an anæsthetic, even with chloroform, than without. The autopsies of deaths under chloroform have not revealed lesions of the valves. McGuire has given chloroform to "hundreds of cases" of valvular disease without accident.[24] For patients with a "nervously weak heart," feeble in action from fear, he and some others would reject chloroform. The effect of morphine and atropine is best adapted to this condition, quieting the emotional element, which has sometimes alone been the source of danger and death. There is like unanimity of opinion as to disease of the respiratory organs. Here chloroform should be preferred. Hyperæmia of the larynx, bronchitis, and pneumonia, or a tendency to these diseases, forbid the use of ether. Pleuritic effusions add very much to the dangers. Three cases of death from ether in patients with empyema were reported at one society.[9] In some cases, as of emphysema with enlarged heart, judgment is difficult; there is danger on either hand. Here, as in many other cases, Buxton and Hewitt advise the A. C. E. Disease of the kidneys has been held to be a contra-indication to ether since Emmet, in 1872, first called attention to the subject. In recent years, however, the injurious effect of ether in patients thus affected has not only been questioned but denied, and at present very considerable difference of opinion prevails. Fueter reports a series of experiments with results wholly negative. He reports also four cases of patients with albuminuria to whom ether was administered without increase of albumin afterward.[6] Weir also reports five cases of patients who presented evidence of diseased kidneys before operation and without injurious effect.[4a] Buxton says that a considerable experience with operations on the kidneys in which he had given ether, induces him to attach less importance to this point than formerly.[1a] This is negative testimony. Looking over the positive evidence, such as that presented by Carpenter,[9d] the number of cases in which nephritis followed the administration of ether, those of death under ether in which the autopsy showed diseased kidneys, and it must be conceded that the weight of testimony sustains the view that ether exerts an unfavorable influence upon the kidneys and should not be given when they are diseased. To support this proposition Weir's statement may be quoted, that he found nine cases of transitory albuminuria after thirty-four administrations of ether.

Various measures have always been resorted to before inducing anæsthesia to modify the process, and with a view of lessening its dangers. The one most generally used, and in which the utmost confidence has been expressed, is a dose of some alcoholic stimulant. Clinical proof of the inefficiency of this measure is abundant. In about five per cent. of the deaths from chloroform this plan was followed. Since both Wood and McGuire have recently expressed the opinion that the influence of alcohol rather increases than lessens the danger from chloroform this plan will probably be abandoned. The sole excuse for resort to it would be great fear on the part of the patient, and this condition is much better met by the influence of narcotics. This latter modification of the anæsthesia is the most important measure of the kind. The method consists in giving hypodermatically $\frac{1}{6}$ to $\frac{1}{4}$ grain of morphine (0.0108 to 0.0162), and from $\frac{1}{150}$ to $\frac{1}{120}$ grain of atropine (0.0004 to 0.0005) about fifteen minutes before the administration of the anæsthetic. Much additional testimony in favor of this "mixed anæsthesia," or "mixed narcosis," has been recently given. A paper has been published in this country advocating it and presenting its especial advantages in gynecological practice.[25] Dastre has warmly advocated it, and given both physiological and clinical evidence in support of it. His testimony is very strong: "With chloroform alone we lost one dog out of three, and often had dangerous symptoms in the other two. During ten years with the mixed method I have not seen a single one die." Dastre supports the method in the human subject theoretically by claiming that "it is equivalent to a section of the vagi;" that "all arrests of cardiac action under chloroform are certainly active, not paralytic; they are due to the action of the pneumogastric nerve, and may be prevented by the suppression of the activity of this nerve." However this may be, sound physiological support of the measure is to be found in the stimulating influence of atropine on respiration and cardiac action, as first shown by Harley and by Bartholow. Dastre presents a large amount of favorable clinical evidence from the surgeons of Lyons, where the practice has been followed for eight years, and in "several thousand cases" without accident. The plan is advised and followed by Buxton and McGuire. Pozzi[20] says that to this method "can scarcely be awarded too much praise in operations of any considerable length. . . . It pre-

vents the initial excitement, diminishes the nausea, limits the amount of chloroform used, and consequently lessens the chances of chloroform-poisoning in operations of long duration."* The changes, then, which have occurred in this branch of artificial anæsthesia in the past few years may be said to be: 1. The presentation of a large amount of evidence, both experimental and clinical, in favor of its greater safety. 2. An increase of evidence as to its influence in lessening vomiting. 3. The great probability that the benefits of the measure are not restricted to chloroform. Kappeler[26] had given his opinion against the administration of narcotics before ether, believing that they increased the danger. Experience has not sustained this. Julliard gives morphine and atropine before ether. The writer has used them before the A. C. E. during a lifetime, and has not once seen dangerous symptoms. Shrady advises morphine before ether in drinkers. The latter writer also presents strong testimony as to great economy of anæsthetic and of time by this method. Plastic operations under ether which required one hour were performed in half that time when morphine was given first.[9] Adverse opinion has been expressed upon this method; adverse testimony, however, is not strong. The Hyderabad Commission is not favorable to atropine, but advises the use of small doses of morphine under some circumstances. Macewen states that "the action of morphine becomes intensified in the presence of chloroform." Yet there has been such an amount of clinical experience with this method that if it added to the danger the fact would be apparent. Some deaths have been reported;[26] one recently in this country after the administration of a quarter of a grain of morphine,[46] preceding chloroform.

Two points in regard to anæsthesia may be considered settled: 1. There is no especial mode of death under either anæsthetic; that ether always causes death by the respiration, and chloroform always by the heart, is no longer tenable. Wood's statement (*v. ante*) gives our present knowledge as to modes of death and their relative frequency. 2. All anæsthetics are dangerous; no care, no precaution, no particular apparatus or method of administration insures absolute safety. This is the expression of all recent authorities, the Hyderabad Commission alone excepted.

In measures for resuscitation of patients in danger from anæsthetics some changes have taken place. The beneficial effect of galvanism remains unproven. Two remedies generally resorted to have been shown by Wood to be not only useless but injurious; they are the administration of ether and of alcohol. Unsupported by reason, experiment shows that they should be abandoned. Digitalis, given hypodermically, exercises a marked influence upon the circulation, and Wood saw, several times, the death of animals averted by it. Strychnine also produces a marked stimulating effect upon the respiration with a rise of blood-pressure;[13] but Reichert's experimental studies do not sustain Wood's opinion of the value of strychnine as a respiratory stimulant.[27] Hankel recommends it, however, "as the strongest stimulant of the respiratory centre and of the motor cardiac nerves." As to nitrite of amyl, the testimony is conflicting. Wood found its effect negative. Buxton says it is not a physiological antidote to chloroform. On the other hand, Shrady and others report having used it with benefit, and Burrall has published a paper with a collection of cases in its support.[9c] Inversion of the body scarcely holds the confidence it once had. The existence of cerebral anæmia, upon which this measure is theoretically based, is doubted by Wood. Dastre says that ether causes cerebral hyperæmia, and that therefore, with this agent, the dependent position of the head is likely to aggravate the symptoms. The measure originated from observation of its good effect on animals, and experiment still sustains it. Wood saw its good effect frequently, and in some cases repeated so often that it could not be attributed to accident. There is very strong clinical evidence in its favor. Chisholm has reported cases of recovery quite as striking as the one first described by Sims in Nélaton's practice. He gives four successful cases; in one the measure was repeated three times before the completion of the operation.[9c] Artificial respiration still maintains the leading position it has always held. Authorities are unanimous as to the superiority of this measure. It has the strongest support from experiment. In man, if respiration be in abeyance, this is the direct and only way to restore it. If the heart is paralyzed nothing can restore its vitality, but its action may be so reduced as to be imperceptible, and then the manipulation of the chest-walls is an effective means of increasing it. Early resort to it is important. The Hyderabad Commission found it successful almost without exception if not more than thirty seconds had elapsed before it was commenced, and almost useless if not begun until after fifty seconds. Nussbaum emphasized the importance of the first minute. Whatever method be followed thorough expiration should be first effected. By this means the anæsthetic vapor of the residual air is expelled. Again, expiration is much more affected by anæsthetics than inspiration.[21] In deep anæsthesia expiration is purely passive, very feeble, and danger to respiration comes in this way. Nussbaum's plan was, thorough slow compression of the thorax and abdomen with both hands, and this repeated every three or four seconds. He had 15,000 administrations of chloroform without a death; nine times, however, the escape was narrow, and once ten minutes elapsed before the first breath was drawn, and thirteen more before respiration was established.[14] König's plan is similar; it consists in compression of the cardiac region, repeated thirty to fifty times in the minute, one thumb pushing deeply into the space between the ribs and left edge of the sternum. Maas reports two striking recoveries by this method.[7b] The patients were nine and a half and thirteen years old; both were pulseless, with suspended respiration and dilated pupils; in one artificial respiration by Sylvester's method and inversion of the body was tried; in both there was opportunity to observe the good effects of the measure several times, and over an hour of perseverance was required before recovery was assured. McWilliam found that the most powerful way of increasing the carotid blood-pressure in animals deeply narcotised by chloroform was by firm intermittent compression of the abdomen.[15]

Considerable attention has been directed of late to the purity of chloroform. Probably very few, if any, deaths have been caused by an impure article. Dastre found no instance in 132 fatal cases which occurred from 1865 to 1880, and he thinks this a convenient explanation of death for the relief of the administrator. Recently, however, DuBois-Reymond has made a study of this subject. He has followed a plan devised by Pictet, of Geneva, whereby chloroform is submitted to the influence of intense cold and impurities in it thus removed. Chloroform thus purified showed far greater stability;[27] exposed to air and light it remained unchanged for a week, while ordinary chloroform showed signs of decomposition within two days, sometimes in a few hours. Anæsthesia was produced by the purified article more promptly and was more enduring. Experiments were made on animals with the residue and the injurious effect of the impurities thus demonstrated.[28] In Germany, according to Foy,[29] great impurity of chloroform is not rare. In England chloroform is likely to be contaminated with the methyl compounds from the use of methylated spirit in its manufacture.[8c] Reynier found necessity for investigating the purity of chloroform in France.[30] He attributes cough, vomiting, bronchial hypersecretion and arrest of respiration to impure chloroform. He had observed a far less mortality in dogs experimented on since he had used only chloroform rectified the evening before and kept in colored bottles. In the debate M. Lucas-Championnière maintained the importance of this point; with pure chloroform anæsthesia is regular; with impure there are irregularities

* This writer claims it as "the method of Dastre and Morat." It was used in this country from 1870, continuously since, and publicly advocated as early as 1876.[25] Dastre's work appeared in 1890.

and accidents. In obstetrical practice he had found it of especial importance. "If I have good chloroform I effect readily that demi-anæsthesia desired in natural labor; if not, I fail; I narcotise too much or not enough." DuBois-Reymond's chemical position has been called in question by Schacht.[21] In this country pure chloroform, the product of reliable manufacturers, is everywhere at command, yet the necessity of care in selection is shown by the following official table of examinations of the articles:[31]

		Number of examinations.	Good quality.	Fair.	Inferior.	Not ether at all.
1889.	Chloroform	21	15	5	1	..
	Ether	68	40	4	22	2
1890.	Chloroform	13	8	4	1	..
	Ether	30	17	..	12	1
1891.	Chloroform	17	15	1	1	..
	Ether	61	38	4	19	..

The vapor of chloroform undergoes decomposition when exposed to the flame of artificial lights. Zweifel first called attention to this fact in a paper on pneumonia after laparotomy from decomposition of chloroform in gas-light.[7c] He maintained that gases are formed which are very irritating to the respiratory organs, occasion cough, and may be the cause of inflammatory affections. By the contrast of daylight operations and of those conducted under ether he furnished abundant clinical proof. Basshard studied the subject chemically and demonstrated that free chlorine and phosgene gas are formed when chloroform is exposed to gas-light.[18c] Eisenlohr and Fermi furnished experimental proof that injurious and dangerous gases may be thus generated.[17b] Amidon read a paper upon the subject which called forth reports of other cases from New York surgeons.[4c]

Fatty degeneration of the tissues is occasioned by prolonged and repeated inhalation of chloroform. The fact was noticed by Nothnagel in 1866. Attention was directed to it again by Unger in 1887, and his observations have been confirmed by Strassman and by Ostertag.[8d] The experiments of these observers showed that in animals exposed to prolonged inhalation of chloroform the internal organs had undergone fatty degeneration; that certain individuals exhibited a greater susceptibility to this change than others; and that in these animals death took place by paralysis of the heart. The fact should be known as one having clinical possibilities.

Bichloride of methylene, introduced by Richardson in 1867, has not succeeded in gaining a footing in this country. Nor has it advanced in favor elsewhere, notwithstanding Wells's experience of twelve hundred administrations without a sign of danger. Pleas have recently been made in its favor by Day,[1d] and by Richardson,[16b] the latter giving a large, varied, and successful experience. Bichloride of methylene, pure, is a "convulsive anæsthetic," not adapted to surgical use. The liquid which passes under this name as methylene is a mixture of chloroform 10 parts and alcohol 30 parts.[21] Kappeler obtained several specimens from the best English sources and found them to consist of "a mixture of chloroform and methyl alcohol, with traces of chloromethyl."[19] Richardson does not claim that it is pure, but that "a less refined product answers even better for anæsthesia than the real CH_2Cl_2." The rate of mortality of this agent has been high. Kappeler refers to 14 deaths collected by himself in 1879, and gives 5 more. Hankel says that the few leading English journals, 1869–80, contain reports of 11 deaths from it, 7 by syncope. This was the same mortality as that from ether during the same period with a very far greater number of administrations. Dastre attempts to reconcile the high rate of mortality in general with Wells' and Richardson's successful experience. He believes an explanation may be found in the different temperatures at which the agent was administered, in changes which take place in the liquid even during administration, and especially in the use of Junker's inhaler, a closed apparatus, which influences both the other factors.

The bromide of ethyl seems to be actively recovering from the neglect into which it fell about a decade ago. The reaction began in 1888, and has been the work of German dentists. Strong testimony in its favor, experimental and clinical, was presented to the Tenth International Congress by Holländer and Abonyi. A paper embodying the experience of 1,500 administrations is given by Gilles.[7d] It is stated that there have been 20,000 safe administrations in Germany, the accidents being attributed to impurity of the article used. In this country it has been advocated by Montgomery, 500 cases, by Kuykendall, 250 cases,[27bis] and it is stated that Chisholm and Prince have administered it to several thousand cases.[27] It has been opposed by Mittenzweig, who gives three cases of poisoning in Berlin, two fatal.[1b] Brinton was led to abandon its use from unpleasant experience.[27] Dastre says: "If physiological analogies do not deceive us, the bromide of ethyl, for long operations, offers greater dangers than ether or chloroform." Kappeler found that it exercised a marked influence upon the pulse-curve, and hopes that it will be "consigned to forgetfulness."[19] The writer inhaled it three times, under the supervision of medical friends; its effect upon the pulse was so marked that he decided never to administer it.[32] To all previous adverse experience the friends of this agent urge that the purity of the article is essential; and it is an article very difficult to obtain pure. Nevertheless Witzel, who terms it "the safest narcotic for human beings," saw, in 465 administrations, disagreeable symptoms 28 times, asphyxia in a number of cases, and twice artificial respiration was required.[27c] Gilles urges the importance of a special technique: it should be given more freely than chloroform; the mask should consist of several folds of gauze, so as to carry considerable liquid, and over this should be an impermeable cover. Anæsthesia by this agent is exceedingly pleasant, very rapid, with equal rapidity of recovery. The writer can testify to these points from personal trial, and, if safe, he would term it the ideal anæsthetic. The time required for complete anæsthesia is fifteen to ninety seconds, average eighteen. The following points are derived from the writings of advocates as well as opponents: 1. Bromide of ethyl is adapted only to very short operations, those lasting not over a minute or two. 2. Not more than five to ten grammes should be administered. 3. Muscular relaxation is not obtained; a gag is necessary for tooth-extraction. 4. Muscular rigidity is frequent, sometimes tetanic, with opisthotonos. 5. Excitement, although unusual, is sometimes greater than with chloroform. 6. Dreams are extremely vivid and sometimes erotic. Gilles denies that they are of this character "in one-third of all cases." He saw sexual movements in one case, and Wetzel saw them in women several times in 465 administrations. 7. In some cases it is followed by distressing vomiting, even when but a small amount has been given. 8. Arterial hemorrhage is favored. 9. An unpleasant odor of garlic is present for some days in the breath of those who have inhaled it. In view of the conflicting experience, this agent should be submitted to further careful chemical and experimental investigation. The authors of the papers above quoted concur in the statement that neither pulse nor respiration are materially affected in patients submitted to its influence.

There has been no change worthy of note in either the theory or practice of anæsthesia in obstetrics. No addition to the mortality in natural labor, the anæsthetic being administered by a medical man, can be recorded. A brief treatise upon the subject has been published in this country as part of an obstetrical work.[33] Baldwin has made a plea for a more general resort to chloroform in labor,[12b] and Barker has published an inquiry as to the influence of anæsthetics in causing post-partum hemorrhage.[18b] This paper is based upon the observation of several thousand cases, and the author's conclusion is that chloroform, properly administered, need never be withheld on account of hemorrhage. The experience given in support of the doctrine that valvular disease of

the heart is no bar to the use of chloroform is especially valuable. Montgomery has advocated the use of bromide of ethyl in labor, and reported cases.[27c] The administration of this agent is restricted by its best friends to very brief periods. Charpentier presented the subject of anæsthetics in natural labor to the Obstetrical Society of Paris.[4a] He recognized the undoubted tendency of chloroform to diminish the contractile and retractile power of the uterus, and that in some cases it "has been the cause of more or less severe hemorrhage after labor." It is indicated "in primiparæ who are nervous and excitable, and in whom the pain may even cause delirium; in those in whom the labor is greatly prolonged; in all cases in which there is spasm, contraction, or rigidity of the neck or body of the uterus." It is contra-indicated in "absence of severe suffering, the existence of placenta prævia, general prostration, diseases of the circulatory or respiratory organs, cerebral disease, and alcoholism." In regard to cardiac disease, he is not in accord with Barker nor with the general testimony of authorities.

The occurrence of insanity after the administration of anæsthetics has been observed. This is the subject of a paper by Savage, read before the British Medical Association.[1c] Mental aberration has followed all the anæsthetics, as well as other deliriants, such as alcohol and belladonna. Such a result is rare, but its possibility may bear upon the use of these agents with patients having an hereditary disposition to insanity. One case with such disposition was related, in which insanity followed the first confinement, chloroform not having been given, while several times subsequently the anæsthetic was administered and no bad effect followed. Homans[10b] has reported two cases of insanity following ether, and several others are mentioned.[9] Papers upon insanity following operations, especially laparotomy, have been published by Baldy[15] and by Ill.[34] How far the mental disturbance in these cases should be attributed to the operation or to the anæsthetic it is impossible to determine.

Pental (*q. v.*) has recently been used in Germany as an anæsthetic for short operations, and several hundred administrations have been reported. As it caused cyanosis with absence of pulse and suspension of respiration in a healthy student, who submitted to its influence, as Gurlt reported to the Twenty-first German Surgical Congress one death in 215 administrations, and as Brewer, of Vienna, found measures of resuscitation necessary in one of every hundred administrations,[35] the future of this agent is not promising.

Local anæsthesia has been revolutionized within about a decade by the extension of the application of cocaine (*q. v.*). Menthol is also an efficient addition to our means of lessening sensation locally. The following, used with Richardson's spray apparatus, renders good service:

℞. Menthol..... gr. 2.5
Chloroform..... gr. 25.0
Ether..... gr. 37.50
M.

With the means now at command for local anæsthesia a death from chloroform, given for opening a mammary abscess,[36] could not be considered less than criminal.

J. C. Reeve.

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[2] Discussion on Anæsthetics. Glasgow. 1891.
[3] Chloroform the Best Anæsthetic. Baltimore. 1888.
[4] N. Y. Med. Jour., i., 1887; *a*, i., 1890; *b*, i., 1892; *c*, i., 1891.
[5] Rev. Med. de la Suisse Romande, February, 1890–91.
[6] Deutsche Zeit. für Chir., Bd. xxix., 1888.
[7] Berlin klin. Wochenschrift, No. 8, 1890; *a*, 15, 1889; *b*, 12, 1892; *c*, 15, 1889; *d*, 8, 1892.
[8] London Lancet, ii., 1891; *a*, ii., 1890; *b*, ii., 1890; *c*, i., 1888; *d*, ii., 1889.
[9] Med. Rec., i., 1889; *a*, i., 1891; *b*, ii., 1892; *c*, i., 1887; *d*, i., 1886; *e*, i., 1888.
[10] Boston Med. and Surgical Jour., ii., 1888; *b*, cxxi., 1889.
[11] Anæsthetics. Philadelphia. 1888.
[12] Trans. Ohio State Med. Soc., 1891: *b*, 1890.
[13] Wood's Address, International Congress, 1890.
[14] Hankel: Handbuch der Inhalations-Anæsthetica. 1891.
[15] Am. Jour. Obstet., xxiv., p 1461.
[16] Asclepiad, 1892; *b*, 1888.
[17] Ther. Monatschrift, August, 1891.
[18] Med. News, i., 1890; *a*. ii., 1887; *b*, i., 1887; *c*, ii. 1889.
[19] Archiv. f. klin. Chir. 1888.
[20] Pozzi: Treat. on Gynæcology. New York. 1892.
[21] Les Anæsthétiques. Paris. 1890.
[22] Med. and Surg. Rep., 1889.
[23] Treves: Op. Surg. 1892.
[24] The Choice of General Anæsthetics. Richmond. 1887.
[25] Trans. Am. Gyn. Soc., 1891.
[26] Anæsthetica, Deutsche Chir., 1880.
[27] Ther. Gaz., April. May, June, 1892; *b*, May, 1892; *c*, June, 1892; *d*, April, 1892, *e*, January, 1892.
[27bis] Southern Med. Rec., 1891.
[28] Amer. Jour. Med. Sc., April, 1892.
[29] Anæsthetics, Ancient and Modern. London. 1889.
[30] Bull. et Mem. de la Soc. de Chir. de Paris, xv., 1889.
[31] State Board of Health. of N. Y., Dr. W. G. Tucker, Albany.
[32] Cin. Lancet and Clinic, 1886.
[33] Amer. System Obst., vol. i. 1888.
[34] Pittsburg Med. Review, 1888.
[35] Annals of Surgery, January, 1893.
[36] Jour. Am. Med. Assoc., March 7, 1891.

[Since this article was prepared there has been published a large collection of statistics in the *Medical News*, October 29, 1892, and a valuable article on "Recent Physiological and Chemical Research on Anæsthesia" in the *British Medical Journal* of same date. A second edition of Buxton's work on Anæsthetics has also appeared, Philadelphia, 1892.]

ANCHYLOSIS. A new use of the terms *true* and *false* anchylosis, based upon the symptomatology and treatment, has recently been employed by a few orthopedic surgeons. They would have true anchylosis embrace both bony and fibrous union, provided it be complete, sound, and uninfluenced by use; false anchylosis would then be applied to those stiff joints in which some degree of motion is present, those in which disease (unsoundness) still remains, and all joints which by use become more deformed and more stiff, or less deformed and less stiff.

The justification of this terminology rests chiefly in the treatment. True anchylosis should only be subjected to treatment for the correction of existing deformity. *Brisement forcé*, osteoclasis, osteotomy, and excision are demanded, according to the nature of the deformity. False anchylosis, existing without deformity, should be treated by immobilization until the joint is quite sound; if the result is true anchylosis no further treatment is demanded; but if the joint recovers soundness with some degree of motion, the fullest possible restoration of function will be gained in time without further treatment. *Brisement forcé* and passive motion cannot be employed without a risk of rendering the joint once more unsound. If false anchylosis be present in a deformed joint, the deformity should be corrected under an anæsthetic, the surgeon using as much force as can safely be risked, at one or more sittings; after each forced correction the joint should be kept at rest until all pain has ceased, when the attempt to reduce the deformity should again be made. When the deformity has been fully corrected, the joint should be immobilized until it has become wholly sound, after which the rules applicable to a straight limb should govern the management of the case.

It is no longer believed that true anchylosis can be produced by immobilization alone, no matter how prolonged. The fact that anchylosis is present in a joint is a positive indication that it has been, or still is, the seat of some pathological process, and from this the logical conclusion follows that the treatment which will most rapidly cure the disease must result in the fewest cases of true anchylosis.

John Ridlon.

ANEMONINE. The active principle of *anemone pulsatilla, L.*, $C_{12}H_{12}O_6$. It crystallizes in needles, has an acrid taste, is slightly soluble in water, soluble in alcohol and chloroform. It is decomposed by alkalies.

It is recommended as a substitute for pulsatilla. Dose, from $\frac{1}{12}$ to $\frac{1}{2}$ grain. In large doses it is a powerful poison.

It is used in painful inflammatory affections of the ovaries and other pelvic organs, in orchitis and epididymitis, and in all other affections in which pulsatilla is indicated.

The alkaloid requires to be prepared with care, as the presence of anemonic acid converts it into anemone camphor, which produces its irritant and poisonous properties. *Beaumont Small.*

ANGEIO-NEUROTIC ŒDEMA. Definition: A vasomotor neurosis, characterized by the appearance of circumscribed swellings on various portions of the body, by preference the face, throat, and extremities, without apparent cause or premonition, and non-inflammatory in character.

Synonyms: Acute circumscribed œdema; acute idiopathic œdema; periodic swelling; urticaria tuberosa, or giant swelling; acute non-inflammatory œdema; Australian blight.

History.—Although references to this affection may be found here and there in medical literature since 1827, it is only within the past ten years that it has been recognized as a disease having sufficient individual characteristics to have a history and special designation of its own. It is to Quincke, and his pupil, Dinkelacker, that we are indebted for calling the attention of the profession to this disease, in such a lucid manner that it was at once recognized by other physicians.

Etiology.—*Age.*—The period of early life furnishes the greatest number of cases; the average age in a series of seventy-five cases examined by the author being twenty-seven. It rarely occurs for the first time in individuals upward of sixty years of age. Childhood, however, is by no means exempt; a case is reported by Dinkelacker, in which a child, whose father suffered from the disease, had an attack for the first time when it was three months old.

Sex.—It occurs nearly twice as often in males as in females, except in this country, where the proportion would seem to be reversed.

Occupation.—Those whose occupation tends to the production of excessive bodily and mental fatigue, are the only persons who show an increased susceptibility to the disease.

Heredity.—This is one of the most important and interesting elements in the genesis of the disease. It has been seen to run in families one generation after another. In a remarkable series, reported by Osler, the disease was demonstrated to be present in five generations, including in that time twenty individuals.

Previous and Present Condition of Bodily Health.—No relationship can be traced to previous, immediate, or remote disease, and the majority of the cases presenting themselves with this disease are in fairly good health.

Exciting Causes.—Of the directly exciting causes cold and traumatism are the most obvious. Others, such as fright, grief, anxiety, worry, and the ingestion of certain kinds of food, such as apples or fish, have all been found to be exciting causes in some patients. An attack is most commonly excited by cold, as in passing from a warm into a cold atmosphere, although it does result after severe muscular exercise with consequent sweating and then becoming cool very rapidly. The period in the twenty-four hours when attacks are most liable to show themselves, is during the time between 1 and 5 A.M., when the tide of life is at its lowest ebb, and the parts are least resistant.

Area of Distribution and Primary Point of Manifestation.—In a total of seventy-one cases the swelling showed itself for the first time: in the face, in twenty-nine cases; on the extremities, in twenty-two; in the larynx, in five; on the genitals, penis, and scrotum, in three; on the body, in six; on the gums and palate, in one; in the stomach, in three; on the neck, in one; and behind the ears, in one. Of the cases in which the swelling showed itself upon the face, three were restricted to the forehead; three occurred first on the eyelids; seven on the lips, and the remainder were distributed over various portions of the face. On the extremities the hands were by far the most often attacked, and after these the forearms were the next most frequent seat.

The occurrence of the swelling in one spot seems to predispose the place for future attacks, and it is the exception for it to be once seen in a place which thereafter remains free. Parts of the body which have received injury or have been the seat of protracted pain seem occasionally to be favorite places for the development of the swellings. Occasionally there seems to be a periodicity in the appearance of the swelling.

Symptomatology and Clinical Course.—The manifestations of the disease generally present themselves without warning, and the suddenness of their appearance and departure are rather characteristic. Possibly the patient may complain for a short time before the appearance of the swelling, of vague feelings of malaise, general disinclination to do anything, and a feeling of depression associated with ill-defined gastro-intestinal symptoms. The œdema comes on quickly, generally reaching its full development in a few hours, and gives the patient very little trouble, except by its mere presence; there is a feeling of stiffness and unwieldiness and a sensation as if the parts were on the stretch, but this sensation is not attended with pain or distressing throbbing, or any of the subjective symptoms of inflammatory swelling. The swelling is generally clearly circumscribed and plainly differentiated from the surrounding surface, and of a varying color. In some cases, but probably not in the majority of them, the skin is of a dark-red, dull roseate hue, while in others the marked contrast between the pale, almost waxy color of the swollen surface and the skin around it, is very striking. As has already been stated, the swellings have marked predilections for certain parts of the body. The œdematous part does not pit on pressure, or, if it does, only in a few cases, and in these not to any marked extent, so that the indentation produced by the forcible pressure of the finger is quickly effaced.

The subjective symptoms complained of by the patients are a sense of scalding or burning as the swelling is showing itself, these sensations being probably due to the marked tension under which the skin is suddenly placed; and after this, there is generally a feeling of itchiness. Outside of these, if the swelling does not encroach on any organ, such as the eye, the stomach, the penis and testicles, or does not block up the conductivity of a passage, as it sometimes does, and so produce trouble, there will be hardly any other subjective symptoms complained of. Frequently the surface temperature of the swollen part has been found to be slightly elevated, while on the other hand carefully made observations have demonstrated that the specific heat of these parts was considerably lowered. It is probable that at the beginning of an attack the surface temperature of the part is somewhat elevated, while later, or just before the swelling is going to wane, the temperature falls.

The swelling generally reaches its height in any one part in a few hours after its appearance, in some cases in a few minutes, while in others from six to eight hours will elapse. After remaining for a period varying from a few hours to as many days, it will begin to disappear, ordinarily with a rapidity corresponding to that with which it showed itself, and frequently its disappearance from one part is the signal for its appearance in another, which may have no anatomical or physiological relation to the part previously affected. As a rule it does not show itself in more than two or three localities at one visitation, and frequently only in one. The disease recurs, and in the analysis of the cases spoken of above, the time between the attacks averaged nineteen days. Occasionally a patient will have three or four attacks in a month, while others go for three and four months, and even longer, before they have a recurrence.

The symptoms of the disease when some of the mucous membranes are attacked are well marked and suggestive. As has already been said, the mucous surfaces most often attacked are those of the stomach and of the larynx. In about one-third of the cases gastro-intestinal symptoms are prominent. These symptoms are first a feeling of uneasiness and tension, as if something undigestible had been taken and had remained in the stomach. With this there is loss of appetite generally associated with constipation, which is soon followed by a distended appearance of the epigastrium; and then follows a sharp colicky pain,

often attended with profuse vomiting and great thirst. The pain is often so severe as to demand the administration of morphia. The character of the material vomited depends at first upon the contents of the stomach, but later on it becomes watery and somewhat stringy from the mucus which it contains, and frequently profuse in quantity. When this continues for any length of time the thirst becomes greater, and large quantities of urine are frequently passed, which, however, contains nothing abnormal with the exception of increased quantities of earthy phosphates. After this exacerbation in the symptoms has ceased, the reaction sets in, and there is frequently a diarrhœa of a colliquative nature, with an apparent retraction of the abdomen and a general feeling of lassitude and prostration, and the characteristic symptom of the disease shows itself in another part of the body, or, if it has already done so, it now begins to disappear.

When the swelling appears in the larynx it of course produces symptoms in proportion to the amount of encroachment that it makes. This is often so great that distressing symptoms of suffocation are produced, and, indeed, in some instances, in consequence of the œdema, death has taken place, and in many others the symptoms are so severe as to demand liberal scarification, or, more rarely, tracheotomy. As a rule the swelling does not pass by any continuity from the pharynx into the larynx, but when it is to attack the latter it shows itself with the same degree of abruptness and vigor there as in other parts of the body, and as a consequence the horrible sensation of choking to death is added to the patient's misery. Difficulty in swallowing when the seat of swelling is in the pharynx, is not so common as the corresponding symptom in the larynx, nor does it ever become so distressing. If it be granted that the œdema in question may manifest itself in the lungs, as many good observers would have us believe, the symptoms resulting will not differ materially from those of acute pulmonary œdema, except in the suddenness of its onset, the urgency of the symptoms, and the abrupt mode of departure.

Of the general health between the attacks but little is to be said. Generally there is nothing noticeably wrong; for a day or two after an attack there may be a slight feeling of prostration, especially if the gastric or intestinal mucous membrane has been attacked, but this soon passes away and the condition of the body is excellent until the next attack shows itself. Frequently there is not even this feeling of lassitude.

Diagnosis.—The diagnosis of a case of angeio-neurotic œdema will be attended with little or no difficulty if arrived at by the process of exclusion. The spontaneous appearance of the œdema, its recurrence at certain intervals, the absence of inflammatory symptoms, either local or constitutional, and the abruptness of its disappearance, are generally sufficient to enable us to recognize the disease at once.

It may be confounded with the blue œdema of hysteria, as described by Sydenham, or the white œdematous swellings occurring with the same disease, as described by Charcot. In hysteria, however, and especially if the hysterical attack is sufficiently profound to have œdema as one of its attendants, there will always be found the well-known stigmata which will be sufficient to make the diagnosis. Other factors, such as the abruptness of onset and the mode of departure, as well as the distribution of swelling in angeio-neurotic œdema, will corroborate the diagnosis.

There are a certain number of affections described under other names which are in all probability modified forms of this disease. They are, urticaria tuberosa, Australian blight, malarial œdema, etc. As will be seen at the beginning of this article these terms are considered as synonyms of the disease in question, and therefore require no further description.

Duration and Prognosis.—The duration of the disease varies from a period sufficient for one attack to a lifetime. The statistics bearing on prognosis do not allow us to draw conclusions that are of any great value on account of the fact that the patients do not often remain under the same physician's care sufficiently long to enable him to study the natural termination of the disease. From the evidence in our possession I am inclined to believe that the disease disappears after lasting a variable time, of from two to three years, in about one-half the instances. In the other half it may remain dormant for prolonged periods, but you can never prognosticate when or where it is next going to manifest itself. In others it continues to recur with varying intervals during the patient's entire life, which may not, however, be perceptibly shortened by the exhibition of these attacks. In some cases the manifestations cease to present themselves when the exciting cause can be obviated. It rarely causes death, and then almost alone by the involvement of the larynx and consequent suffocation. Whether or not the possession of this infirmity tends to shorten life by predisposing to other conditions which destroy the life of the patient, nothing definite has been observed, and there must necessarily be a greater number of observations before any justifiable conclusions could be drawn in regard to this point.

Pathology.—The pathology of the disease is as yet rather obscure. The nature of the lesion is unquestionably that of a non-inflammatory œdema circumscribed in form. The fact that the epidermis is not involved is an important corroborative fact, even if it was not so evident clinically that the œdema is in no way connected with an inflammatory condition. The seat of the œdema is probably most often in the connective tissue of the derma, beneath the papillæ, and in the subdermal tissue; very rarely the œdema confines itself to the more superficial parts. It is probable that although the lesions or the irritants on which the disease is dependent may attack the other parts of the system, yet the result directly appears through the sympathetic system of nerves. Furthermore, the nerves affected are undoubtedly the vaso-motor nerves. The disease in its development has a close relation to other vaso-motor neuroses, such as morbid blushing and flushing, exophthalmic goître, and to many of the arthropathies as yet not well understood. An œdema very similar to it is associated with tic douloureux, migraine, nerve-stretching, and the œdema occurring in hypnotizable subjects, following a séance.

Treatment.—Therapeutic measures are of little avail, either in mitigating the length or the severity of an attack, or in increasing the intervals between their occurrence. The greatest success will be obtained by adopting such measures as give tone and stability to the nervous system. As an all-round vaso-motor and general tonic to the nervous system of the body strychnia most nearly reaches the mark. It should be given in large doses and until its full physiological effects are manifest, particularly on the spinal cord; for although the affection is one indicating defect in the sympathetic nervous system, we must not forget that the origin of that system is in close relation genetically with the spinal cord. The next most important drug in the treatment is atropia; it should be likewise given in moderately large doses, and its administration continued during the intervals between the attacks. Tonics, invigorating baths, exercise, massage, and the prevention of trauma are the most important factors in the treatment of this disease. It is unnecessary to enter into details concerning the treatment for symptoms as they arise. If there be an excess of uric acid in the blood, as manifested by a disproportionate relation to the urea in the urine, this condition demands regulating. The same may be said of constipation, menstrual irregularities, and the like. The treatment at the time of an attack will depend somewhat on the part of the body where the disease is manifest. If the dermal surface of the body be involved, the most satisfactory plan of treatment is to keep the patient quiet, in an equable temperature, and apply dry heat to the swelling; and if there be much uneasiness or restlessness, a mild anodyne should be administered. Compression by means of a bandage or a Gamgee dressing is occasionally of benefit. When the disease manifests itself in the mucous membranes the treatment is entirely symptomatic. As has been before said, when the gastro-intestinal symptoms are prominent, morphia fulfils two conditions: it relieves the severe

pain and distention, and checks the vomiting for the time being. When the disease shows itself in the throat and larynx, it will occasionally be necessary to scarify and sometimes, but rarely, to perform the operation of laryngotomy. The use of electricity, although recommended, has not been attended with any better success than has followed the employment of the other remedies mentioned.

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Wilcox: St. Louis Med. and Surg. Journ., vol. lv., p. 273.

Joseph Collins.

ANISIC ACID, an isomer of methyl salicylic acid, is obtained by the oxidation of oil of anise. It crystallizes in brilliant, colorless crystals, slightly soluble in hot water, very soluble in alcohol and ether. It forms alkaline salts, which are freely soluble.

It possesses antiseptic and antipyretic properties resembling those of salicylic acid, but it is free from any of its disagreeable effects.

Locally applied as a powder to wounds or ulcerating surfaces it checks the secretion of pus and hastens repair.

Internally, the anisate of sodium is employed in all conditions in which salicylic acid is used. As an antirheumatic it is highly recommended. It is easily taken, and may be administered in doses similar to those of salicylate of sodium. *Beaumont Small.*

ANTHRAX, SYMPTOMATIC. The bacillus of symptomatic* anthrax was first obtained, in cultures which were known to be absolutely pure, by Kitasato. At first he was able to cultivate it only in a liquid medium made of the flesh of a susceptible animal †—*i.e.*, bouillon made from a guinea-pig. Subsequently ‡ he was able to cultivate the organism in ordinary neutral agar and gelatin. In order to obtain pure cultures he resorted to a special form of apparatus, also used in isolating the bacillus of tetanus (see under the heading Tetanus). The bacillus is an exquisite anaërobe. It will grow in deep stabs in tubes containing a large amount of agar or gelatin, to within a finger's breadth of the upper surface. The colonies in gelatin are irregularly spherical, with a warty surface. Subseqeuntly they have a ray-like zone of liquefaction and a dark centre. There is a production of gas, with a peculiar penetrating odor. Spores are formed at the temperature of the human body in thirty hours. These are oval, and have one side somewhat flattened, and form near to, but not quite in, the centre of the rods, which become spindle-shaped. Addition of grape-sugar, eikonogen, or other reducing agents to culture media, helps the growth of the organism. The bacilli have independent motion, but only when they do not contain spores. They do not lose virulence on solid media, but they do in guinea-pig bouillon.

Meade Bolton.

ANTOGAST. A thermal and climatic station in the Black Forest, Germany.

LOCATION.—Antogast is situated in a narrow valley of the Black Forest of Baden, about 1,500 feet above the level of the sea. Fine promenades in the surrounding pine woods make the place attractive. The springs are alkaline chalybeate ones, containing traces of arsenic. The waters are cold and pleasant to the taste.

ACCESS.—By omnibus from Oppenau, a station on the Oppenweier branch of the Baden Railroad.

INDICATIONS.—The waters are used both for baths and internally in cases of anæmia, neurasthenia, catarrhal affections of the organs of digestion and respiration. The *Kuranstalt* is equipped with modern appliances for the various hydrotherapeutic procedures. Season, June to October.

ACCOMMODATION.—There is a new *Trinkhalle* and some small hotels, and a number of lodging-houses. It is a quiet and cheap resort, but quite popular.

Edmund C. Wendt.

APOCODEINE is a reddish amorphous powder, almost insoluble in water, soluble in alcohol, ether, and chloroform. The hydrochlorate of apocodeine is a grayish amorphous powder, very soluble in water. It is obtained by heating hydrochlorate of codeine for fifteen minutes with a concentrated solution of chloride of zinc, at a temperature of 170° or 180° C. On cooling, a yellowish-brown mass separates from the liquid. This is drawn in thin, silk-like threads, and is almost pure hydrochlorate of apocodeine. The preparation is easy, and there is yielded a much greater product than the morphine salt; it is also much more stable. The base may be obtained by precipitating it from a solution by the addition of carbonate of sodium and extracting with ether.

The reaction of reagents upon apomorphine and apocodeine is almost identical, with the exception that the blood-red coloration produced by nitric acid is much more permanent with the latter.

This drug has recently been introduced as an expectorant and emetic. The dose is from $\frac{1}{10}$ to 1 grain. It is recommended in the treatment of chronic bronchitis, croup, whooping-cough, etc. A one or two per cent.

* Read symptomatic anthrax for sympathetic anthrax wherever this latter occurs in the article Schizomycetes. See this Handbook, vol. vi., p. 336, 2, eleventh line from the bottom.

† S. Kitasato: Zeitschrift für Hygiene, vol. vi., 1889, p. 105, Über den Rauschbrand-bacillus und sein Chlturverfahren.

‡ Ibid., vol. viii., 1890, p. 55.

solution may be prepared, and from five to ten minims administered. It acts rapidly, and the effect is prolonged. It may also be used hypodermically.

Beaumont Small.

ARISTOL is the registered trade name of dithymoldiiodide. It is prepared from thymol, $C_{10}H_{13}HO$, by substituting two molecules of iodoxyl, IO, for two of hydroxyl, HO. It contains forty-five per cent. of iodine. A moniodid and a triiodide have also been prepared. The latter has been called *annidalin*, and is used for the same purposes. Aristol may be made as follows: 1½ drachm each of thymol and caustic soda and 1½ drachm of potassium iodide are gently heated with enough distilled water to make 1 ounce 4½ drachms, and then cooled. This solution is added to eight ounces of a concentrated solution of hypochlorite of soda and agitated. The solution is then filtered and the precipitate washed with water and dried.

It is a light, reddish-brown powder, with a very faint odor, insoluble in water, slightly soluble in alcohol, soluble in ether, collodion, and oils. It should be carefully preserved, as it is decomposed by light and heat.

Therapeutically it is recommended for the same purposes as iodoform, but it is less active. Its advantages are that it is devoid of the disagreeable odor, and does not possess the toxic properties of the latter drug. It has been used in the treatment of eczema, psoriasis, scabies, chronic inflammation of the mucous membranes of the nose and pharynx, erosions of the os uteri, condylomata, granulating wounds, and ulcerating surfaces. It possesses the power of causing rapid cicatrization in a marked degree, and has proved of greatest service in the latter class of cases, particularly in the treatment of varicose ulcers. In lupus, tubercular and syphilitic ulcerations it was supposed to possess specific powers, but experience has not supported this view.

The powder is best applied by dusting on the part, or by insufflation; it may be used as an ointment, one part in ten, or dissolved in ether or collodion.

As it is partly eliminated through the lungs, it has been used in phthisis by hypodermic injections of a one per cent. solution in sterilized oil of sweet almonds. It is said to lessen the cough and night-sweats.

Beaumont Small.

ARSENICAL PARALYSIS.—Paralysis from arsenical poisoning has received little attention in treatises on nervous diseases. Most classical works on the subject do not even mention it. The most recent text-book on medicine, by Osler, gives it a short description. And yet this, though not the commonest symptom of arsenical poisoning, is not very rare. It was spoken of by Albani in the thirteenth century, and by others at an almost equally early period. Dana,[1] in giving the bibliography of this subject, cites more than one hundred articles published prior to 1887. Since Dana's publication I find about fifteen further articles, simply reports of cases, or more or less extensive dissertations on the subject. The absence of pathological data and the uncertain nosological position of the disease in part account for its apparent neglect. The last few years have partly removed these difficulties.

Etiology.—The largest number of cases of arsenical paralysis are due to acute poisoning, the poison being taken either by the mouth, designedly, or accidentally, or introduced into the system by external applications, as in the use of arsenical plaster. In all such cases the paralysis develops subsequently to the appearance of ordinary symptoms of acute arsenical poisoning. Paralysis from chronic arsenical poisoning is less frequent, but this statement must be accepted as applied to recognized arsenical paralysis, for doubtless many cases of chronic arsenical paralysis occur which are not recognized as such. The largest number of cases of paralysis from chronic poisoning are due to the internal administration of the drug. In some instances the quantity taken was quite small. Semple[2] reports the case of a boy of six, suffering with chorea, in whom, after the use of from three to ten drops of Fowler's solution three times a day for one month, there were brown pigmentation of the body, paralysis of the legs, chiefly of the toes and feet, with reaction of degeneration in the affected muscles and loss of the knee-jerks. Two months after the withdrawal of the drug the pigmentation had disappeared and the paralysis was better. A case of Hastings's,[3] who had taken three to five drops of Fowler's solution for some weeks, had burning pain in his feet and partial paralysis of the four extremities. A case of Hooper's[3] took five drops of Fowler's solution three times a day for six months. The drug was then discontinued on account of ophthalmia, but nevertheless the patient began to suffer with headaches and progressive paralysis, and died within a few months. Similar cases of paralysis following medicinal doses of arsenic have been reported by Jones,[3] Gaillard,[3] Dana,[1] and Ferguson.[4] These are the only cases in which I have found decided paralytic manifestations reported after the internal administration of medicinal doses, though less marked nervous disturbances are more common. It is noteworthy that in these instances such marked disturbances followed the administration of comparatively small quantities, whereas this remedy is so commonly used, often in large doses and for long periods, without toxic manifestations, and among the peasantry of Styria, who are accustomed to take arsenic regularly and continuously in quantities ordinarily toxic, no case of paralysis has been recorded. We are, therefore, justified in assuming that, in such instances, there is either some special predisposition to the symptoms manifested, or a special idiosyncrasy to the drug.* Other modes of chronic poisoning are from the external use of arsenic in salves, baths, etc., or contact with the poison as used in the arts and found in many fabrics employed in clothing, wall-paper, carpets, artificial flowers, etc. Barton[5] reports two cases, husband and wife, with almost typical histories of paralysis following acute poisoning — first the gastric symptoms, then pains and paralysis of the four extremities—where the man had for seven years been rubbing a mixture of four parts of arsenic to three parts of plaster-of-Paris into the skins of animals and birds, and the wife cleaned the room twice a week. Similar cases from dealing in stuffed birds, from working with arsenical draperies, or living in rooms where there were draperies or wall-paper containing arsenic, are recorded by Seeligmueller,[6] M'Clure,[7] Holm,[8] and Malmsten.[8]

Symptomatology.—The symptoms vary to some extent, according to the amount of arsenic taken and the manner of poisoning, that is, whether it were acute or chronic. But where well-marked paralyses have developed there is usually considerable uniformity in the clinical pictures presented. In cases of acute poisoning the paralytic manifestations appear shortly after the disappearance of the severe gastro-intestinal disturbance. Paralysis of twenty-four hours' duration immediately after the ingestion of the arsenic has been spoken of, but must be rare or escape detection. The onset of the paralysis occurs usually from several days to several weeks after the poison has been taken. It is commonly preceded by sensory symptoms, tingling, numbness, intense pains, etc. The paralysis itself begins more or less gradually. Not uncommonly its onset is not observed, but when the acute symptoms have subsided and the patient attempts to get out of bed it is found that he cannot walk or cannot hold anything in his hands. Occasionally the paralysis is complete, or at least no longer progressive, at an early period, but usually some weeks elapse before it has reached its greatest intensity. Almost always, when observed from the beginning, it has been found to commence at the distal ends of the extremities, the fingers and toes—usually first in the lower extremities,—and

* Jaccoud (Brissaud, Des Paralysies toxiques, 1887) says alcoholic excesses constitute one of the most active predisposing causes of arsenic poisoning, but in the study of the literature I have found no cases to substantiate this view. According to Putnam, while arsenic is usually eliminated in from twelve to twenty days, there are cases in which it is found months after it had been taken. Possibly it is this slow elimination that favors chronic poisoning from ordinary medicinal doses.

thence extends upward. The parts below the knees and elbows are most profoundly paralyzed. Some writers state that the paralysis does not extend above the knees and elbows, but, possibly, in all cases where the paralysis has been profound, other muscles, especially of the thighs, have been at least paretic. I shall report a case below where the legs were completely paralyzed and even the muscles of the trunk were affected. The extensor muscles—the radial group in the upper, and anterior tibial group in the lower, extremities—are as a rule most profoundly affected. When the paralysis is complete the paralyzed muscles are quite flaccid, and we find wrist-drop, foot-drop, etc. At a later period there are very frequently contractures, more or less strong, affecting particularly the least paralyzed muscles. Tremor, often fibrillary in character, is not infrequently observed in the affected muscles. The paralysis just described, affecting the four extremities, the lower more than the upper, is that usually found. In rare instances it is otherwise distributed; sometimes in hemiplegic, and more rarely in monoplegic form. In almost all instances there is a great loss of flesh, a general wasting, but in addition there is special and pronounced atrophy of the paralyzed muscles. The electrical reactions are those of peripheral paralysis. The reaction of degeneration—no muscular contraction when either current is applied to the nerves, or when the faradic current is applied to the muscles, contraction of the muscles, but a reversal of the normal formula, when the galvanic current is applied to them, that is, the anode closure contraction occurs more readily than the kathode closure contraction, and the resulting contractions are tardy, sluggish, not the quick, lightning-like contractions of normal muscles—becomes more or less pronounced a few days, or a few weeks, after the occurrence of the paralysis. At a later period, if the paralysis be profound, all electrical reactions may cease. In some instances slight changes in electrical reactions may be observed before there is any manifest paralysis, particularly that it requires a stronger faradic current than usual to produce muscular contractions. In lighter cases such electrical responses, especially in the anterior tibial group of muscles, may be the only indication of incipient paralysis.

The sensory symptoms are at times even more pronounced than the motor paralysis. These symptoms are paræsthesiæ of various kinds, tingling, numbness, "deadness," coldness, etc.; pains, tenderness, and anæsthesiæ. As a rule the tingling and numbness, and very frequently the pains, precede the paralysis. The pains are often intense and the most distressing element in the disease. They are usually described as burning, cutting, boring, etc., and are often accompanied by sudden starts, cramps, or spasmodic movements of many muscles of the body. They are usually more or less paroxysmal, and are likely to be worse at night and keep the patient awake. They occur most frequently in the feet and hands, sometimes appear to be in the joints or bones, and occasionally in the course of the nerves. Tenderness of the affected muscles is also a common and prominent symptom. The tenderness may be so great as to make the handling of the patient extremely painful, and, on account of the suffering produced, electrical examinations become very difficult. In some instances the tenderness is observed to be in the course of the nerves, but generally it is so diffused that it is hard to state that it is especially over the nerve-tracts. Often hyperæsthesia or hyperalgesia is observed, although this may be only an expression of the great tenderness. Loss of, or impaired sensation, anæsthesia, is also a common symptom. It is found most frequently in the feet and hands, and especially the finger-tips and toes or soles of the feet, although it corresponds somewhat to the extent of the motor paralysis. It has been found to follow the distribution of certain nerves. For instance, in a case of Seligmueller's it was limited in the upper extremities to the distribution of the median nerves. Probably in all cases where there is extensive paralysis, anæsthesia occurs, but it is likely to disappear much sooner than the paralysis, so that it may be reported as absent, when the patient is seen some time subsequent to the inception of the nervous symptoms. Sometimes there is only loss of cutaneous sensation—sensation of touch is impaired and the patient cannot feel things with his fingers, does not know that he is holding something in his hands, etc. With the loss of tactile sensation there is likely to be loss of the sensation of temperature and pain. Sometimes loss of muscular sense is very marked, the patient does not know the position of his limbs, etc. In all cases of marked paralysis, the patellar tendon reflex, if spoken of at all, was reported to be absent. It was also found to be absent, or lessened, when the paralytic manifestations were not very pronounced. When once lost, the knee-jerk is slow to return. Various vasomotor and trophic changes are common, as slight œdema, particularly of the feet, profuse perspiration, loss of the nails and hair, and desquamation of the epidermis. Not rarely there is a brownish pigmentation of the skin; even herpes zoster has been observed. Muscular atrophy has already been mentioned. The clinical picture would not be complete without the statement of some symptoms that are as invariably absent. That is, the cranial nerves are never affected, there is no decubitus, and the functions of the bladder are always found to be intact.*

As has already been stated, usually several days or several weeks elapse before the disease reaches its acme. Then, after an interval, which may be of only a few days' duration, but sometimes runs into months, the patient begins to improve. The anæsthesia almost always begins to disappear before the motor paralysis. It disappears in the reverse order of its appearance; first from the trunk and the upper part of the extremities, remaining longest in the fingers and toes. The motor paralysis disappears in the same manner—first in the upper part of the extremities, then in the muscles below the knees and elbows. The flexors usually improve more rapidly than the extensors, leaving the only motor symptoms manifested in slight cases, paralysis of the extensors of the feet and toes, and of the extensors and small muscles of the hand. At a late period there are liable to be contractures in the still paralyzed parts. The pains also become modified in intensity after the lapse of some time, but unfortunately they are likely to persist with a greater or less degree of severity throughout the whole course of the disease. The vaso-motor symptoms, œdema, pigmentation of the skin, etc., usually disappear at a comparatively early period. The whole duration of the disease is extremely variable. Alexander puts it as from eight days to a number of years. It may be stated in general that mild cases usually get well within six months, possibly in a few months, whereas in severe cases one or two years elapse before there is complete recovery, or, in those cases in which a cure remains incomplete, before there is a definite cessation of improvement.

Dana has described a form of arsenical paralysis as pseudo-tabes, in which ataxic manifestations are prominent. In a few cases the symptoms of motor incoördination are more prominent than those of paralysis, so that to these, as there are also sensory symptoms, the term pseudo-tabes seems quite appropriate. But ataxia is spoken of in many cases after the motor paralysis is beginning to disappear, when it is really the remains of the paralysis. In fact, a degree of paralysis has been, or is, present in all these cases of pseudo-tabes, distinguishing it in this respect from true tabes, but it may be in so far deserving of a special name as the motor incoördination may, in part at least, be due to sensory disturbances, impaired muscular sense, etc., which doubtless in part explain true ataxia.

The disease, as so far described, is that following acute arsenical poisoning. In some cases following chronic poisoning the symptoms are much the same, only the

* Optic neuritis is spoken of in two cases, that of Dana (Brain, January, 1887) and of DaCosta (Medical Times, 1881, p. 385). Putzel (Medical Record, June 2, 1888) merely mentions, without further detail, that he had seen a case of acute arsenical paralysis in which there was paralysis of the bladder and rectum.

onset is likely to be less sudden and the symptoms less profound. In other chronic cases the symptoms are very slow in appearing, and may have been in part masked by the symptoms of gastric irritation. The pains are likely to be proportionately greater, and the paralysis slight in degree. But, even when the paralysis is slight, the changes in the electrical reactions are likely to be found. In such instances the motor manifestations may be rather like those of ataxia than of paralysis. Sometimes a sense of profound prostration is the only indication of motor impairment.

There is another class of cases in which the poisoning appears to have been exceedingly slow and insidious, the symptoms usually very obscure, the cause arsenical wall-papers or the like. Among the symptoms in these instances are, gastro-intestinal irritation, neuralgia, headache, insomnia, general prostration, mental depression, impairment of memory and mental endurance, and epileptiform convulsions. As this article is devoted to arsenical paralysis no further attention will be here given to this class.

In order to illustrate the picture of arsenical paralysis, and inasmuch as such cases are comparatively rare, I shall give the history of two cases which have come under my own observation. The report of the first, of which I have few notes, will be necessarily fragmentary.

A drayman, seventeen years of age, on September 8, 1886, ate by mistake a piece of bread on which "Rough on Rats" had been spread. For four days he had acute gastro-intestinal symptoms, vomiting, prostration, etc. A few days afterward he was again driving his team, though he was feeling very weak. Between two and three weeks after the arsenic had been taken he observed that his legs were getting weak, and some time later the same condition was observed in the arms, though he worked for a week after these symptoms began to appear. Six weeks after the poisoning he was unable to walk alone; there was paralysis of muscles of the leg, especially of the dorsal extensors of the feet and toes, paralysis of the extensors of the fingers, and impaired cutaneous sensation in the same parts. He suffered with severe pains in the arms and legs, and there was excessive tenderness over the paralyzed muscles. He also complained of a sense of numbness and tingling in his extremities. His hands felt numb; he could not tell by the sense of touch that he had anything in his hands. Patellar tendon reflex absent on both sides. The paralyzed muscles did not respond to the faradic current. About a month later he had improved so much that he was able to walk without assistance. His own statement is that he began working nine months after he had been poisoned, but he thinks it was fully a year, or a year and a half, before he had regained his full strength. At present he is again acting as drayman, does heavy work, lifts heavy loads, showing a full restoration from the disease. Its only traces are that he becomes fatigued more easily than before the accident, and is somewhat constipated, which had not been his former habit.

The second case, a man, thirty-five years of age, contractor, on account of financial losses, took Paris green with suicidal intent. He suffered for several weeks with violent gastro-intestinal disturbance, and six days after the poisoning he became violently maniacal, and remained so for several days. It was observed when he got out of bed, several weeks after he had taken the poison, that he was weak on his legs, and that his hands trembled. One week before I saw him, which was seven weeks after the poisoning, he became bedridden on account of his inability to walk. He began suffering with severe pains in his arms and legs, even before the paralysis was observed. When I saw him, June 6, 1892, there was absolute paralysis of the feet and ankles, muscles flaccid, foot-drop, considerable weakness of the extensors and flexors of the knee, and some weakness, though less, in the hips. The upper extremities were quite paretic; fingers and hands almost paralyzed, pronation and supination very feeble, the flexors and extensors of the elbows also much weaker than normally, and the muscles of the shoulder slightly paretic.

There was more or less anæsthesia in the paralyzed parts, most profound in the legs. Over the latter firm pressure could not be felt, as far as the gluteal region. A pin-prick was recognized but was not painful. In the upper extremities anæsthesia was most pronounced in the hands and back of the forearms. There was considerable tremor of the fingers on attempted movement. Patellar tendon-reflex absent on both sides. All the muscles respond to the faradic current, but the left peroneal group requires a stronger current than normally. There was considerable tenderness over the left calf and over both crural nerves. He suffered intensely with pains, either burning or boring in character, sometimes feeling as though the limbs were in a vise, the pains being often attended with starts and spasmodic movements. The pains were worse at night and kept him awake. The muscles of the trunk seemed normal, and sensation was normal in the same part. No symptoms on the part of the cranial nerves, bladder, or rectum. The optic disks were normal.

June 17, 1892.—No power in the legs whatever. Paresis of the muscles of the trunk and slight anæsthesia. Upper extremities weaker than at last note. Some œdema of the right fingers. The pains appear to be worse and are often attended by spasms, opisthotonic in character. A great tenderness over all the paralyzed muscles and joints, movements of the joints excruciatingly painful. This tenderness makes the electrical examination very painful and difficult. Only the left peroneal group of muscles was examined. They do not respond to the faradic current; the anode closure contraction obtained before the kathode closure contraction.

June 28th.—Sensation decidedly better, pains and motor paralysis unchanged.

July 12th.—Sensation much improved. He has some power in the knees and hips, there is increased strength in the upper extremities, and the pains are less severe.

On the date of this writing, November 26th, a little over seven months after the date of the poisoning, cutaneous sensibility is normal, or nearly so, everywhere. The left arm and hand have almost regained their normal strength. In the right upper extremity the fingers, especially the extensors, are quite weak; muscles of the elbow have a fair amount of strength, though weaker than normal; those of the shoulder are more paretic than those of the elbow. In the lower extremities there is some power in the muscles of the hips and knees, but very slight, while the ankles and feet are still completely paralyzed, and the feet are held rather firmly in the position of talipes equinus. There is still a little tenderness about the right upper extremity, especially over the muscles of the hand, far more over the muscles of the legs, though the latter does not compare in intensity with what it was some months ago. The pains are also far less severe and less frequent. They are still worse at night, and often keep him awake.

Pathology.—Leyden in his classical work on "Diseases of the Spinal Cord," published in 1875, spoke of neuritis as the cause of arsenical paralysis. Subsequently a number of writers (DaCosta, Mills, Seguin) attributed it to myelitis. Of late years there has been a certain unanimity of opinion that neuritis is the real pathology, an opinion with some experimental and post-mortem observations to substantiate it; but quite recently in one case decided changes were found in the central nervous system, and it is yet to be seen to what extent the views on the subject will thereby be revolutionized.

The experimental investigations in this direction are not all in accord. Popow, experimenting upon dogs, produced acute or chronic poisoning by means of larger or smaller doses of arsenic, and found thereafter myelitis, especially of the anterior cornua. Kreyssig and Schulze, repeating Popow's experiment, did not find any pathological changes in the cord. Some control experiments, showing how easily methods of hardening and staining may give the appearance of morbid changes in nerve-tissues, lead them to infer that Popow's description was, chiefly, of such artificial products. More recently, Alexander experimented on rabbits. After pro-

ducing paralysis of the posterior extremities by means of arsenical poisoning, he found the cord to be normal, while there was extensive neuritis and primary disease of the muscles. He attributed the inflammation in muscles and nerves to the occlusion of innumerable capillaries, which he supposed were primarily attacked by the poison.

Two post-mortem examinations in man have been reported.* The first was a case of Ferguson's.[4] The patient, a consumptive, took for a lengthy period Fowler's solution, twenty to thirty drops three times a day, which had been recommended as a cure for consumption, and was not discontinued when diarrhœa and headache came on. When seen by Ferguson the face was brown and mottled, there was impairment of cutaneous and muscular sensation, tenderness and intense pain in the legs, extending to other parts of the body; the gait was paretic, the most marked paralysis being in the anterior tibial group of muscles, in which the reaction of degeneration could be obtained. She died shortly afterward of phthisis. At the post-mortem examination evidence of neuritis was found in many of the peripheral nerves—the nerve-sheaths and connective tissue swollen and infiltrated, the medullary sheaths and axis-cylinders broken up—as well as marked degeneration of the muscles. In the very brief report there is also a simple statement of disorganized cells being found in the cord. The second case, the one above referred to as possibly having a revolutionizing effect on the present views of the pathology of this condition, is one of Erlicke and Rybalkin's,[9] a man of fifty, who died twenty-six months after the arsenical poisoning. Shortly after the poisoning there was paralysis of the four extremities, and at the time of his death—due to a subsequent chronic lung disease—there were still paralysis and contractures in the hands and feet, attendant muscular atrophy, pains in the feet, and absent knee-jerks. The post-mortem revealed distinct changes in the anterior cornua throughout the cord—the morbid appearances not extending above the pyramidal crossing—especially in the cervical and lumbar enlargements, affecting both the nerve-cells and the fine net-work of fibres. There was a great reduction in the number of cells, both in the anterior cornua and in the area between the anterior and posterior cornua. The cells remaining were not normal, their protoplasm was altered, and they were either rounded in outline, reduced in size, had fewer processes, or were without nuclei. Some cells had vacuoles in them, others contained leucocytes. The nerve net-work in the anterior cornuæ was mostly replaced by fine neuroglia. Of the nerves, only the radial and perineal were examined, and presented distinct evidence of neuritis. The nerves were found to contain normal and degenerated fibres, as well as regenerated ones. The authors conclude that there was a chronic pathological process in both cord and nerves, and that it began about the same time in each. They suppose that the cause was, not the entrance of the poison into the cells, but the changes produced by the arsenic in the circulation and the blood.

The clinical manifestations of arsenical paralysis, and it is chiefly upon these that the views of its pathology have hitherto been based,† point strongly to neuritis as the basis of the paralysis. The paralysis, evidently of a peripheral character, with rapid development of atrophy, and the reaction of degeneration, as well as the sensory symptoms, are very easily explained by neuritis. It is true that a poliomyelitis produces the same kind of paralysis, but the sensory disturbances cannot be explained by poliomyelitis and scarcely by a more diffuse myelitis. The full restoration to health, as occurs in most instances, is altogether at variance with such an explanation, and the invariable absence of paralysis of the bladder and decubitus, symptoms so common in extensive myelitis, is strong evidence that myelitis does not account for the symptoms. Furthermore, the occasional impairment of a single nerve, as anæsthesia limited to the area supplied by the median nerve, and the presence of herpes zoster, are proofs that neuritis must be present in such instances. In the foregoing is sufficient proof that there must be neuritis in these cases, but it does not follow that we have only neuritis. The post-mortem mentioned, as well as some clinical data, indicates that there are, sometimes, at least, also changes in the cord, myelitis. The clinical manifestations force the belief that neuritis is the chief and most extensive pathological condition, and largely the cause of the symptoms, but, it is not improbable that in those cases where there is permanent paralysis there has been more extensive myelitis, which in itself has produced many, if not most, of the symptoms. In the case of Erlicke and Rybalkin, with such extensive changes in the cord, the permanent paralysis was greater than in any other case I have seen reported. In some cases of chronic neuritis it is probable that the latter is due to changes in the trophic centres of the cord, and, possibly, a similar relationship exists in many cases of multiple neuritis. As arsenical paralysis sets in, as a rule, a few weeks after the poisoning, and both the post-mortem examination of Popow above given, and the frequent occurrence of delirium soon after the poisoning, indicate that the central nervous system may be affected at a much earlier period, the thought occurs that the extensive neuritis in these cases may be really due to prior and slighter changes in the cord. With this view, morbid changes in the cord would be the rule, but they would, usually, be slight and their effects transitory. But it is more probable that so far as the two conditions, neuritis and myelitis, occur together, they are independent of one another, and each due to the circulatory and blood disturbances produced by the arsenic.

We may then summarize the foregoing by saying that neuritis is the chief pathological condition producing arsenical paralysis, that where there is permanent paralysis there is more or less extensive myelitis, while in curable cases, if myelitis be at all present, it must be of a mild grade.

Diagnosis.—When it is known that the patient was poisoned with arsenic, as is usual in acute cases, the cause of the resulting paralysis is apparent. When there is no such knowledge the history of severe acute gastro-intestinal disturbance preceding the kind of paralysis just depicted should be almost enough to make the diagnosis certain. The picture of the paralysis is almost characteristic: the four extremities usually affected—the lower more frequently and more extensively,—the paralysis being always greatest in the digital extremities and attended by atrophy and altered electrical reactions, the absent knee-jerks, the intense pain and extreme tenderness, and the absence of bladder symptoms and decubitus.

When the paralysis is less marked, and the whole array of symptoms less conclusive, the greater prominence of the sensory symptoms and the presence of altered electrical reactions in the slightly paralyzed muscles—in this instance it requires a very careful examination to reveal such reactions—may arouse a suspicion of the true condition.

The cases with ataxic gait may resemble locomotor ataxia, and Seeligmueller mentions a case of his own which was falsely looked upon as one of locomotor ataxia. The severe pains and lost knee-jerks heighten the resemblances of the two diseases. But with careful examination such errors will rarely occur, for it will usually be found that the difficult gait is rather paretic than ataxic, and, furthermore, symptoms on the part of the bladder and the eyes, such common and early manifestations in locomotor ataxia, are absent.

* A case of Popow's (Virchow's Archiv, cxii., 2) should be mentioned, though not strictly belonging here, as the man died thirty-two hours after the poisoning. The vessels of the cord were distended, there were numerous smaller or larger hemorrhages into the cord, and, in some parts, plastic exudation, the changes being chiefly in the cervical and dorsal regions, especially their central parts. Some cells were clouded, their nuclei indistinguishable, and were nearly or altogether without processes.

† The similarity of the clinical picture to that of alcoholic neuritis has also furnished a strong ground for pronouncing this neuritis. But it has recently been denied that all the lesions in alcoholic paralysis are peripheral ones.

In cases of chronic poisoning the detection of arsenic in the urine may assist materially in diagnosis. In acute cases the arsenic has usually been eliminated before or soon after the paralysis appeared.

PROGNOSIS.—Mild cases may get well in a few months, though rarely less than six, but when there has been profound paralysis recovery cannot be expected in less than one or two years.

The prognosis is always favorable in so far that most cases recover, and all, if they survive, improve very much, but there is prevalent a too favorable opinion of the curability of the disease. For instance, Dana says almost all cases recover. I have carefully examined all the reports of cases made in recent years; twenty-two in number. Of these, two died, two recovered, and the other eighteen were still uncured at the time of the reports, from two months to several years after the inception of the paralysis. It may be assumed that of those reported at an early period most, or all, recovered. But a number were reported after more than a year had elapsed, and in four cases—those of Putzel,[11] Peterson,[10] Erlicke and Rybalkin[9]—after a lapse of two years or more, paralysis, more or less extensive, remained, indicating permanent impairment.

If we can draw any conclusions from such small numbers we may say that in twenty per cent. of the cases, or more, there will not be full restoration to health. I have already ventured the opinion that in the latter cases myelitis is present.

TREATMENT.—The first object must be to eliminate the arsenic from the system as rapidly as possible, for which purpose iodide of potassium seems to promise most, and has been almost universally used in such cases. Only moderate doses are indicated. Leyden suggests warm and sulphur baths. For the pains, often excruciating, opium or morphia is demanded.

Further than this the indications are, the toning of the general system—for poor nutrition and great prostration are rarely missing—by careful feeding, strychnia, iron, and the direct treatment of the paralysis by electricity, massage, counter-irritation, etc. It can scarcely be doubted that in the most cases the tendency is to recovery, and the patient gets well quite irrespective of treatment.

Philip Zenner.

[1] Brain, January, 1887.
[2] The Lancet, June 14, 1887.
[3] Quoted by Putnam, Boston Medical and Surgical Journal, July 5, 1888.
[4] Canada Medical and Surgical Journal, July, 1887.
[5] The Lancet, July 19, 1890.
[6] Deut. Med. Wochensch., 1881, p. 217.
[7] The Lancet, June 22, 1889.
[8] Quoted by Seeligmueller.
[9] Archiv f. Psych. ü Nervenkr., xxiii., p. 861.
[10] Medical Record, August 4, 1888, and personal communication.
[11] Medical Record, June 2, 1888.

ARTHRITIS DEFORMANS. In the differential diagnosis it is important to keep in mind that this disease, beginning its destructive work with the articular cartilage, and progressing without suppuration, will lead to gradual but very considerable diminution of the articulating surfaces, and to osseous proliferation with excrescences at the periphery of the joint. The form and shape of the affected joint, particularly of the caput femoris, will consequently be considerably altered, flattened sometimes like a mushroom, but the mobility is generally not abolished, and anchylosis, as we see it in certain cases of chronic rheumatism, does not occur. While at the commencement of the disease it will often be difficult to distinguish the same from chronic rheumatism, a correct diagnosis will be obtainable later on. Arthritis urica, real gout, which produces alterations of the small joints of the hands and feet, similar to those made by arthritis deformans, has its periodical, often intensely painful, paroxysms, quite different from the mild exacerbations of arthritis deformans.

Aside from the great value of prolonged and often repeated plain warm baths at home, or in thermal watering places, in the general management of the disorder, steam-baths, steam-douches, sulphur- and mud-baths may also be used. In overcoming or correcting and improving contractures and false positions, and relative immobility of the joints, it is well to employ massage and mechanico-therapeutics, the action of which may again be supported and maintained by orthopedic apparatus. Intercurrent exacerbations are to be treated by mild antiphlogistics and counter-irritants. In extreme cases of deformity the question of surgical interference, *i.e.*, resection of joint, might come up, but there is not as yet sufficient experience to serve as a guide in that direction.

Leonard Weber.

ARTIFICIAL FEEDING OF INFANTS. During the past few years the subject of the artificial feeding of infants has still claimed much attention from the profession, both in Europe and in this country, and several distinct advances may be noted. The various lines of investigation mentioned in my previous article, Vol. VIII., had made us aware of many of the difficulties which lay in the way of obtaining a perfect substitute for mother's milk. Cow's milk, or some preparation of it, was universally regarded as the only efficient basis for a good working substitute, and it was hoped that the difficulties, which had previously been encountered in its administration, could now be overcome. At the date of the previous paper the situation might be briefly stated as follows:

1. Our more definite knowledge of the chemical composition of the two milks enabled us to alter the substitute so as to render it the chemical analogue of mother's milk.

2. By means of the process of sterilization at the temperature of 212° F., we were able to secure a practically sterile food, and thus to avoid the introduction of myriads of bacteria, with all their poisonous possibilities, into the infant's stomach.

3. Our more exact knowledge of the capacity of the infant's stomach enabled us to regulate the proper amount of food to be given at a time, and thus to guard against the evils of over-feeding.

Thus, theoretically, we appeared to be able to supply the infant with an ideal food, a close approximation in chemical composition to mother's milk, absolutely sterile, in proper amounts, and at sufficient intervals to insure due digestion and nutrition. In practice these measures, carefully carried out, yielded gratifying results in some cases, but in many others hopes were disappointed. Among those reporting results we may mention Dr. Koplik,[1] of New York, who, with a large experience among dispensary patients, found milk thus prepared and sterilized of distinct benefit in acute cases, but was disappointed with the results obtained in chronic cases of gastro-intestinal disease. Dr. Davis,[2] of Philadelphia, found nutrition under its use distinctly fail. Corroborating this clinical experience were the results obtained by Dr. Leeds[3] from investigations in the laboratory on the changes produced in milk by the prolonged heat necessitated by this absolute sterilization. His results were stated as follows:

1. The starch-liquefying ferment, galactozymase, which exists in normal cow's milk in minute quantities, is destroyed when the heat rises much above 165° F. (75° C.).

2. A portion of the lactalbumin is coagulated, thickening the milk and intensifying its colloidal properties.

3. The casein, after the action of the prolonged heat, is less readily coagulated by rennet, and yields only slowly and imperfectly to the action of pepsin and pancreatin.

4. The fat-globules are injuriously affected by this heat. The fat, to some extent, is freed, and, after standing, small lumps of butter-fat are sometimes observed on the surface of the milk; while the portion not freed has a decidedly lessened tendency to coalesce. This is possibly owing to the coagulated proteid matters attaching themselves to the minute fat-globules, thus preventing their coalescence. It was also found that when sterilized and unsterilized portions of milk were churned, and a note made of the time required to form appreciable

amounts of butter, the unsterilized yielded a larger amount in considerably less time than the sterilized.

5. Milk-sugar by long-continued heating is completely destroyed; that it undergoes some change during the process of sterilization, is shown by a lessened dextro-rotatory power.

It would appear, therefore, that milk sterilized for any prolonged period at a temperature of 212° F. must be regarded as distinctly less readily and less perfectly digestible than raw milk. The destruction of the galactozymase, the coagulation of the lactalbumin, and the alteration of the casein, so that it becomes more slowly acted on by rennet, all presumably diminish its digestibility by the gastric juice of the infant; while the changes in the fat-globules can be shown to interfere to a large extent with their digestion and assimilation.

The question arose, therefore, whether it was not possible to avoid the disadvantages of this prolonged and absolute sterilization, and yet obtain a practically sterile food, the importance of having such being recognized on all sides. This was answered in the affirmative by Dr. Leeds. He found that milk rendered feebly alkaline, and heated, as soon as received in the morning, to a temperature of about 155° F. (somewhat short of the degree of heat necessary to coagulate the galactozymase) is rendered practically sterile. "It is evident," he says, "in the first place, that no milk having an acid reaction is in a proper condition to be heated, because of the effect of acidity upon coagulation, and inasmuch as cow's milk, as delivered to consumers, has usually developed a notable acidity, the addition of the requisite amount of a suitable alkali is the first point to be considered."

By experiments he found that to neutralize this acidity it required about 2½ grains sodium carbonate, or 9 drachms ordinary lime-water, to the pint of milk. Even this appeared to limit the development of some of the bacteria. Dr. Leeds says: "On making gelatine-peptone cultures, one drop of the original milk yielded 400 colonies of bacteria after five days' culture at common temperatures, while the same milk rendered feebly alkaline with lime-water yielded only 230 colonies. In some other experiments that he quotes the result was even more striking. After the milk was thus rendered slightly alkaline he tried the effects of lower temperatures. It was found that such milk maintained at a temperature of 155° F. (68° C.) for an hour proved practically sterile. Shorter periods were then tried, and an equally good result was obtained at the end of twenty minutes (only one to two colonies per drop). On cooling and diffusing the cream, which the heating had brought to the surface, the appearance and properties of the milk thus heated and prepared in nowise differed noticeably from raw milk.

A difficulty arises in securing the proper amount of heat, if we are to have this degree of sterilization carried on in the household. At my suggestion, a series of experiments were made with milk contained in glass flasks and heated in an Arnold sterilizer. It was found that with the water in the sterilizer and the milk in the flasks at ordinary temperatures, on placing the sterilizer over an ordinary Bunsen gas-burner it took about twelve minutes for the milk in the flask to reach the temperature of 155° F. If now the gas be turned out, and the milk be left in the sterilizer for another ten minutes and then removed to a cool place, all the sterilization necessary will have been effected and none of the deleterious changes will have taken place.

More lately, however, Dr. Freeman,[4] of New York, has devised a very simple apparatus, by which the milk to be sterilized is immersed in water at the boiling-point, the amounts being so proportioned that as the temperature of the water is lowered the milk is raised to the necessary heat of 165° F. The apparatus consists of two parts, a pail for the water and a tray containing a set of zinc cylinders which are to hold the bottles of milk. The pail is a simple tin pail with a cover. On its side is a groove indicating the level up to which it is to be filled with water. The tray is made in two sizes; one which will hold ten six-ounce bottles, the other seven eight-ounce bottles. The first is suitable for infants below six months of age, the second for those older. The pail is filled with water up to the groove, and placed on the stove to boil. The bottles are filled with milk and stoppered with a pledget of cotton, and then dropped into their places in the cylinders. Sufficient water is now poured into each cylinder to surround the body of the bottle. This is necessary for the conduction of the heat. When the water in the pail boils briskly, it is taken off the stove, and placed on a mat or table; the lid is removed, the tray containing the bottles of milk is placed inside and the lid replaced. The whole is allowed to stand half an hour, after which the bottles of milk are to be taken out and cooled rapidly, either by placing them on ice in a refrigerator, or by standing them in cold or ice water, which should be changed occasionally as it becomes heated. Milk thus prepared shows no change for several days.

Mr. Dyer, a pharmaceutical chemist in this city, has made a sterilizer for me, according to these instructions, and, after careful experimentation to obtain the correct size, has furnished me with the following dimensions: The tin pail should be 8¾ inches deep, 10½ inches in diameter, 5¼ inches to water-line. The zinc cylinders should be 6½ inches deep, 2⅝ inches in diameter. There are seven cylinders in the tray; the bottles of milk hold eight ounces each. With the milk and the water in the zinc cylinders at a temperature of 65° F., the following is the memorandum of the temperatures obtained in this apparatus:

In ten minutes the milk in the bottle reached the average temperature of 164° F.; in twenty minutes, 166° F.; in thirty minutes, 164° F.; in forty minutes, 161° F.; in fifty minutes, 158° F.; in sixty minutes, 154° F.

Dr. Freeman in his paper says, "I have made a series of experiments at the Bacteriological Laboratory of the College of Physicians and Surgeons, to test the efficiency of this apparatus in the pasteurization of milk. Specimens of milk obtained from different sources and at different times have been examined to determine the number of bacteria contained in one cubic centimetre before and after pasteurization. And while the raw milk used contained from 8,000 to 230,000 to each cubic centimetre, the same milk after this pasteurization practically contained none." This process he finds quite sufficient to destroy most of the ordinary bacilli found in milk, and tubercle bacilli. He quotes Van Gruns as stating that it also kills the typhoid bacillus, the cholera bacillus, and the pneumococcus of Friedländer. It does not appear in any way to affect the milk.

Dr. Rotch,[5] of Boston, has reduced the artificial feeding of infants to a still more exact system. As the result of much clinical experience he concludes that slight changes in the percentages of the three elements of milk of which we have the most accurate knowledge, namely, the fat, sugar, and albuminoids, are of real practical value in managing the digestion and nutrition of the infant.

Infants, like adults, require special modification in their food to suit the particular digestion of the individual. To prove this he presented the analyses of several human milks. In these analyses the fat, sugar, and albuminoids varied to a marked degree, and yet the infants all digested and throve well on their special percentage, while what agreed with one produced at times serious symptoms in another. He considered, therefore, that, so far as milk is counted upon as a food, it should be understood as a general name for a composite meal, the special ingredients of which should be modified to suit the digestion of the individual infant. To obtain this possibility Dr. Rotch established a milk laboratory where physicians could send prescriptions for milk of a definite formula, and have them dispensed accurately. The milk used in this laboratory is obtained from a herd of cows, of special breed, and so systematically fed that the analysis of their milk is of almost unvarying percentage. The morning milk of these cows, milked into glass, and kept scrupulously clean, is rapidly cooled, and is delivered at an early hour at the laboratory. Here, by means of a separator, a stable sixteen per cent. cream is

separated from the milk. The amount of albuminoids in the separated milk is known, and by means of a sugar-of-milk solution of definite strength, the amount of the sugar is carefully adjusted. As the chemistry of the mineral matter in woman's milk is little known, for the present that element is ignored. In writing a prescription, therefore, the three average percentages, namely, those of the fat, sugar, and albuminoids—4, 7, and 1.50—have only to be remembered, and starting with these figures any of the ingredients can be increased or decreased according to the need of the special infant.

In dispensing the prescription, the superintendent of the laboratory from the above materials is able, by a comparatively simple calculation, to dispense a milk containing the exact proportions ordered. The quantity required for each feeding is placed in bottles corresponding in number to the number of times that the infant is to be fed in the twenty-four hours. The day's food, each feeding in its own bottle, is then placed in a basket, or suitable receptacle, and sterilized for half an hour at a temperature of 167° F. It is then ready to be sent out to the infant. When the time for feeding arrives, the nurse takes a bottle from the basket, warms it, replaces the stopper by a suitable nipple, and gives it to the infant.

The following are given by Dr. Rotch as examples of suitable prescriptions for infants at varying ages, and under varying conditions:

1. For a healthy baby, four months old and normal weight, milk to be of following composition:

Fat	4.0
Milk-sugar	7.0
Albuminoids	1.0

Send six tubes, each four ounces, with lime-water one-twentieth. To be sterilized at 167° F., for twenty minutes. Feed every three hours.

2. For the same baby sick, albuminoid digestion weak, as evinced by vomiting, colic, and curds seen in the dejections, milk of following composition:

Fat	3.0
Milk-sugar	6.0
Albuminoids	0.50

Send eight tubes, each containing three ounces, with lime-water one-tenth. Sterilize as above. Feed every three hours.

3. For an infant six months old in whom the sugar digestion is weak, milk of following composition:

Fat	3.0
Milk-sugar	4.0
Albuminoids	2.0

Send six tubes, each containing six ounces, with lime-water one-twentieth. Sterilize as before. Feed every three hours and a half.

4. For an infant twelve months old with duodenal jaundice, milk of following composition:

Fat	0.50
Milk-sugar	5.00
Albuminoids	4.00

Send five tubes, each containing eight ounces, with lime-water one-eighth. Sterilize as above. Feed every four hours.

The exact capacity of the infant stomach, as regulating the quantity of food to be allowed at each time of feeding, is a matter of much importance. At the meeting of the American Pediatric Society in 1890, Dr. L. Emmett Holt[6] read a paper on this subject, in which he gave the result of his observations at one hundred and forty-two autopsies. Very careful precautions were taken to insure as accurate data as possible. The measurements obtained in ninety-one cases he tabulates as follows; the others, most of them his earlier cases, being discarded on account of imperfections in the methods employed:—

Table showing Average Capacity of the Stomach in Ninety-one Cases.

Age.	Number of cases.	Average capacity.	
		Ounces.	
Birth	5	1.2	
Half month	7	1.5	
One month	4	2.0	
One and a half month	11	2.27	
Two months	4	3.37	
Two and a half months	2	4.25	
Three months	6	4.50	
Three and a half months	3	5.00	
Four months	4	5.62	= 5 average.
Four and a half months	5	4.50	
Five months	4	5.62	
Five and a half months	2	5.25	= 5.75 average.
Six months	8	5.94	
Seven months	6	7.00	
Eight months	3	6.66	= 6.88 average.
Nine months	—	—	
Ten months	5	8.40	
Eleven months	2	7.50	= 8.14 average.
Twelve months	1	9.00	
Thirteen months	4	8.75	= 8.9 average.
Fourteen months	5	9.00	

These facts he summarizes as follows:

1. A very general correspondence between the age and capacity of the stomach is clearly shown.

2. Starting at birth with a capacity of about one ounce, the stomach increases in size, at the rate of one ounce a month during the first three months, reaching at this time about one-half the capacity seen at one year.

3. From three to eight months its growth is much slower, being on an average half an ounce a month.

4. From eight to fourteen months the rate of growth is still less, being on an average about one-third of an ounce a month.

These statements of course express only averages, and it is to be expected that unusually large, or unusually small, children will be either a little above or a little below these figures. Dilatation of the stomach in healthy infants appears to take place readily.

We may safely infer that the amount of food to be given at a single feeding should not much exceed the capacity of the average stomach at that age, as it does not seem at all likely that any considerable portion of the food leaves the stomach during the few minutes that elapse while the infant is feeding. Dr. Holt also found by experiment with stomach-washing that in infants of one or two months, with apparently good digestion, two hours usually elapsed before all the milk left the stomach; in infants of five to eight months, the time required was generally about three hours. It is evident, therefore, that no feeding should be repeated short of these periods, and it is better in most instances to allow a short interval of rest. *A. D. Blackader.*

[1] New York Medical Journal, January 31, 1891.
[2] Am. Journal of the Medical Sciences, June, 1891.
[3] Ibid., June, 1891.
[4] New York Medical Record, July 2, 1892.
[5] Trans. Am. Pediatric Society, 1892.
[6] Ibid., 1890.

ARTIFICIAL IMMUNITY. In the study of immunity from infectious diseases two questions present themselves, viz.: How to explain natural or racial immunity on the one hand, and acquired or individual immunity on the other. In the first place, how is it that in some cases a whole race of animals enjoys immunity from a disease which kills other animals; why is it that certain human races are exempt, or nearly so, from diseases which carry off thousands of individuals of other races? In the second place, how is it that susceptible individuals on recovery from an attack often acquire immunity from a disease? It is clear that where animals are exposed alike to infection, those which do not take the disease must have a natural or acquired power of resisting the attacks of the micro-organisms, and the problem is to find out wherein this power lies. In times of an epidemic the micro-organisms of a disease must surely find

entrance into insusceptible as well as susceptible races of animals or individuals of the same race, in one case doing no harm and in the other producing disease. Why do they find unfavorable conditions for their growth in one case and not in the other? How does the immune race differ from other races, and the immune individual from susceptible individuals?

Two explanations have been offered for the first of these questions, but neither of them has been generally accepted as sufficient. One of these is advocated by Metchnikoff, and bears the name of Metchnikoff's phagocyte theory. According to this theory the white corpuscles of the blood eat up the bacteria, and in animals which have no blood the cells of the connective tissue destroy the bacteria. Metchnikoff [1] bases his theory upon a large number of experiments with different micro-organisms on a great variety of animals. He found that in sponges, mollusks, daphniæ, and earthworms, also in frogs, and in rabbits and other mammalia, the introduction of small foreign bodies, such as carmine granules, or bacteria, was followed by a massing together of the cells, and that these cells either take up the foreign bodies, or surround them. He also verified the observation often made previously, that destructible foreign bodies become dissolved and disappear in the interior of the cells which have taken them up. This theory has attracted a great deal of attention, but has been shown to be inadequate. As pointed out by Ziegler and others the cause of the massing of leucocytes about a foreign body is not due to an intentionally defensive attitude on the part of the animal tissues. Certain substances have the power of attracting leucocytes by so-called chemotaxis,[2] and any foreign bodies which happen to lie in the path of the wandering leucocytes are taken up by these, and may be assimilated. The chemical and physical characters of the tissues and juices determine the direction in which the leucocytes wander, and if the leucocytes are not actively attracted in one direction they wander in the direction of the least resistance. If they are repelled or lamed by the chemical character of a foreign body, they are actually driven away or remain stationary instead of grouping themselves around the foreign body. The idea of an active warfare between bacteria and leucocytes, *i.e.*, phagocytes, must therefore be abandoned. Phagocytosis is a frequent but not characteristic partial phenomenon of inflammatory processes, and not always has the same significance. In some cases phagocytosis results in the destruction of foreign bodies, such as bacteria. In other cases it results in the spreading of the disease to different parts of the body, as in leprosy and mouse septicæmia, where the bacilli grow specially well in the leucocytes, and become subsequently liberated. Phagocytosis must consequently be regarded as merely an incidental process which is often useful, but not always so.

The germicidal properties of the serum of the blood devoid of the cells has also been offered as an explanation of natural immunity. Nuttall, v. Fodor, Buchner, and others have demonstrated the powerful germicidal properties of extra-vascular blood-serum, and there is every reason to believe that the serum in the animal has the same power. This is a most important discovery, but it does not suffice to explain immunity. If natural immunity were to be explained in this way, it is evident that the blood-serum of the immune animals should possess germicidal properties, and the blood-serum from susceptible animals should be devoid of these properties; animals should be immune just in proportion to the degree of the germicidal power possessed by the blood-serum. Such, however, is not always the case. The blood-serum of a susceptible animal often has as much germicidal value as serum from an immune animal. This property of the blood varies, it is true, and in some cases there does seem to be a direct proportion between the extent to which the blood-serum possesses the power of killing the bacteria on the one hand and the degree of immunity on the other.

It is evident from the foregoing that natural immunity is at best but imperfectly understood. On the other hand, artificial or acquired immunity from certain diseases has recently been made the subject of a great amount of experimental research, and many important facts in regard to it have been established.

It is now known that in this kind of immunity the fluid portion of the blood, the blood-serum, acquires the power of neutralizing the disease-producing property of certain micro-organisms. This power of the serum of the blood is acquired on inoculating with cultures of the micro-organisms treated in a special manner beforehand, the details of which are given below. Blood-serum which has acquired this power not only protects the animal in which it is formed, but it also protects or cures other animals when drawn and injected into these. The protective property lies in the serum of the blood and not in the corpuscles.

Immunity that has been conferred in the manner referred to above is also transmitted to the offspring by the mother. Such offspring not only acquire a certain amount of immunity while in utero, but they derive a still larger amount from the mother's milk.

The establishment of these facts is largely due to the investigations of Brieger, Kitasato, and Wassermann, working together, of Behring and his colaborateurs, and Ehrlich. The first of these, Brieger, Kitasato, and Wassermann, emphasize the distinction between infection and intoxication as first made by Koch. Whether the distinction can be sharply drawn in all cases or not, it is important for the understanding of their work to know just what is meant by these terms. The definition below is essentially that given by these authors.

In infection the micro-organisms of a disease gain entrance into the body of a susceptible animal, it may be in very small numbers, and spread and multiply through all the tissues and organs of the animal, plugging up capillaries, depriving the parts of oxygen, and offering a mechanical hindrance to the functions of life. In intoxication the micro-organisms when inoculated in small quantities often produce no disease; they tend to remain more or less confined to one part of the body, their seat of multiplication is localized; they often do not spread to other parts, and are sometimes incapable of growing except on certain tissues; but once having formed a focus they produce a poison which is the cause of the disease. There are two kinds of these poisons found in cultures of bacteria, viz.: ptomaïnes and toxalbumins. The ptomaïnes are crystalline alkaloidal bodies; the toxalbumins are colloidal. The former were obtained first by Brieger, the latter by Brieger and Fraenkel working together, and appear to be the disease-producing constituents of pathogenic cultures. Animals inoculated with them alone show the same symptoms as animals inoculated with ordinary cultures.

The micro-organisms of anthrax produce a typically infectious disease. They find entrance into the body, possibly in very small numbers and only at one minute spot, but if the animal is susceptible they rapidly spread to all parts, so that in one day or less they can be found with the microscope in the smallest drop of blood drawn from any part of the body, and from the smallest bit of any of the soft tissues. The organisms of tetanus, typhoid fever, diphtheria, and cholera, are examples of the bacteria which produce intoxication. They set up a local disease at first, but sooner or later produce specific poisons which cause general intoxication. They are sometimes found in parts of the body remote from the point of original infection, it is true, but not in sufficient numbers or so widespread as to account for the general symptoms of the disease, and moreover, the symptoms are those of profound intoxication. In tetanus the local trouble is often very insignificant and the number of tetanus bacilli, even at the point of infection, surprisingly small, often disappearing entirely before the death of the animal. In diphtheria the bacilli are usually confined to the throat, though they have been found distributed through the blood in other regions of the body. Typhoid fever bacilli are found in the spleen and blood, but are found most extensively in the ulcers of the large intestines. Cholera bacilli are found for the

most part exclusively in the intestines, but occasionally also in the stomach. The bacteria of these diseases are therefore seen to have a tendency to remain localized. The general symptoms are brought about by poisonous products which these bacteria produce. It is not even necessary that these bacteria themselves shall be introduced to produce any of the diseases in question artificially. They may be grown outside the body and their products alone successfully used to produce disease; the bacteria themselves may be killed or entirely removed from such cultures, and still the substance which remains will produce the disease. From the above enumeration of these diseases it is clear that the production of immunity from them is of prime importance in human medicine, and it is precisely in these diseases that recent experiments give the best hope of early practical results.

This difference between infection and intoxication has made it necessary to discriminate between immunity from infection and immunity from intoxication, and for immunity from intoxication the very appropriate term "giftfest," poison-proof, has been introduced. If the micro-organisms of a strictly infectious disease are incapable of increasing in the tissues of any given animal this animal has immunity from the disease in question. Not so with the strictly toxic diseases; for the micro-organisms of these may be incapable of growing in the tissues of an animal, but their toxic products contained in a culture may still be poisonous for this same animal. The animal may acquire the power of preventing the growth of toxic organisms in its tissues, yet be unable to resist the toxic albumin produced outside of its body in cultures. Such an animal resists the inoculation of small amounts of a culture, because the micro-organisms are unable to grow and produce the poison, and there is too little of the ready-formed poison in the small amount of the culture introduced to produce disease. If larger amounts of the culture are introduced, so that enough of the poison already formed is present, the animal dies with all the symptoms of the disease. The animal is not poison-proof, though it may be, strictly speaking, immune from ordinary infection with the micro-organism. But, on the other hand, an animal may be made to resist the poisonous products of a given micro-organism, and still allow the micro-organism itself to grow in its tissues. The animal is poison-proof against the toxic products of the micro-organism in question; the micro-organism has become harmless, or nearly harmless, for this particular animal, and can produce at most slight local trouble, but can no longer exert any general specific action. Consequently, in the artificial production of immunity the object to be attained with infectious diseases is to make the animal incapable of supporting the life of the micro-organisms in its tissues. The object in the toxic diseases is to make the animal capable of withstanding otherwise fatal amounts of the toxalbumins; in other words, to make the animal poison-proof.

The procedure for the production of artificial immunity from the strictly infectious diseases is essentially the same in all cases. It consists in inoculating with attenuated cultures—*i.e.*, with cultures of micro-organisms of weakened pathogenic power—and gradually passing on to cultures of increased virulence, finally using cultures of full strength. Several methods for the attenuation of the virulence of a culture are employed. One method, the practical efficacy of which is doubtful, is to pass the micro-organism through animals of slight natural susceptibility. Pasteur advocated this method to produce immunity in hogs from the so-called swine erysipelas. He found that by inoculating from rabbit to rabbit the virulence of the micro-organisms of this disease increases for rabbits, but, on the contrary, decreases for hogs. Inoculations of the bacilli of hog erysipelas, which have thus been "acclimated" to rabbits, produce slight sickness in hogs, and, after recovery, these animals resist inoculations of cultures of full virulence for about a year.

Other methods of decreasing the virulence of pathogenic micro-organisms are the use of certain chemicals, and of heat, on the cultures. In general, it holds true that all agencies which are injurious to the micro-organisms, if allowed to act for a short time, or if used in relatively small quantities, will produce attenuation. Carbolic acid, in the strength of 1 to 600, deprives anthrax cultures of all virulence without killing the organism if allowed to act on the cultures twenty-four days. Bichromate of potassium, if used in solution of 1 to 1,700 of water, kills anthrax bacilli; if used in more dilute solution, 1 to 2,000 or 1 to 5,000, it weakens the virulence of these bacilli to such an extent that they will no longer produce the disease in sheep, but are still capable of killing guinea-pigs and rabbits. Again, cultures of anthrax bacilli may be attenuated by subjecting them to temperatures between 42° and 55° C. for lengths of time varying from ten minutes to four weeks or more, the length of time varying in inverse ratio to the degree of heat. A combination of heat with the action of chemicals on the cultures has also been successfully used. But whatever method is employed, the object is the same, viz.: to obtain cultures which produce on inoculation little or no disturbance in the health of the animal, but enable the latter to resist more and more virulent cultures, to bring about such a condition that the micro-organisms are incapable of growing in the tissues of the animal. Recent experiments of Brieger, Kitasato, and Wassermann have shown, however, that with anthrax increased resistance, but not full immunity, may be produced in this way. Animals so treated resist inoculations of somewhat weakened but still virulent cultures, but they succumb without fail to inoculations with tissues of animals dead of anthrax. In mouse septicæmia complete immunity can be produced by combining these methods with those described below for the toxic diseases, making the animals so treated incapable of infection, and also poison-proof.

The bacterial proteïds or toxalbumins are unstable and easily destroyed. This might lead to the supposition that they can be as readily destroyed within the animal body as outside, but such is not the case. Many of the chemical and physical means so efficacious in rendering cultures harmless are either inapplicable or powerless in the animals. Some of them, however, give good results.

The efficacy of Pasteur's inoculations for hydrophobia will now probably be universally conceded. The etiology of this disease is still obscure; there is every probability that it is caused by a micro-organism, but this has not yet been discovered. Pasteur found that the poison of hydrophobia is contained in greatest amount, if not exclusively, in the central nervous system, and moreover that the surest way to produce the disease is by subdural application of cerebro-spinal substance from an animal suffering from rabies. Animals inoculated in this way always have violent hydrophobia in from fourteen to twenty-one days. The virulence of the material is weakened by passage through apes, but is increased on passage through rabbits. By inoculation from rabbit to rabbit through forty or fifty of these animals successively, Pasteur obtained a "virus fixe" which had a period of incubation of only seven days, and differed from ordinary "street hydrophobia" not only in the shorter period of incubation, but also in that it produced the disease on subcutaneous injection. A series of exactly graduated virulence was obtained by successive inoculations of the material which had been weakened by passage through an ape. By inoculations with the series so obtained dogs were given immunity. Pasteur subsequently changed this method of attenuation, and has used it for several years upon human beings. The method Pasteur now employs consists in using the dried spinal cord of animals suffering from rabies. It was observed that the spinal cord of such animals gradually loses its virulence if dried at 20° C., and ceases to act if dried for sixteen or eighteen days. Starting with cord that has been dried for fourteen days, the injections are made in more or less quick succession, often several a day, till material of full virulence is used. The injections are made in the abdominal wall above the groin.

Koch prepared a lymph which was successfully used in some cases of tuberculosis. This lymph, or tuberculin, was made by extracting cultures of tubercle bacilli

with glycerin. The cultures were made in glycerin bouillon, and the bacilli which accumulated on the surface of such cultures were skimmed off, extracted with glycerin, and sterilized. Individuals suffering from tuberculosis react in a characteristic manner when inoculated with this lymph, but the expectations in regard to its curative value at first aroused have not been fulfilled. Similar lymph has been prepared from cultures of glanders, and used for diagnostic purposes. This so-called mallein was prepared by Kalming, Preusse, and Pearson, each independently.[3]

The application of certain substances at the seat of inoculation prevents infection. The most potent substances of this kind are the trichloride of iodine and the double chloride of gold and sodium. These substances must be applied shortly after inoculation, they fail to act a few hours later. They also fail when injected at a place remote from the seat of inoculation.

These substances also destroy the pathogenic power of bacteria when put into the cultures, or when mixed with the culture-medium upon which the bacteria are grown. Behring was the first to observe these facts,[4] and he has shown that better results are obtained by using cultures containing the trichloride of iodine than with any other method.[5]

But cultures containing watery extracts of the thymus gland were employed by Brieger, Kitasato, and Wassermann in a number of diseases with satisfactory results.[6] These authors succeeded, by the use of cultures grown in thymus bouillon, or by mixing the thymus extract with cultures, in producing in animals immunity from tetanus, cholera, diphtheria, typhoid fever, erysipelas. A certain amount of resistance was also obtained with anthrax, *i.e.*, animals resisted somewhat weakened but still virulent cultures, but not tissues from animals dead of anthrax. It could hardly be expected that immunity from anthrax could be obtained in this way, as it is a typically infectious, and not a toxic, disease. Immunity from mouse septicæmia could only be obtained by using cultures of the organism in thymus bouillon, and afterward inoculating with old weakened, but still somewhat virulent cultures, *i.e.*, combining the method for the toxic diseases with that for the infectious.[6] There are several theoretical considerations which led to the employment of the extracts of thymus gland. There is a certain analogy between the enzymes or physiological ferments and the bacterial proteids: the former, like the latter, are albuminoid poisons. Gautier, Bouchard, and others have shown that the physiological ferments act as poisons; this being the case, they could not circulate as they do in the blood without injury to the animal unless there be some arrangement for neutralizing their toxic qualities. This arrangement, it is held, probably lies in the protoplasm of the cells of the tissues, and for this reason those organs which are richest in cells and blood seem best adapted to this function. It would appear for this reason that the thymus, thyroid, and lymphatic glands act as purifiers of the blood that streams so abundantly through them, and direct observations go to show that the thyroid gland has the power of destroying this kind of poisons to a remarkable degree, for, as pointed out by Horsley and others, extirpation of the thyroid is followed by symptoms closely resembling those of chronic intoxication, and these symptoms, as shown by Vassale, can be successfully combated with injections of the juice from the thyroid gland of other animals. Transplantations of the thyroid gland in man and animals are also followed by improvement in the symptoms where the transplanted gland grows. The lymphatic glands appear also to possess this quality. They seem to be inserted into the lymphatic circulation for the purpose of arresting poisons contained in the lymph, for it often happens that a local affection spreads to the nearest lymphatic glands and there ceases. It is believed that this power of the glands to counteract poisons consists in the production of specific antitoxins which are given up to the blood on its passage. The antitoxins are supposed to be formed in the animal when the poisons are introduced. If the amount of poison introduced, or formed by the growth of bacteria in the body, is not sufficient to kill the animal, it brings about the production in the animal cells of an antitoxin, and after complete recovery the animal is able to bear larger doses. But in every case inoculations must finally be made with increasing amounts of cultures of full virulence.[5]

In this way the antitoxic property of the blood can be produced, and greatly, perhaps indefinitely, increased by the cautious introduction of larger and larger amounts of cultures, which have been modified by heat,* by the addition of trichloride of iodine or extracts of the thymus gland, or by increasing doses of the toxalbumins themselves.

The latter method has been clearly demonstrated by Ehrlich.[7] Vallet[8] in this connection produced immunity from intoxication with cultures of B. coli communis by feeding rabbits with diluted sewage. It is true that Ehrlich at first used toxalbumins derived from higher plants, and not bacterial proteids, but the analogy is very close between the two kinds of poisons, and Ehrlich's results have been found to agree with results obtained subsequently with bacterial toxalbumins. The substances which Ehrlich used are more easily procured, and the amounts can be more accurately determined than with the indefinite mixtures found in cultures of bacteria, and for this reason the experiments with the former are not complicated by variability in the action of given amounts. The advantage of working with definite quantities is evident, and this is clearly impossible with bacterial proteids till these have been obtained pure. In the one case the effects produced by a given quantity are the same in all cases, in the other the effect has to be determined in every case beforehand, because the amount of toxalbumin varies in different cultures. For this reason Ehrlich decided to study the production of immunity from abrin, a toxalbumin derived from the jequirity bean; risin, a similar poison obtained from the castor-oil bean; and, in a different set of experiments, robin,[9] from acacia bark. Ehrlich found that by feeding mice at the start with biscuits containing much less than the fatal doses of these poisons, the animals gradually bore greater and greater amounts till they could be inoculated without injury with amounts of the poisons sufficient to kill a great number of mice. The mice were made "abrin-proof," "risin-proof," or "robin-proof." In every case the process is specific, an animal which is abrin-proof is not proof against poisonous doses of risin or robin, and *vice versa*. This is also true for the bacterial poisons. An animal that has been made proof against the poison of tetanus is not necessarily proof against the toxalbumin of cholera or typhoid fever.

As stated above, the antitoxic property of the blood of poison-proof animals not only protects the animal itself, but the blood can be drawn and used to protect and even cure other animals. The testimony in regard to this is constantly increasing, and its practical importance is evident. Thus Stern[10] found that freshly drawn blood from typhoid fever convalescents protects mice. G. and F. Klemperer[11] found that blood-serum, and also sputa, from persons that have passed the crisis in croupous pneumonia, possess anti-toxic properties. They also made an extract from the tissues and intestinal juices of a pneumonia-proof animal, and used it successfully on pneumonia patients. Sternberg[12] found that blood-serum from a vaccinated calf neutralizes both bovine and human virus. It must be clear that if it is possible to obtain blood acting as above described it is only necessary to make large animals poison-proof, and use their blood for the prevention and cure of disease. As pointed out by Behring, the possibility of this "blood-serum therapeutics" is now clearly demonstrated, it only remains to obtain large animals in sufficient numbers to put the method into general use; it would also require considerable time to make the animals poison-proof, and a certain percentage of loss would also have to be reckoned upon. In view of any eventual practical utility of

* Vaillard produced immunity from tetanus in rabbits with cultures heated to 60 or 65° C.

the blood-serum therapeutics the selection of the animals from which the serum is to be obtained is a matter of great importance. It would be practicable to use only large animals, so as to get sufficient quantities of serum. It is also necessary that the animals be susceptible at the start. It is true that claims have been made for the inherent protective value of blood-serum from non-susceptible animals, but these claims have not been substantiated. Kitasato has shown that the blood of chickens ordinarily has no protective value against tetanus when injected into other animals, although chickens have natural immunity from tetanus. Still Vaillard[13] has shown that even such animals can be made to furnish protective serum by inoculating them with very large amounts of a virulent culture. Chickens injected with 15 to 20 c.c. of a filtered but not heated culture furnish blood of high protective worth. But it is only blood-serum from animals naturally susceptible, but rendered poison-proof, that attains the highest protective value. So in the different diseases it would be necessary to use different animals. Thus for tetanus horses are the best suited, they can supply a large amount of blood, and are naturally very susceptible. In fact, horses have been used for this very purpose.[14] Tissoni and Catanni, and others, have also reported a number of cases of tetanus in the human being cured with blood-serum of tetanus-proof dogs. The most suitable animals to use for diphtheria are sheep, and they have also been used for this purpose.[15] The more susceptible an animal is by nature the higher the degree of curative value obtainable; and the higher the degree of resisting power produced in the animal the stronger the power of its blood. The value of the blood-serum depends, in other words, upon the extent to which the animal from which it has been obtained has been made poison-proof. The degree to which an animal has been rendered poison-proof is expressed by the number resulting from dividing the minimal fatal dose into the largest amount which the animal can bear without serious symptoms. In animals of the same kind the size of the fatal dose increases with the weight of the animal. The minimum fatal dose is that which is just able to kill an animal of a given kind and size. Thus if two guinea-pigs of approximately the same weight are inoculated, one with .01 c.c. of a diphtheria culture, and the other with .005 c.c. of the same culture, and the animal inoculated with the larger amount dies, while the latter shows very slight symptoms or none at all, the minimum dose of this culture for guinea-pigs of such weight is .01 c.c. If a guinea-pig of equal weight with the two in the example above withstands an inoculation of .01 c.c. of the same culture, this animal is said to have one degree of immunity; if it withstands .02 c.c. it has two degrees; if it withstands 1 c.c. it has one hundred degrees of immunity, and so on. This is Ehrlich's method of expressing the degree of immunity in poison-proof animals. The protective value of the blood-serum of such animals may be expressed numerically, as suggested by Behring and Wernicke, as follows: The smallest amount of blood-serum necessary to protect an animal is taken as a unit and compared with the weight of the animal, and this proportion is used to express the protective power of the serum. Suppose three guinea-pigs are used to test the value of the serum of a diphtheria-proof animal, and suppose one of them receives .5 c.c. of serum to every one hundred grammes of its weight, a second 1 c.c. of serum to every one hundred grammes of weight; the third 2 c.c. to every one hundred grammes of weight, the protective value of the serum would depend upon which of the animals showed marked symptoms of diphtheria poison upon inoculation of a fatal dose. If the animals which received .5 c.c. and 1 c.c., respectively, should die, and the other one showed no marked symptoms, the blood-serum would have a protective value of 1 to 50. If the animal inoculated with .5 c.c. alone was affected the protective value would be 1 to 100—the animal receiving the blood-serum in this proportion not having been affected by subsequent inoculation with a certainly fatal dose. Animals which show marked local or general symptoms on inoculation with a fatal dose are not regarded as having been protected, even if they eventually recover.

The transmission of immunity by poison-proof animals to their offspring has been thoroughly studied by Ehrlich for animals made proof against the toxalbumins of some of the higher plants, those already mentioned, and also in animals rendered proof against bacterial toxalbumins. The observations in the latter case were few in number, but they tally precisely with the observations made in the former as far as they went.

It is conceivable that immunity may be transmitted by the father and the mother both. Such, however, has been found not to be the case. Immunity is transmitted by the mother alone. It is immaterial in any case whether the father enjoys immunity or not. Immunity in the father does not even increase the immunity transmitted by a poison-proof mother.

Immunity in the offspring might be either a purely maternal gift, or it might be brought about by rendering the mother poison-proof during gestation. These are evidently two different things. In the one case, mothers which have attained a fixed degree of immunity would transmit a part of this to the children; in the other, the same process which renders the tissues of the mother poison-proof would act upon those of the fœtus as well. These two means of acquiring immunity must be considered apart.

Ehrlich distinguishes two kinds of immunity, active and passive. In active immunity there is a peculiar adaptation of the animal organism to resist toxalbumins, *i.e.*, the production in the body of antitoxins, and it is characterized by extraordinary stability. In passive immunity there is an introduction of a certain amount of the ready formed antitoxin; as soon as this is eliminated from the body the animal is no longer poison-proof. Thus by the introduction of autitoxic serum into an animal it is possible to produce often astoundingly high degrees of resisting power, but, from the nature of the case, the resistance is limited in time. The ready-formed antitoxin is eliminated in from thirty to sixty days, and as the animal is not given the power in this way to actively renew it, the latter is no longer poison-proof.

Now, the immunity transmitted by the mother is of this kind; she does not transmit the power of actively forming the antitoxins, but merely gives a part of that which is formed in her body. The offspring of a poison-proof mother are poison-proof to a high degree about four weeks after birth, but at the beginning of the third month, or more certainly by the end of the third month, all traces of immunity are gone. By this time the antitoxin derived from the mother has been eliminated, and neither these animals nor their offspring, *i.e.*, the grandchildren of the poison-proof animals, have any resisting power.

The second possible way of producing resisting power in the fœtus, viz., by rendering the mother poison-proof during pregnancy, has not yet been sufficiently tested by actual experiment to be decided upon. It cannot be decided on general principles, for the embryonic tissues may not react as the adult tissues do. The probabilities are that they are not as susceptible to the action of the toxalbumins as the adult tissues, and the production of immunity depends upon this susceptibility. One observation of Ehrlich's seems to show, however, that the fœtus can be given active immunity along with the mother. A pregnant mouse was fed continuously with risin, and the young were risin-proof to a high degree four months after they were born; but the experiment was not beyond the suspicion of error, according to Ehrlich's own statement. Experiments of others in this direction are not convincing, because in all cases the test was made at a time when the young may have still had some of the maternal antitoxin remaining, or, as will be seen below, they may have been deriving it from the milk.

That the offspring of a poison-proof female derive antitoxin from the mother's milk is shown very strikingly by Ehrlich's experiments. Ehrlich found in many cases that the young showed resistance to toxalbumins for a

longer time than could be accounted for by a maternal gift of antitoxin at birth. They are protected after the antitoxin derived from this source is eliminated; so they must derive additional protection from some other source, and this proved to be the milk. Indeed, this in sucklings could be the only source. This is proven beyond question experimentally by the results of "swapping offspring, or the wet-nurse experiment." If the litters of the same age from a poison-proof mother and of an ordinary non-poison-proof mother are swapped around at birth, it is possible to observe, in the first place, just how long the immunity derived from the mother as a gift before birth lasts, and in the second place the degree of immunity acquired by normally susceptible offspring from the milk alone. Whatever resistance is shown by the offspring of a poison-proof mother in this experiment must be due alone to the antitoxin acquired in utero; the milk of the susceptible foster-mother contains no antitoxic properties. Whatever resistance is shown by the offspring of the normally susceptible mother must be derived from the milk of the poison-proof foster-mother. The immunity derived in this way alone from the milk of a poison-proof foster-mother is higher in degree than that derived in utero alone. Offspring of an ordinary non-poison-proof mother derive eight times the resisting power from the milk of a poison-proof foster-mother than the latter is able to confer upon her own children, unless these are allowed to suckle her. An illustration will serve to make this clear. A normal, non-poison-proof female was given four offspring of a highly abrin- and risin-proof mother to suckle; this highly poison-proof female was given the five offspring of the normal mother to suckle. The highest degree of immunity observed in the former case was scarcely 5, the highest degree in the latter fully 40, *i.e.*, one of the offspring of the poison-proof mother that suckled the normal female, barely withstood five times the fatal dose at twenty-one days old; one of the offspring of the normal mother which suckled the highly poison-proof foster-mother withstood forty times the fatal dose at about thirty days old. Another experiment of Brieger and Ehrlich[16] which also gave striking results, was made with tetanus upon a pregnant goat and her kid. The goat was treated by the Brieger-Kitasato-Wassermann method, viz., by inoculations of cultures in beef-tea, with the addition of thymus extract. Inoculations were begun six days before parturition, and continued for twenty-seven days after. The kid was found to be highly poison-proof. The protective value of the milk inoculated into mice was shown to be astoundingly great, 1,600 to 2,400 degrees. The serum of the milk was equally potent, and the evaporated serum had 5,000 degrees potency.

It is evident that in inherited artificial immunity, where the poison-proof mother is allowed to nourish her own young, there are two factors: the antitoxin derived by the fœtus, and, still more important, that obtained from the milk. Now, it is evident that this power of the milk must lie in the antitoxin which the latter contains, and the question arises whether this antitoxin is formed by the milk-glands or whether it is formed elsewhere, and is merely eliminated by these glands. It has been found that the latter is the case. If a normal animal is dosed during lactation with blood-serum from a poison-proof animal, the sucklings acquire typical protection from the milk. Experiments with tetanus on mice showed that great immunity up to forty degrees can be produced in this way in the sucklings. Immunity produced in this way is passive, as would be naturally supposed; but it makes its appearance very quickly, within twenty-four hours after the mother has received the protective serum.

Even normal sucklings which are inoculated with a splinter of wood with tetanus organisms on it, and then allowed to suck a highly tetanus-proof foster-mother, recover even if tetanus symptoms appear.

Meade Bolton.

[1] Metchnikoff: Arb. aus d. Zoolog. Inst. zu Wien, vol. v., 1883; Biolog. Centralbl., iii., 1883–84; Virchow's Archiv., vols., 96, 97, 107, 109, etc. Also various articles in the Ann. de l'Inst. Pasteur. Also Fortschritte d. Med., iii., 1884, etc. Compare Ernst Ziegler: Historisches und Kritisches ü. d. Entzündung, p. 198 et seq. Abdruck aus Beiträge zur path. Anat., etc., vol. xii., Jena.

[2] Stahl and Pfeffer, Leber, Buchner, Massart and Bordet, Gabritschewsky, Steinhaus et al. See Ziegler, loc. cit., page 180.

[3] Eber A.: Über Rotz lymphe (Mallein). [A Review.] Centralblatt für Bact., etc., vol. xi., No. 1, p. 20.

[4] Zeitschrift für Hygiene, vol. xii., No. 1.

[5] Die Blutserumtherapie, etc. Leipzig. 1892.

[6] Über Immunität und Giftfestigung, Zeitschrift für Hygiene, vol. xii., No. 2.

[7] Ehrlich, Paul: Deutsche Med. Wochenschrift, Nos. 32 and 44, 1891.

[8] Transactions of the Seventh International Congress for Hygiene, etc., London, August, 1891.

[9] Ehrlich, Paul: Über Immunität durch Vererbung und Säugung, Zeitschrift für Hygiene, etc., vol. xii., No. 2.

[10] Deutsche Med. Wochenschr., No. 37, 1892.

[11] Berlin klin. Wochenschr., August, 1892.

[12] Trans. of Assn. of Am. Phys., vol. vii., 1892.

[13] Vaillard: La Semaine Méd., No. 31, 1891.

[14] Behring: Über Immunisirung und Heilung von Versuchsthieren beim Tetanus, Zeitschrift für Hygiene, vol. xii., No. 1. Also Schütz, ibid.

[15] Behring und Wernicke: Ibid.

[16] Brieger und Ehrlich: Deutsch. med. Wochenschr., No. 18, 1892.

ASEPTOL (Sulpho-carbolic acid; Sozolic acid) is prepared by mixing sulphuric acid and phenol in chemically equivalent parts. It is a sirupy, reddish-brown fluid. Specific gravity, 1.400. Miscible in all proportions in water, alcohol, and glycerine. It is less poisonous than carbolic acid and has a more agreeable odor. The aseptol of commerce is a solution of varying strength, about thirty-three per cent.; specific gravity, 1.168. It possesses antiseptic properties and is used externally for the same purpose as carbolic acid. It is devoid of caustic properties and is less irritating and not so powerful an antiseptic. A solution of ten per cent. may be generally employed as an antiseptic wash. In diphtheria it is recommended as a local application. It may be given internally, but the official salt, sulpho-carbolate of sodium, is to be preferred. *Beaumont Small.*

ASIATIC, OR EPIDEMIC CHOLERA is an acute infectious disease that is endemic in certain parts of India, and that has during this century advanced out of that country to other parts of the world, where, in its epidemic form, it has produced great loss of life. It is characterized by its great fatality among the communities to which it may be transported, by the apparent ease with which it has been carried from place to place, and by its invariably following the lines of travel in its march from one place to another. It is distinctly a disease of the gastro-intestinal tract, produced, primarily by a micro-organism, and attended with secondary symptoms, due to the absorption of toxic principles elaborated during the development of this micro-organism.

A study of the history of the epidemics that have occurred outside of India will easily demonstrate the facts in regard to the ways by which the disease is transported from place to place.

There is only a difference of degree between cholera, choleraic diarrhœa, and cholerine—the disease is the same in all these forms provided that they are accompanied by the activity of the spirillum of Koch. So far as true cholera and cholera nostras are concerned, there is a very great similarity, or rather there may be, between the clinical symptoms of the two diseases, but the differentiation may be easily made by the isolation of the specific spirillum of the former. The same thing is true in regard to the differentiation of true cholera from an attack of indigestion, which, if severe enough, may take on many of the characteristics of true cholera. Cholera nostras is a seasonal disease and is not transportable, and it has been known for ages. True cholera made its first advance out of India in 1817, and since that time has been seen periodically in Europe. In all cases it has followed the line of travel, and has never been seen to be distributed in any other way. Therefore true cholera never makes its appearance except after other cases have been seen that might excite suspicion, while cholera nostras appears only in hot weather, in sporadic cases, and dies out if the weather becomes cooler.

The period of cyanotic chills, although one of the most

striking in both diseases, gives no special indications for differential diagnosis, for the same thing is seen as an accompaniment of many other diseases, as acute catarrhal diarrhœas, acute poisonings, etc. The prodromic period exists in cholera nostras practically always, but not nearly always in true cholera.

The period of reaction is of importance in differential diagnosis. In cholera nostras it is usually benign—if the patient escapes the violence of the first attack, convalescence is as a rule easy and rapid ; with true cholera, on the contrary, convalescence is exceedingly dangerous—full of pitfalls, and may terminate fatally at any time.

History of Epidemics of Cholera and Their Lessons.—The dispute is active as to whether true cholera existed in India before its appearance outside of its limits in 1817, but the probabilities are all in favor of its having done so ; the especial point that seems to be changed in its nature being that it then seemed to take on the property of migration. Whether this was in reality a new property, or whether it was simply brought to the notice of Europeans by their being first attacked by it, is an unsettled question. There is no doubt, however, of the very great influence exerted upon its spread by the great pilgrimages to the various shrines of India ; nor is there any doubt that the sole home of true cholera—the one place where it is present all the year in an endemic form—is the delta of the Ganges. There are also certain places in India, Indo-China, China, and Japan in which it seems to be present nearly all the time, but it certainly is not endemic in Persia, on the borders of the Caspian Sea, nor in Mecca.

From this one place in which it is endemic, cholera has always been transported to Europe in the steps of the traveller and along the routes of commerce ;—neither wind, moisture, electricity, nor any of the forces of nature have taken any active part in the actual transportation of the disease, although unfavorable climatic and hygienic conditions, of course, may play a favoring part in the development of the disease, after the arrival of its cause.

Epidemics of Cholera.—Cholera has made five appearances in Europe—in 1830, in 1846, in 1865, in 1884, and in 1892. Each one of these appearances was a great epidemic.

There had been also, in 1823, in Astrachan, a small epidemic of cholera, important, because it traced the route that the succeeding invasions would follow. Leaving Persia, where it prevailed in 1822, cholera invaded the southern provinces of Persia, forming the southern shore of the Caspian Sea. After some ravages, it became quiescent during the winter of 1822, to reappear in April, 1823, at Recht. From this city, following the western shore of the Caspian Sea, it crossed the Russian frontier in June, at the little town of Astara. From Astara it reached Lenkoran on the 29th of June. On the 11th of September it was seen at Bakou, and on the 22d at Astrachan, where it soon disappeared.

The First Epidemic.—The epidemic of 1830 had the same origin. Ghilan and Mazanderan, the two Persian provinces before invaded, were attacked in 1829. The disease was quiescent during the winter, but appeared in the spring in Ghilan and in the little port of Enselli, situated several hours' journey from Recht. As in 1822, the cholera followed the western border of the Caspian Sea, and showed itself about the middle of June, 1830, at Salian. Taking here two different directions, on the one side, it appeared at Bakou, Kouba, and Derbent, and invaded Astrachan ; on the other, following the whole valley of the Koura, it advanced toward Tiflis, passing by Elizabethpol, and spreading throughout the whole of the Caucasus. In this way it reached successively the neighboring regions of Astrachan, and advanced up the Volga. On the 4th of August it was at Saratow, thence extending into Russia, and reached the other European States.

This epidemic, by certain extremely interesting peculiarities, demonstrated from the very first the transportability of cholera.

The Second Epidemic.—In 1846, after having reached Salian by a course identical with the preceding, cholera was seen on November 8th in the city of Chemacka, a short distance from Salian. It was in Bakou and at Derbent in December. Forgotten during the winter, it appeared in April, 1847, in the districts of Derbent and of Kouba, and at Tamir-Khan-Choury. From thence it was transported by sick soldiers to the mineral waters of Kisliar. The disease was disseminated among the Calmucks scattered over the steppes near the Volga.

On July 15th it appeared at Astrachan, and advanced at the same time toward Tiflis. From Tiflis it reached Kontais, and was soon carried to Trebizond.

North of Tiflis, the cholera followed the great military road that crosses the Caucasus at the height of 7,000 feet, and toward the end of July it existed at Stavaropol, on the other slope. (It is to be observed that before reaching Tiflis, the cholera entered Persia by the great routes of travel that pass from Bakou, by Erivan, Natchichievan, Djoufa, Ordoubaz, and on toward Tauris. On the one side it attacked the region of the Black Sea, and invaded all its ports ; on the other, it passed through Russia, Germany, France, and Italy.)

A striking thing about these epidemics, aside from the exact places that they attack, is their progress by successive stages—a form of advance that is always the same, and which is a trait common to all the epidemics of cholera that have followed the land route. This second epidemic persisted until 1855.

The Third Epidemic.—The great epidemic of 1865 was the first one appearing by the sea route. It demonstrated that the danger is not localized on the Caspian Sea, but that it is also present on the shore of the Red Sea. Its appearance by this route upset all the doctrines that had been held until that time, and the panic that it produced in Europe resulted in the first conference at Constantinople. It is interesting to follow in some of its phases the course of this epidemic, because its influence has been great. It started from Mecca, having been brought into that city by ships coming from India filled with pilgrims. Toward the end of April it broke out in Meeca and at Medina. The mortality increased very greatly during the three feast days at Arafat. More than thirty thousand of the pilgrims died of cholera, and the progress of the disease showed that *everywhere it accompanied these pilgrims.* Egypt, by reason of its proximity to Mecca, was the first country attaeked.

From May 19th to June 10th ten steamers landed from twelve to fifteen thousand pilgrims at Suez. By false declarations from the captains they were passed at Suez, although the Sydney, an English steamer, had lost a number of eases during the voyage. The first steamer, landing May 19th at Suez, had thrown its dead into the sea. On the 21st, cases appeared at Suez, and among the number were the captain of the vessel and his wife.

June 2d, the first case appeared at Alexandria, and in two months cholera had four thousand victims in Alexandria, and in Egypt, in less than three months, it produced the death of more than sixty thousand individuals. The foreign population emigrated *en masse,* and carried with them throughout the entire world the germs of the disease. Europeans and Levantines, to the number of from thirty to thirty-five thousand, started for all the ports of the Mediterranean, and cholera developed at Constantinople, at Smyrna, at Beyrout, in Mesopotamia, and at Odessa on the Black Sea, and was carried to New York and Guadaloupe by steamers, *appearing in the port at the same time that the steamer landed its passengers.*

Its importation into New York was as follows : The Atlanta, an English ship, left London on October 10th with a cargo of merchandise and forty passengers. The sanitary condition of London was at that time excellent. Reaching Havre on the 11th, where it remained one day only, it embarked 564 new passengers, mostly Swiss, who had all passed through Paris, where, with certain exceptions, they had remained at least a short time, and where at the same time cholera was raging with great intensity. Two German families had stayed in Paris at the Hotel of La Ville de New York, and five days at the hotels of the Weissen-Lamm and Hultgarderhof. Some emigrants that had arrived several days before in these

last hotels had fallen suddenly ill. The steamer sailed on the 12th, and on the next day there was a death from cholera of a child in the family coming from the Weissen-Lamm Hotel. Five other deaths followed on the 14th, the 16th, the 18th, the 19th, and the 22d, in the family that had stayed at the Hultgarderhof.

On the arrival of the Atlanta the surgeon declared 60 cases of cholera, and 15 deaths during the voyage. Two deaths occurred in port, and of the 142 patients sent to the Marine Hospital from November 6th to 19th, 6 died, which makes a total of 23 deaths. The Atlanta was immediately isolated in the lower bay, and after ten days of quarantine all the sick were removed, and, thanks to these measures, New York was preserved.

There were also importations in 1866 by the steamers Virginia and England.

The epidemic of 1865 ceased in 1874, and there was no other case seen in Europe until 1884, although there were interesting manifestations in other countries and on the sea—interesting from the point of view of the transportability of the disease.

The Fourth Epidemic.—The epidemic in Egypt in 1883 was no surprise to those who knew the sanitary condition of the country. Cholera appeared at Damietta toward June 19th or 20th, possibly a little earlier, and its explosion at this time is ascribed, certainly by the French, to the suppression of all sanitary precautions, including quarantine, by authority of the British government. This epidemic at Damietta, increased for about fifteen days, remained stationary for about five or six days, and then diminished just as speedily. It was almost extinct a month after its appearance, having claimed from two thousand to twenty-five hundred victims. The spread of the disease throughout Egypt was manifest and rapid. (An interesting account of how this epidemic reached Damietta is given in Proust's work on the "Defence of Europe against Cholera," Paris, 1892, p. 7.)

Cholera had not yet died out in Egypt, before the news came that it had broken out among the pilgrims to Mecca, and there has been much discussion as to the origin of this epidemic.

In 1884 a number of vessels left the extreme East, and had cases of cholera on board during their voyage; but, by reason of the precautions taken, Egypt and Europe escaped the danger at this time.

The first case of cholera seen at Toulon occurred on June 13th, on the ship Montebello; a second case on June 14th; a third on the 18th, on the Jupiter, near the Montebello; a fourth, also on the 18th, on the Montebello; a fifth, June 20th, on the Alexander, which was also placed near the Jupiter and the Montebello. After the 21st the disease spread through different quarters of the city, and it is thus shown that it did not make its appearance at Toulon in the city, but just outside.

Its importation into Marseilles occurred by the appearance of the first case on June 27th, in a young man, who had three days before come from Toulon. The next case, which occurred on June 28th, was that of a man who lived in the same neighborhood; and from this time onward the disease continued to spread.

In Paris there appeared two cases on the 13th or 14th of July, but the epidemic did not really begin until the 4th of November.

In Brittany the first case was not observed until September 20th, at Concarneau. Other ports were successively invaded.

Algeria was attacked in 1884, and there was a slight recurrence in Algeria and in Tunis in 1885.

Cholera was brought to Italy in 1884 by the Italian workmen, who, to the number of more than eight thousand, returned to their country after the extension of the cholera to Toulon and Marseilles. The Province of Cuneo, in Piedmont, was the first one attacked, on June 27th, and the disease spread successively to different parts of Italy, to Genoa, Naples, Venice, Sicily, and so on.

It appeared in Spain, in the month of August, in the Province of Alicante, and ceased toward the middle of October, reappearing in the middle of February, in the District of Gandia, raging through the month of June to the month of December, 1885, and producing a considerable mortality. It is remarkable that it attacked especially the small towns more than the large cities. The Commune of Aldea de San Miguel, with only five hundred inhabitants, lost more than half of them in thirty-six days.

Cholera also appeared on the Adriatic shores of Croatia, at the end of 1885, and in 1886 on many points of the Austro-Hungarian shore in Istria and in Dalmatia.

The comparison of the mortality in France, Italy, and Spain is interesting. In France and Algeria together there were 13,000 deaths in a population of 39,000,000—1 in 3,000 inhabitants. In Italy there were 35,000 deaths in 26,000,000, that is to say, 1 death in 600 inhabitants. In Spain there were 180,000 deaths, among 17,000,000 inhabitants, that is to say, 1 death in 100 inhabitants. So it appears that Italy was attacked five times more severely by the epidemic than France, and Spain six times more severely than Italy, and thirty to forty times more severely than France.

Much has been said about the immunity of Portugal during the epidemic of 1884 and 1885 in Spain. Many reasons can be brought forward for this, viz., the slight tendency of the Spaniards to take refuge in Portugal, the geographical conditions, and finally, the prophylactic measures taken at the frontier.

In spite of the imperfect quarantine and incoherent measures prescribed by the governments of South America against the vessels coming from Europe, a ship from Genoa, the Perseo, carried cholera to Buenos Ayres, and the disease spread into the Argentine Republic, Uruguay, and Chili.

From 1884 to 1886, a period of three years, more than twenty vessels coming from the extreme Orient to Europe, on passing through the Red Sea and the Suez Canal, had, either at the moment of their departure, or during the voyage, cases of cholera.

The Cholera of 1889, 1890, 1891, *and* 1892 (*the fifth epidemic*).—In 1890 cholera appeared in Irak-Arabi, in Mesopotamia, in Persia, and in Syria, where it had not been seen for almost twenty years. It had been imported into the region bordering on the Red Sea and into Mecca, where it had not been since 1883, and it was observed in Spain, where it had been extinct since 1835.

In summing up what we know of the origin of cholera in Irak-Arabi and in Mesopotamia in 1889 and 1890, the following must be our conclusions:

It is very difficult to admit that the cholera of Irak-Arabi can be attributed to the revival of the old epidemic of 1871, and if this hypothesis be excluded, we are obliged to accept the idea of importation, and it is only possible to think of one portal of entrance, the Persian Gulf, and one source in India, notably Bombay and its environs.

We know from other sources that during and before the appearance of cholera in Irak-Arabi the mortality of this disease in Bombay and its environs reached the enormous number of more than six hundred deaths a week. The condition of the vessels of the British India Company, that alone regularly frequent the Persian Gulf, bring passengers there, and frequently bring pilgrims from India, has been, to say the least, suspicious. Everything points, therefore, to the conclusion, which bears every appearance of truth, that the cholera penetrated into Irak-Arabi through Chat-el-Arab. The importation was performed in this way much more probably than by any other means.

In regard to the epidemic of 1890–91 in Hedjaz, Proust offered the following conclusions to the Committee of Hygiene, which were accepted: 1, The cholera of Cameran was imported by an English vessel coming from India; 2, the cholera of Hedjaz appears to have been brought by the sea route; 3, the pilgrimage to Mecca is a constant menace to the health of Europe; 4, the measures prescribed for the government of the pilgrims to Mecca have not prevented the cholera from developing, and it is therefore necessary to perfect these measures; 5, the prophylactic measures prescribed by the Alexandrian

Conference, at the time of the return of the pilgrims, have this year prevented the disease from gaining a foothold in Egypt and in Europe. There is reason, therefore, for continuing this Conference and for giving it more authority and making it in reality international. There is also reason for increasing the means for isolation and disinfection on the Red Sea.

The epidemic which appeared in Spain in the month of May, 1890, and lasted until the end of November, gave rise to much discussion in regard to its origin that is not yet terminated.

The epidemic of 1892, appearing first in Southern Russia, and thence extending in isolated instances to ports in the north of Europe, appears to be quiescent at the time of present writing, but nearly all sanitary authorities look for a further outbreak during the coming year (1893).

Thus far no cases of cholera, beyond a few isolated ones in New York (*Amer. Jour. of the Med. Sci.*, June, 1892), have appeared in the United States for nearly twenty years.

Transportability and Means by which the Disease is Transported.—The transportability of the disease is demonstrated by, first, the facts in regard to its propagation after it has been imported; second, by the efficacy of certain measures of prevention; third, by the general march of epidemics of cholera; and fourth, by the development of epidemics in the infected localities.

1. *Propagation.*—Brochard, in "Du Mode de Propagation du Cholera," Paris, 1861, reports a very large number of observations favoring the idea of the transportability of cholera, and the number of instances proving this is so great that they need only to be spoken of to be accepted.

An illustration may be taken from the article by Huette, in the *Arch. Gén. de Méd.*, 5th series, vol. vi., p. 571.

In speaking of cholera in Chatillon, he says that the first case was observed in the Faubourg du Puirault, in a workman, thirty-five years old, who was attacked immediately after his return from Oussoi, where he had gone to take care of his parents who were sick with the disease. His neighbors were very soon attacked, and the epidemic invaded the entire Faubourg du Puirault, where it remained concentrated for some little time. Finally, the inhabitants, frightened by the disease, scattered through Chatillon, and the cholera appeared indiscriminately throughout the city. The instance is interesting, because while the inhabitants remained in the Faubourg du Puirault, the disease stayed there, whereas, as soon as they scattered, it spread with them throughout Chatillon.

Another instance, interesting as an example of the transmission of the disease by clothing, is given by the same authority, in speaking of the Commune of Onssoi. Madame Bresson, of the hamlet of Moulineuf, near Oussoi, a precinct free from cholera, received a boarder from Paris June 27th, who on the next day showed the first symptoms of cholera, and died on July 3d. Some days after, a child of this woman was attacked and died on July 13th. On the same day Madame Bresson herself was taken sick, and died on the 17th, after having been taken care of by two neighbors named Sahan and Moret, who died, one on the 16th and the other on the 24th. The husband of Madame Bresson died on July 26th. Madame Burette, who lived in the extreme end of the hamlet, washed the linen of the two women, Sahan and Moret, and was attacked with cholera. In this way, an epidemic was started that carried off eighteen persons in a very short time. Before the arrival of the person from Paris no case had been observed in this hamlet, that had been spared by the cholera both in 1852 and in 1849. Dr. Huette calls attention to the distribution of this hamlet of Moulineuf, which is composed of ten little collections of houses, separated by great distances. No cases of cholera were observed excepting in three of these collections of houses—first, that occupied by the Bresson and Sahan families; second, that occupied by the Moret family; and third, that occupied by the Burette family. The third collection of houses was situated at the extremity of the hamlet. No case of the disease was observed in the other houses, of which the inhabitants had had no connection with these three families.

Proust (loc. cit., p. 165) quotes an occurrence illustrating another series of facts.

In 1854 the French army was collected at Varna, a short distance from the English army. Some detachments remained at Gallipoli, the original place of debarkation. There was, besides, a small Anglo-French force of occupation in the Piræus, and also some detachments at Constantinople. The armies were reinforced practically every day by new arrivals. The sanitary condition was satisfactory in all respects. On July 5th, the packet Alexandre arrived at Constantinople, having left Marseilles on June 26th with five hundred men of the Fifth Regiment of Light Infantry, coming from Montpellier, and having passed through Avignon, where cholera was raging. It appeared on board, and three men died during the voyage to the Dardanelles. Four cholera patients were landed at the Piræus, where the cholera broke out immediately, and made great ravages. The troops were disembarked at Gallipoli, where two new cases of cholera were immediately sent to the hospital, and the ship, having only a few passengers on board, sailed for Constantinople, where a quarantine was imposed on it. On the other hand, it appeared that previous vessels sailing from Marseilles had already suffered from cholera, and that one of them had landed a patient in the military hospital at Constantinople. On July 15th, after new arrivals of cholera patients, the disease spread at Gallipoli, and there appeared in the military hospital of Constantinople a choleraic focus. Fauvel, struck by the danger, proposed, and had adopted by the Council of Health at Constantinople, a momentary interruption of the communication between Gallipoli and Varna. The measures prescribed were not executed, and in spite of the insistence of Fauvel before the Marshal de Saint Arnaud, many ships sailing from Gallipoli passed the Bosphorus, and went directly to Varna, where free pratique was accorded them. Cholera then broke out in the army among the newly arrived soldiers and in the hospital. On August 5th the epidemic was violent at Varna, especially among the troops sent into the Dobrudscha. The English army was invaded, having the epidemic on board the fleet. In the Crimea, the epidemic, helped on by the arrival of the fresh troops, continued until 1856.

The importation of cholera into Constantinople in 1865 equally deserves to be spoken of. Constantinople was in an excellent sanitary condition when the frigate Moukbiri-Sourour arrived from Alexandria, on June 28, 1865. She had passed more than five days on the voyage, and therefore, in accordance with the rule that then held, free pratique was granted her, the surgeon having declared that there had been no illness during the voyage; but this declaration was false. The evening of June 28th there were landed from this frigate twelve sick persons, of whom one was attacked with cholera, who died during the night, and eleven were affected with cholerine. It was learned on the next day that during the journey from the Dardanelles to Constantinople two choleraic bodies had been thrown into the sea. On June 30th nine other cases were landed. The ship was sent into quarantine at the mouth of the Black Sea. The patients were transported to the Marine Hospital, near the arsenal, and here one special circumstance should be noted. The road that went from the landing to the hospital being opposite, it was necessary to carry the sick past the barracks occupied by military workmen in the arsenal, and the first indigenous cases of cholera occurred among these workmen, and on board a corvette that was near their barracks. On July 3d one of these military workers was received at the hospital with a choleraic diarrhœa, and on the 5th presented all the symptoms of cholera. That same day a new case was furnished by the workmen, and another on the corvette spoken of above. The barracks were then vacated, and the workmen were placed in tents on the heights of Okmeidan; nevertheless, the disease continued to rage among them, and among the ships collected before the arsenal, and it attacked on the one hand the guard in the interior of this establishment, and on the other the workmen at the

Ministry of Marine, situated very near the barracks of the military workmen. On July 8th two cases occurred outside the arsenal, and from July 10th the epidemic commenced to invade the quarter of Kassin-Pacha, near the arsenal, and inhabited by the workmen of whom we have spoken. It then propagated itself throughout the city.

One more instance of the importation of cholera may be given, as illustrating that a single case, carried a great distance by rail, may give rise to an epidemic.

Toward the end of the month of August, in 1865, cholera suddenly broke out at Altenburg, in Saxony, in the centre of Germany. The first case was that of Lady E——, who had left Odessa on August 16th, and had arrived at Altenburg on the 24th, without having stopped on the journey. She travelled with a child of twenty-one months old, who was affected with diarrhœa. She went to her brother's, and sent for a physician to see her child, whose diarrhœa had become very severe. This woman, who was meanwhile well, said that at her departure from Odessa there had not been in that city any disease; but this was an error, for some cases of cholera imported from Constantinople were already in the hospital in the lazaret, and, the day after the departure of this lady, cholera appeared at Odessa. She said also, that having embarked to go up the Danube, everybody appeared to her to be well on board, although the vessel had passed by certain localities where cholera was raging; however that may be, three days after her arrival at Altenburg, on August 27th, and the very same day that the physician had visited her child, this lady fell ill, and the next day the physician recognized all the symptoms of Asiatic cholera. She died on the 29th. On the same day, in the same house, her sister-in-law was attacked, and died on the 30th. The child died on the 31st. From this house the cholera spread into the city and suburbs. The family of a workman, who died on September 13th at Altenburg, carried the disease to Werdeau, and the house occupied by this family was the point of departure of another epidemic that carried off two per cent. of the entire population of the city.

2. *The Transportability of Cholera is Confirmed by the Results of Restrictive Measures.*—We see always that a rigorous sequestration and a rigorous interruption of communication by land or sea, if that be possible, results in preserving certain places or certain countries, and in these facts is a powerful argument against any idea of the transmission of cholera through the air.

In 1867 Messina and the whole of Sicily were entirely free from cholera, and yet vessels coming from infected countries daily passed through the narrow Strait of Messina. And again, during the epidemic of 1856 at Constantinople, the scholars of the Military School, to the number of five hundred, were rigorously sequestrated in the establishment, and escaped the cholera that was raging in the neighborhood; and events that occurred at the lazaret of Fort Genoa, in Algeria, in 1884, demonstrated also the efficacy of isolation in order to prevent the transportation of the disease to the neighboring cities.

3. *Transportability as Shown by the General Progress of Epidemics of Cholera.*—If we look at epidemics as a whole, we see that they always follow the course of human currents of travel. It is in the East, or in the countries bordering upon Europe, that we can best follow the development of this law, because in such places the routes are less frequented, and the demonstration is more striking. In order to pass from Persia into Russia in any way except by the great line of travel passing through Erzeroum, Tauris, and Natchischevan, there are only two ways—that over the Caspian Sea, and the land route that follows the western shore of this sea. Both of these routes pass by Recht, Astara, and Lenkoran, and end both of them at Bakou, and in the same way cholera, in the epidemics of 1823, 1830, and 1846, always and invariably passed through Recht, Astara, Lenkoran, and Bakou. At the latter city the land route splits on the north. It continues to follow the western border of the Caspian Sea, and passes by Derbent, and reaches Astrachan exactly as does the sea route, and we have seen cholera at every one of its appearances, in 1823, 1830, and 1846, pass over this same line, passing by Bakou, Derbent, and Astrachan. In 1823 it stopped at Astrachan, while during 1830 and 1846 Astrachan was only one of the steps of its invading march.

The second line of travel passes over the Caucasus. It leaves Bakou, passes by Tiflis, and follows the Caspian Sea to the Black Sea. The point of departure from the Caspian Sea is Bakou. The point of arrival on the Black Sea is Poti, or Trebizond. The epidemics of 1830 and 1846 divided, following both of the two routes that have been spoken of. One current followed the border of the Caspian Sea, another crossed the Caucasus.

This progress of cholera, always following the same lines, is a striking illustration of the law formulated. It always follows the human currents, in the steps of the traveller. It is imported by man alone, and precisely the same point is shown if we follow the successive steps of the epidemics that have travelled by the sea route.

As an illustration, the epidemic of 1854 in the Crimea was due to vessels coming from Marseilles, and carrying troops from an infected country. Cholera appeared successively at every one of the points where these vessels touched. They landed at Messina, and Sicily was invaded. They touched at the Piræus, and Greece was attacked. They stopped at Gallipoli, and cholera appeared at Gallipoli. Constant communication was being held between Gallipoli and the Dardanelles, Constantinople, and Varna. Cholera developed at all three places. The same was shown in the progress of the epidemic of 1865. It must not be supposed, however, that the assertion is made that cholera took the special direction from east to west; on the contrary, it radiated from India in all directions—north, south, east and west—according to the ease and number of the means of communication.

4. *Transportability as Indicated by the Evolution of Epidemics in Infected Localities.*—Many examples of this may be quoted, among which are the following:

In Constantinople it is possible to trace out the successive extension of the disease up to the time of its general diffusion. At Constantinople it manifested itself first at the arsenal, where it had been carried by the sick who were landed from the ship Moukbiri-Sourour. From the arsenal it reached the neighboring quarter of Kassin-Pacha, and then a few cases appeared in different parts of the city, for the most part of persons who had fled from the quarter first attacked. Up to July 16th the total of the deaths from cholera in the entire city, except those at the Marine Hospital, reached 130, when suddenly it was learned that the disease had broken out with violence at Eini-Keni, a village situated on the Bosphorus, twelve or fifteen kilometres from the quarter where the epidemic had begun. It was established that the first case of cholera had appeared on July 11th, in a Turkish café, in a workman coming from Kassin-Pacha; that the next day many of the individuals who frequented this café fell ill, and two died; that during the following days the disease was propagated in the quarter until the 16th, when, after the occurrence of several deaths among prominent families, a panic seized the whole population of the village, who fled in all directions. Mussulmans, Greeks, Armenians, and Jews fled into other villages and quarters of the city which were then unaffected, where they transported the disease. The Jews in particular, who had been the most seriously attacked, and who carried with them their soiled clothing and their dead, became the especial propagating agents of the disease. At Koustoundjouc, at Kas-Keni, and at Balata, the epidemic broke out immediately after the arrival of these fugitives. From this moment dates the generalization of the epidemic. It is not necessary to add other examples. The same thing is shown in the history of every local epidemic that has been intelligently traced.

It has been opposed to this idea of the transportability of cholera that sometimes a restrictive intercourse failed to arrest the progress of the disease; but in all these cases the measures were either tardily employed, or applied without scientific rule. Others have spoken of the immunity of countries which had not protected themselves by any sanitary measures. The answer to this is

the question, whether cholera, although it is a disease capable of spreading by infection, must, therefore, be possessed of a method of forcing this infection. And, in conclusion, no matter what the differences of opinion are, the law of transportability remains absolutely established by all the facts yet obtained in regard to cholera.

Methods of Transportation of Cholera.—In a consideration of the question of the method of transportation of cholera, we are to look at two principal points, the agent of cholera, that is, the organism of the disease, and second, the medium.

The agent of cholera is unquestionably a bacterium, having India for its origin. It extends itself, and reproduces itself indefinitely, and many media serve as vehicles for its transportation throughout the entire world, but this choleraic agent would be wholly powerless if it did not encounter favorable conditions for its development. The medium, therefore, is indispensable to its power, and this favorable medium is made up of certain telluric conditions, the surroundings, and so on. So far as the methods of transportation of cholera are concerned, therefore, we have to consider more the medium in which it appears than the cause of the disease itself. Fauvel has expressed this truth as follows: "That a fire is not proportionate to the spark which gives it birth, but to the combustibility and mass of the material that it encounters." So, frequently, a few cases, or one only, as at Altenburg, are sufficient to produce the explosion of an epidemic.

The clinical consideration of the means of transportation of cholera is to be made under the following headings:

First, the transportation by men attacked by cholera, and the rôle played by the closets that have received choleraic excreta. A person arriving from an infected place is always necessary for the beginning of an epidemic. In other words, man himself is the most powerful agent for the spread of cholera, the specific micro-organism being found, as has been demonstrated by innumerable experiments, in the excreta. Washerwomen have been attacked by the disease after washing linen soiled by evacuations, while others, who had simply touched this linen, also contracted the malady. Budd relates (quoted by Hirsch in *Schmidt's Jahrbucher*, vol. xcii., p. 255) that in 1854 a person affected with cholera arrived in an English factory of 645 workpeople. There followed 144 deaths from cholera in five weeks. The disease developed solely among those who made use of the closets where choleraic dejecta were deposited. Instances of this kind can be multiplied almost indefinitely.

Second, the transportation by means of choleraic diarrhœa. As illustrations of this, innumerable instances might be quoted, especially that mentioned by Budd in the reference given above. A person sick of diarrhœa came into the midst of a perfectly healthy population in a colliery, and died. Diarrhœa became general, and seventeen persons contracted cholera. The case of Dr. Alexander, in the *Gazette Médical* for 1849, is also an illustration of this point. There was not at Hamel, a village twenty-five kilometres from Amiens, any indication of cholera, when, on April 4th, from Paris, where cholera existed, there arrived a soldier sick with diarrhœa. He was received into his parents' house where he remained three days. On the 14th he went to the Hôtel-Dieu, and the same day his brother, who had come a number of times to see him, was attacked by foudroyant cholera, and died in twelve hours. His wife died three days afterward. The father, who had shown some symptoms of cholerine, was attacked with cholera on the 11th, and died on the 15th. Another son of this man, seventeen years old, and a child of four years, his grandson, were attacked with cholera, and got well. The father-in-law of the brother who had taken care of him and his daughter were attacked by cholera, but recovered. A child of eleven years, who was often at the house, and whose parents had taken care of the same brother and his wife, was attacked on the 14th, and died the following day.

Third, can the bodies of persons dead of cholera communicate the disease? Although the evidence seems to point toward this being a possible danger, it is not a serious one in civilized countries.

Fourth, can cholera be transported by healthy individuals? This must be answered in the negative. The facts quoted that seem to show that this can be so, must be explained by supposing that the individuals who were believed to be entirely well were in reality sick of a choleraic diarrhœa, or else that they carried clothing or linen soiled with choleraic material.

Fifth, can cholera be transported by living animals? Animals are not susceptible to the disease. A certain number of experiments have succeeded in producing cholera in animals, but with great difficulty. There is no fact to support the supposition that animals can carry the disease, either on the skin or hair.

Sixth, the transportation of cholera by means of clothing, personal effects, and so on. The disease cannot be so transported unless these materials have been contaminated by cholera dejecta. This, of course, is an exceedingly important point, for if soiled, the material may be dangerous; if not soiled, there is no danger at all, even if it comes from cholera centres. It is of equal importance to know whether contaminated objects have been packed up, or exposed to the air. A contaminated object exposed to free air for a definite time loses its power of transporting the virus. The Conference of Constantinople considered that a very short time was sufficient to do away with all danger, and recent bacteriological research has wholly confirmed this opinion. On the other hand, contaminated objects that have been packed up and kept closed from air retain their virulence for a greater or less time, as may be shown by many instances.

Seventh, can cholera be transported by merchandise? Although merchandise imported from India, whether to Suez, or directly to Europe, has never been known to transmit cholera, this method of transportation is not absolutely impossible, and many of the materials brought from India—cloths, and so on—retain in their interstices a confined air that certainly might preserve and transport for a great distance the contagion with which they may be impregnated; but although this is a possibility, it is not probable, and the Conference of Constantinople unanimously accepted the absence of proofs of the transportation of cholera by merchandise, while it admitted the possibility of its being done, under certain conditions. Since that time, Zehnder, the Swiss delegate to the Vienna Conference, in 1874, cited facts in favor of the danger of rags in transporting contagion (see the report of the International Sanitary Conference of 1874, page 272). But at the Conference in Rome, in 1885, Koch disputed the interpretation that had been put upon these facts.

Eighth, water is perhaps the most important agent in the spread of cholera, and evidence to this effect was obtained long before the discovery of the cholera spirilla. J. Simon brought out some facts in England showing it. At London thirteen deaths out of a thousand inhabitants occurred among those whose houses were supplied with river water in the neighborhood of the sewer. Tested at this point, the water yielded forty-six grains of solid residue to the gallon. In other houses in the city that were in the same hygienic condition, but not supplied with this water, the mortality was only three and seven-tenths in a thousand, but the water which they used had been taken from outside the city, and yielded only thirteen grains of solid residue to the gallon.

At Halle, Delbruck noticed that in prison, where the epidemic had developed very largely, the wells communicated with the drains. At Brachsted the epidemic arrested itself just as soon as a suspected well was closed. Delbruck explained the less intensity of the epidemic of 1867, compared with that of 1866, by the fact that the carrying of the water had been modified. Water was furnished almost pure in 1867, while up to the autumn of 1866 the conduits carried the water from the Saale through a region where all the discharges of the city were scattered. Ballot also spoke of the influence of impure water on the spread of cholera in Holland.

Snow, in England, and innumerable other writers in Europe, India, and America, lay the greatest possible stress upon impure water as the special means for the conveyance of the infective agent of cholera.

The contamination of water played an extremely important part in the extension of cholera in Egypt in the epidemic of 1883. The Mussulman population of Egypt bathe very frequently, but they are not careful about the water that they use for drinking. At Damietta the water is exceedingly foul upon the points of the Nile from which the water-carriers fill their water-casks, and just at these places are the special spots selected for bathing. The houses along the bank discharge their foul material directly into the river, and drains carry to it discharges from other houses, and from the mosques. According to Koch, these mosques play an extremely important rôle in the spread of cholera. The German cholera commission was able at Damietta to examine a number of mosques, the description of the arrangement of which is as follows: Only that part of the mosque that is directed toward Mecca is used for prayers. At the other end is an open space, in the centre of which is a tank for bathing, and sometimes this water remains several weeks without being changed, and surrounding the basin are a series of urinals and closets. The discharges from the whole are passed into the Nile, so that it is not strange that the infected material should be transported by such a water-supply.

The epidemic of 1884 furnished new proofs in favor of the spread of cholera through the agency of water. Messrs. Marey, Brouardel, and Thoinot especially insisted upon this point. Marey, at the sitting of the Academy of Medicine, October 14, 1884, said: "Among the influences that can cause the spread of typhoid fever or cholera there is one that by its intensity dominates all the others—that is the contamination of public water-supplies." If a number of epidemics of cholera be studied, it can be determined, in effect, that cholera easily follows watercourses; that it is especially along small watercourses that it is propagated, is most frequent and striking. In order to explain this, there are but two hypotheses that are possible.

First, brooks, torrents, or rivers flow in valleys that are often narrow and shut in, and the villages found there often can have no communication except with each other. When one is attacked, it is a perfectly simple matter that the others should be also in their turn. This explanation is very plausible; for certain cases, and some epidemics, can be explained in no other way. The great rivers, the large watercourses, along which are scattered regions attacked by cholera, serve for the propagation of this disease, like the great roads of travel, in this way only, that they are lines of communication frequented by travellers.

Second, water is certainly a propagating agent of cholera. It is the water of a torrent, a brook, or a small river, contaminated in one part of its course, that transports the disease to the inhabitants on its borders that drink of the water, and innumerable instances can be brought forward to illustrate this point also.

Proust (loc. cit., p. 216) speaks of the choleraic agent having for its vehicle of transportation either the air or the water, but the evidence in favor of the air as one of the transporting agents of cholera is nothing, and the weight of scientific evidence of late years militates against such a means of transportation. Altitude seems to have but slight influence upon the development of the disease up to a certain point, although Farr (in the Registrar-General's Report on the Mortality of Cholera in England, London, 1852) has attempted to demonstrate that the mortality from cholera was in inverse proportion to the elevation. The objection to this is, that the less frequent occurrence of cholera on the most elevated points may be due to the fact that the less accessible points are more thinly inhabited.

Moisture, taken in connection with the subsoil water, is a favoring cause of the greatest importance, and observations in this direction have furnished the basis for Pettenkofer's theory of the connection of subsoil moisture with cholera.

The development of the epidemics of 1836 and of 1854 seemed to coincide with the period of greatest diminution of the subsoil moisture in Munich, and therefore the choleraic contagion with which the soil is impregnated appears to disengage itself more easily. Hirsch reached a similar conclusion. Kreuzer, in 1855, at Vienna, and again Pettenkofer, at Munich, observed the same facts. Pettenkofer's theory differs from others, in that, putting aside the chemical composition of the earth, he attaches a special importance to its physical characteristics, its density, its porousness, etc. He considers that the condition of the subsoil of localities and of houses plays a rôle of special importance in the propagation of cholera, and upon this special cause he places the development of an epidemic, after an importation from without; and, studying almost exclusively the physical condition of the region, the compact or porous condition of the subsoil, he considers that not only the primitive earth, and the soils of the transition period, but also the secondary formations, produce immunity when they are exposed to air in the condition of rocks. On the other hand, every porous soil that is susceptible of imbibition can become easily impregnated with fluid, or with gas, and vegetable earths as well as silicious earths, may form "fat," always moist, lands, throwing out continual moisture about them, favoring the diffusion of the germs of cholera. Where the soil is made up of a compact calcareous rock, cholera never becomes epidemic, and a few cases observed in such situations as the result of importation, do not propagate the disease.

Pettenkofer's theory has two points that must be distinguished from each other.

First, the nature of the soil. The soil must be porous, easily permeable, and also easily impregnated by liquids and gas. This condition is a permanent one.

Second, the level of the subsoil moisture. This level being movable, the effect is variable; when subterranean waters have reached the maximum of their elevation, there is neither decomposition of organic materials, nor throwing off of miasms. If the subsoil moisture descends to a lower level, putrefaction begins, the miasmatic vapors are thrown off more intensely, and just at this time the epidemic reaches its greatest development. This second point of his theory, certainly an ingenious explanation of certain cases, appears to be much more hypothetical than the first, the question of the porosity of the earth.

To sum up, Pettenkofer's theory, while it scarcely has the value ascribed to it by him, certainly seems to be a partial explanation of the propagation of cholera by means of the porosity and moisture of the earth.

Ninth, atmospheric conditions play a not very important rôle, although the influence of season is manifest, and apparently storms sometimes seem to aggravate considerably an epidemic.

Somatic Conditions.—Race or nationality has no influence upon the development of cholera. The special influences favoring it are those of misery, fatigue, cold, and depressing mental conditions, which, by diminishing the resisting power of the body, render it more susceptible to the influence of the epidemic. Collections of human beings, in other words, agglomeration, plays a very considerable rôle in the propagation of epidemics; so also do methods of transportation. Railroads are often the means of propagation, as was the case in the instance of Altenburg, quoted above. The epidemic of 1865, in Paris, was started by a woman who left Marseilles, with a choleraic diarrhœa, and was attacked with cholera upon her arrival in Paris. Transportation by caravans does not give much chance for the spread of the disease, when the distance passed over is of great extent; in fact, a great desert is the best of all obstacles to the propagation of cholera. In ships is most often found united the conditions of crowding and confinement favorable for the development of the choleraic agent.

Proust appears to believe that these elements do not have much potency if the entire ship's company come from the same infected region—in other words, have

acquired an immunity in a choleraic focus; but if the ship's company has received a partial renewal, if new persons have come on board among the acclimated passengers, cholera finds a new favorable medium for attack, and, if aiding circumstances appear, the ship may become the centre of an intense epidemic. He goes on to speak of this "law of accustoming," in what takes place in armies, the great fairs, and the pilgrimages, for when cholera is carried into these great collections, if the mass of people have not undergone the "choleraic acclimating," the explosion of the disease is rapid, and the mortality considerable, but only continues for a few days, and ceases soon. The Crimean War furnishes an example of the rapidity of development and intensity of the disease among vessels free from the choleraic influence.

At the commencement of April, 1855, there reached Constantinople from France, fifteen to twenty thousand troops, made up in part of the Imperial Guard. These troops had not, during their voyage, a single case of cholera among them. They camped on the heights of Masslak, in an extremely healthy situation, and at that time there were in the city of Constantinople but very few traces of cholera. The rolls of the French military hospitals gave only fifty-three cases during March, and the roll of April 11th showed none. In the Crimea the cases of cholera were also very few, and nevertheless the troops were hardly settled at Masslak, when, on the night of April 14th and 15th, cholera broke out among them, and a severe epidemic followed.

Fauvel ("Memoire lu à l'Acad. des Sciences," Paris, 1883) sums up this question of immunity in the following propositions:

"1. The ports of India that are the seat of endemic cholera are never the scene of a great epidemic.

"2. This fact relates to the general, but not absolute, immunity enjoyed by the native population of these parts.

"3. This immunity does not exist in the endemic localities for strangers who are in a condition favorable for contracting the disease. These are especially the Mussulman pilgrims who come to Bombay to embark for Mecca.

"4. The epidemics of cholera that develop in India, in the regions where the disease is not endemic, come from the places where it is endemic, and are favorable for attacking the Hindu pilgrimages.

"5. The epidemics observed among the pilgrims to Mecca can also be traced to the localities where cholera is endemic.

"6. A severe epidemic of cholera confers upon the country or upon the locality which it has attacked a more or less complete immunity, which is more or less durable, and of which it is impossible to formulate the law for Europe, but which in India appears to last for a number of years.

"7. In the Hedjaz, and in the sparsely populated parts of Arabia, cholera has but a feeble tendency to propagate itself among the native population.

"8. The fact of the existence of a great epidemic of cholera in any country whatever is a proof that cholera is not there endemic."

To sum up, new scientific facts bear upon the question of immunity and make them clear upon a side hitherto unknown. The etiology and prophylaxis, in especial, of cholera receive from these facts new indications, and these facts also appear to be the expression of a law that includes an entirely different category of infectious diseases, which leave after them an immunity of a greater or less extent."

Period of Incubation.—The question of the period of incubation of cholera gives rise to a great deal of discussion. It appears, however, that in the immense majority of cases a period of a few days is sufficient for the incubation, and that sometimes this may require only a few hours. This fact is easy to observe if the beginning of the disease in a city or upon a ship be studied.

The Cholera Conference at Constantinople concluded as follows: "That all the facts cited in regard to a period of incubation longer than a few days are based upon cases that are not conclusive, either because the premonitory diarrhœa was comprised in the period of incubation, or because the infection could have occurred after the departure from the infected locality. The following is an instance:

On November 3, 1848, upon the ship Swanton there were two hundred and eighty-nine emigrants for New Orleans, and the cholera did not break out on board until November 25th,—that is to say, the twenty-third day of the voyage,—and occasioned thirteen deaths. A certain number of these emigrants came from points in Germany where the cholera existed. This long period of incubation can be explained upon two hypotheses: either the passengers had with them clothing soiled with choleraic materials, which, placed in a confined air, could transmit cholera; or certain of the individuals embarked might have been affected at the time of their embarkation with a diarrhœa that might later have developed into true cholera. The duration of this premonitory diarrhœa has been much discussed, and in general it has been concluded that it does not last more than three days, and when it does pass this period, it is rarely prolonged beyond a week, and that therefore an individual isolated from all sources of contamination, and in whom the diarrhœa should be prolonged more than eight days after this isolation without presenting any characteristics of cholera, could be considered non-choleraic. But Griesinger among others dissents from this opinion, and declares that the period of incubation of cholera may be much longer. Bacteriological examination is the only method of settling the question.

Description of the Disease. — Asiatic cholera, in individual cases, has no marked characteristics distinguishing it from similarly violent attacks of "cholera nostras;" the only absolute method of making a diagnosis in single cases is by the discovery of the spirillum of the disease and its identification. In general, an attack may suddenly develop, its onset being marked by great uneasiness, repeated discharges from the bowels, followed by syncope. This attack may overtake the victim while walking on the street in apparently good health. It is often preceded by a state of vague suffering, rapid prostration, deep colicky pains, anorexia, sometimes a diarrhœa, profuse sweats, disturbance of the senses, and more or less of retardation of the pulse. After the development of the disease the symptoms follow each other in such a way as to allow of a division into two distinct periods.

First Period.—This is marked by an increase in the number of dejections and acts of vomiting; a flux is established which is at first serous or slightly bilious, and afterward becomes "choleraic." This term is used to designate those characteristic discharges of cholera which are liquid, whitish, grumous, sometimes resembling unclarified whey, sometimes a decoction of rice or oatmeal, and sometimes thickened meal, and nearly clear, which emit an insipid spermatic odor, and sometimes present traces of blood or bile. These evacuations are rarely absent, often continuing to the termination of the disease. Burning thirst, pain in the epigastrium, and prolonged hiccough are usual accompaniments. Intense cramps of the limbs occur, particularly in the calves of the legs; the muscles are often in a state of tonic contraction. Spasmodic movements, as involuntary flexion and extension of the fingers and toes, may often be seen. The pulse is very feeble, often imperceptible. The features are altered, trembling and great agitation come on, the pulse becomes suppressed; bluish spots appear, first upon the extremities; the skin becomes blue or black almost everywhere; the nails are livid and almost black, the fingers wrinkled, and the genital organs retracted. The volume of the body diminishes rapidly and perceptibly; the eyes sink in and are dull, with a bluish circle surrounding them; the conjunctiva fades, respiration is slow and feeble, the breath cold, and the pulse is reduced to a mere oscillation. The secretions are arrested, especially the urine, the voice is reduced to a whisper, the nose is cold and—rarely—gangrenous, the cornea is flattened and puckered; spots of blood appear on the sclerotic, viscid sweat on the face and limbs; the intellect

becomes obscured, respiration is embarrassed, hiccough commences, and death follows, in the midst of an apparent calm. This is called the *cold*, *livid*, or *asphyxic* period. When patients escape death in this stage they enter upon the

Second Period.—In this the coldness ceases to increase, warmth returns, the pulse improves and gradually becomes febrile, the face regains color, the eye becomes animated, and a general reaction occurs.

If recovery is to be easy and rapid, vomiting becomes less frequent, the diarrhœa remains, but the discharges no longer present the appearance peculiar to the disease; the secretion of urine returns, nausea, thirst, and pains in the stomach cease to be felt, the pulse becomes regular, and convalescence begins.

If reaction is incomplete, the cold stage returns with renewed severity, or, on the other hand, if reaction be too severe, such accidents may occur as apoplexies, spasms, convulsions, local congestions and inflammations, and occasionally latent pneumonia. Stupor is sometimes present, with some of the signs of the last stage of typhoid fever. Swelling of the parotid glands and various skin affections, as roseola, urticaria, erythema, erysipelas, etc., may appear toward the close of the disease.

The average duration is from one to three days, but sometimes death occurs in less than six hours, and is occasionally delayed a long time—in one case for fifty days.

Complications and Secondary Affections. — Complications are rare, and apparently accidental; among them peritonitis, jaundice, gangrene, œdema of the lungs, erysipelas of the face, abscesses, ulcerations of the eyelids, and aphthæ may be mentioned as of occasional occurrence. Secondary affections are, however, very common. They may consist of gastro-intestinal inflammations—immediate or occurring after some days of convalescence—or of affections of the respiratory organs. In other cases, persons who have apparently escaped the accidents of cholera have a secondary fever, described as of a typhoidal type —dry skin, tension and tenderness in the epigastrium, jactitation, dry tongue, bilious stools, and chills. Various skin eruptions occur, and temporary albuminuria has been observed following an attack of cholera. The most grave of the secondary affections, however, are those which affect the nervous system. The cerebral congestions during reaction are, in some cases, followed by a typical meningitis with trismus. Rayer's "État Cérébral cholérique" includes a group of phenomena distinct from those of meningitis, which supervene upon the cold stage; the skin is cold, the pulse feeble, the head heavy, the countenance stupid, and sometimes the cholera tint remains. Another affection is a sort of non-febrile delirium, lasting for two or three days, and the spasmodic contraction of the forearm which occurs during convalescence. True intermittent febrile attacks, with initial chills, occurring every day during reaction, have also been observed. All these affections are, for the most part, more rapid than when occurring in an individual previously healthy.

Course, Duration, and Termination.—If death does not occur during the algid stage, a peculiar transformation in the disease takes place and *reaction* sets in. This reaction varies in different cases, being slow and tedious in some, and abrupt and rapid in others; its course is not essentially modified by any antecedent disease, even those occurring as complications.

In the vast majority of cases cholera runs its course with great rapidity, the greater number of attacks lasting from eighteen to twenty-four hours, the shortest from one to six hours, and the longest from fifteen to twenty days. Its duration is the shortest at the height of an epidemic.

The termination of epidemic cholera may be favorable, the progress of recovery varying widely in different cases; it may be complete in a few hours even, and the patient may return to his ordinary occupation; on the other hand, it may be delayed until after a long and perilous struggle against complications and secondary affections. There may remain a general debility such as is not often seen after any other disease; the emaciated features, languishing expression, capricious appetite, obstinate gastralgia, colic, wakefulness, tendency to coldness, partial or general, and intellectual and moral dejection persist for a long time. An attack has been known to change the whole constitution and temperament of a patient. One attack appears to furnish no immunity against another, and relapses are always to be feared.

Forms.—The forms spoken of—the common or grave, such as has just been described, "cholerine," foudroyant cholera, and paralytic cholera, described by the Russians and Germans—are all merely the same disease, occurring in varying forms of intensity.

Pathological Anatomy.—The alterations of the internal organs in a case of death from cholera bear little relation to the violence of the disease. The appearances are about as follows: Emaciation is general, and there is marked lividity of the lips and nostrils. Rigor mortis is not rare before the warmth of the body has wholly departed. The peritoneal surface is sticky and covered with a viscid exudation; the vessels of the mesentery are engorged with blood. The calibre of the intestinal canal is more often increased than diminished, and always contains some fluid choleraic matter. The fluid is blood-serum, and the thicker material found in it is made up of intestinal epithelial cells and mucus. The intestinal mucous membrane is usually normal in thickness, but is generally denuded of epithelium. The villi are swollen, giving the surface a velvety appearance, and Peyer's patches and the solitary follicles are much enlarged. The glands of the stomach and of the duodenum are enlarged, and the surface is largely denuded of epithelium. There are no special lesions of the other organs. The liver is rarely enlarged, but is usually congested with dark, thick blood. The gall-bladder is also generally distended with bile, which is thicker than normal. The biliary duct is not obstructed. The pancreas presents no marked alteration. The spleen, in rapid cases, is small, hard, and wrinkled upon its surface, of a deep red color on section, and sometimes dotted with ecchymoses; in slow cases it may be slightly enlarged and less deep red in color. The blood is thicker than normal, coagulates slowly, and the separation into clot and serum is very incomplete. The corpuscles are not altered in shape, but there is a remarkable diminution in the proportion of water and neutral salts, and a decrease in the amount of fibrin and albumin. The heart is usually soft and flabby, with ecchymoses in the pericardium. The left side is apt to be empty and contracted, the right distended with dark, thick blood. The arteries are, in general, nearly empty, the veins distended with blood. The pleuræ are very frequently coated with a glutinous, stringy substance, and ecchymoses often appear in the sub-pleural cellular tissue. The lungs are usually healthy, but presenting engorgements at the posterior portions. The bronchi are much congested, and may contain a white, stringy mucus, analogous to that found lining the intestinal canal. The condition of the brain and spinal cord, together with their appendages, is merely that of congestion without special lesion, although it has been declared that there is a sensible increase in their consistency. The ganglionic system presents no change worthy of notice. The muscles are often engorged with blood, and a very marked reddish-brown discoloration of the bones and of the teeth has been noticed in those dying of asphyxia. Renal congestion is the marked symptom in connection with the genito-urinary tract, and the straight tubules are often completely stripped of their epithelium. In those dying in the cold stage the bladder is empty and firmly contracted.

Description of the Spirillum of Cholera and of Certain Organisms Allied to It.—*The Nature of the Contagium Vivum of Cholera* (see Sternberg's "Manual of Bacteriology," New York, 1892.).—Asiatic cholera is without doubt due to a special organism—the so-called "comma bacillus" of Koch—this name being a misnomer, for the bacterium is not a bacillus, but a spirillum.

The parasitic nature of the disease was suspected for a long time. A number of observers had noted the presence, in the cells, of bacteria answering the description of this special one, but it was not until the advance in methods of observation had progressed a long way that it was possible to isolate the organism, and study it under artificial conditions in such a manner as to obtain the evidence necessary to connect it with the process as a causal

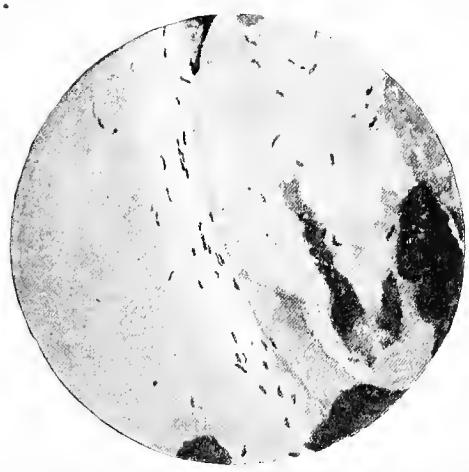

FIG. 17.—Cholera Vibrio. Intestinal Contents of a Man Dead of Cholera. Cover-glass Preparation Stained with Fuchsine. (Fraenkel.) × 1000.

factor. It was in the year 1883 that Koch first discovered and described the spirillum of Asiatic cholera, which he first found during his investigation in Egypt during the epidemic there, and studied further during the following winter in India.

The organism occurs especially in the small intestine, is generally wholly confined to the contents of the intestine and the glandular cul-de-sacs, but is occasionally found in the intestinal walls. It is exceptional to find it in any other part of the body, and it is not strange that investi-

FIG. 18.—Cholera Vibrio. — Bouillon Culture, Two Days Old. Cover-glass Preparation Stained with Fuchsine. (Fraenkel.) × 1000.

gations undertaken with the idea that cholera was a generalized disease were not productive of results. The bacterium is found in large quantities in the dejecta, and sometimes—in fact not infrequently—in almost a pure culture.

In the intestines and in the dejecta it presents the appearance of a short, thick rod, slightly curved in the long diameter, hardly half as long, but considerably thicker than the bacillus of tuberculosis. It usually occurs in this situation singly, but not infrequently it is arranged in pairs, with the curves opposed to each other, and thus recalling the shape of the letter "S". Under cultivation in bouillon it appears longer and thinner, and there are many true spirilla to be seen in the preparations made from such a culture.

A characteristic that is of especial interest, is its

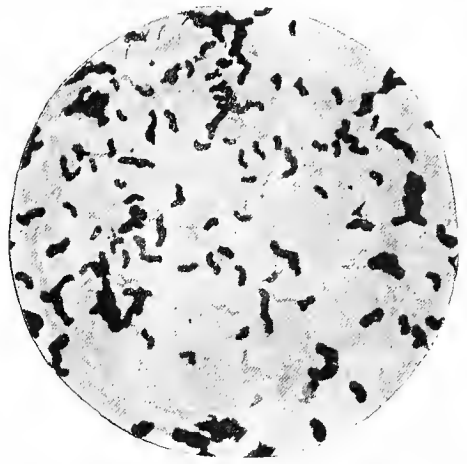

FIG. 19.—Cholera Vibrio. Agar Culture, Twenty Hours Old. Cilia Bearing Cells. Cover-glass Preparation, Stained with Fuchsine. (Fraenkel.) × 1000.

extreme motility, which has been demonstrated by Löffler to be due to a fine cilium placed at one end of the organism.

Shape and motility are not, however, sufficient to differentiate this bacterium from others with similar characteristics—and there are many that possess such,—but the method of development upon the various culture-media is entirely characteristic, and, as shown by Koch, is all that is necessary for separating this one in particular from the others that resemble it. It liquefies gelatine,

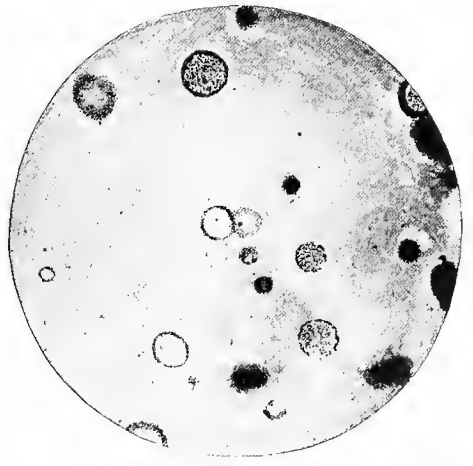

FIG. 20. — Cholera Vibrio. Colonies on Gelatine Plate, Twenty-four Hours Old. (Fraenkel.) × 100.

but it does this slowly, and at the same time a certain part of this liquefied portion evaporates, and as a result there is a special appearance that can hardly be confounded with anything else. At the upper portion of the gelatine, there is a round cavity full of air, and as the surrounding gelatine has remained solid, the appearance is that of a bubble of air in the midst of the upper part of the gelatine and above the liquefied part. The

appearance is wholly different when the organism found by Finkler is put under the same conditions, and equally so with the cheese-spirillum of Deneke.

Description of the Cholera Spirillum.—Discovered by Koch, in 1884, in the excreta of cholera patients, and in the contents of the intestine of recent cadavers. The etiological relation of this organism to Asiatic cholera is now generally admitted by bacteriologists.

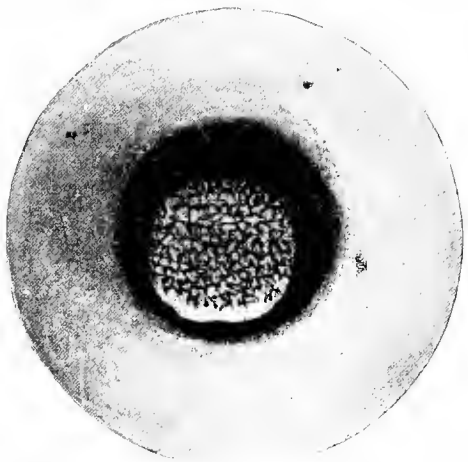

FIG. 21.—Cholera Vibrio. Colony on Gelatine Plate, Forty-eight Hours Old. (Fraenkel.) × 150.

Morphology.—Slightly curved rods, with rounded ends, from 0.8 μ to 2 μ long, and about 0.3 μ to 0.4 μ broad. They are usually but slightly curved, like a comma, but are occasionally in the form of a half-circle, or two united rods curved in opposite directions, forming an S-shaped figure. Under certain circumstances these curved rods may develop into long spiral filaments, and in hanging-drop cultures the S-shaped figures may also be seen to form the commencement of a spiral. In stained preparations the spiral character of the long filaments is often obliterated, or nearly so. When development is very rapid, the short curved rods, or S-shaped spirals, only are seen, but in hanging-drop cultures, or in media in which the development is retarded by an unfavorable temperature, the presence of a little alcohol, and so on, the long spiral filaments are quite numerous, and it is quite generally agreed that the so-called comma bacillus is really only a fragment of a true spirillum.

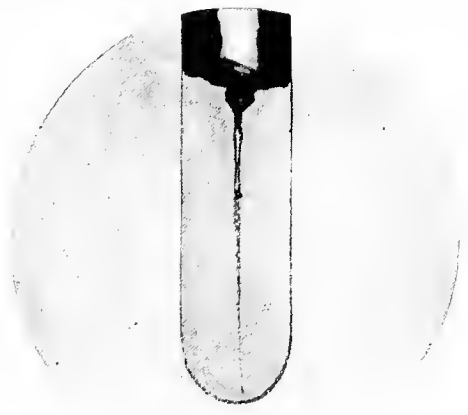

FIG. 22.—Cholera Vibrio. Needle Culture in Gelatine, Forty-eight Hours Old. Natural Size. (Fraenkel.)

By Löffler's method of staining, the rods may be seen to have a single terminal flagellum. In old cultures the bacilli frequently lose their characteristic form, and become variously swollen and distorted. Hueppe has described the appearance of spherical bodies in the course of the spiral filaments which he believes to be reproductive elements, the so-called arthrospores. The cholera bacillus stains with the usual aniline colors, but not as quickly as many other bacteria. It is best stained by a watery solution of fuchsin. It will not stain by Gram's method. Sections may be stained by Löffler's methylene blue.

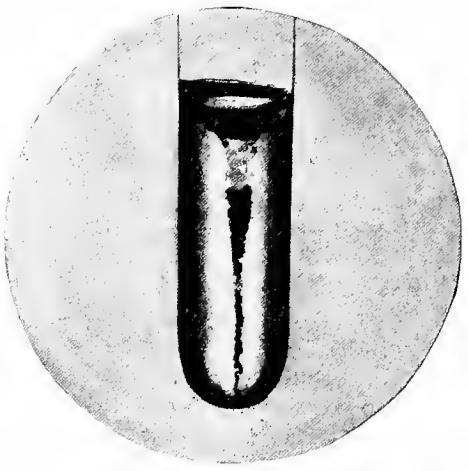

FIG. 23.—Cholera Vibrio. Needle Culture in Gelatine, Six Days Old. Natural Size. (Fraenkel.)

Biological Characters.—It is an aërobic, facultative anaërobic, liquefying, motile spirillum, grows in the usual culture-media at the room temperature, more rapidly in the incubator, does not develop above 42° C. or below 14° C., does not form endogenous spores. It forms arthrospores, according to Hueppe. In gelatine plate cultures, at 22° C., at the end of twenty-four hours small white colonies may be perceived in the depth of the gelatine. These grow toward the surface, and cause liquefaction of the gelatine in the form of a funnel that gradually increases in depth, and at the bottom of which is seen the colony, in the form of a small white mass. As a result of this, the plates on the second or third day appear to be perforated with numerous small holes; later, the gelatine is entirely liquefied. Under a

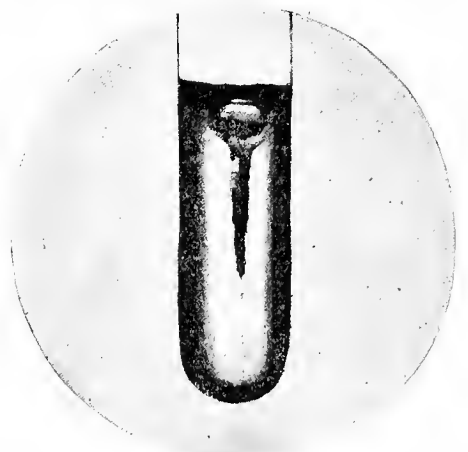

FIG. 24.—Cholera Vibrio. Needle Culture in Gelatine, Three Days Old. Natural Size. (Fraenkel.)

low power, the young colonies, before liquefaction has commenced, present a somewhat characteristic appearance. They are of a white, or pale yellow color, with a more or less irregular outline, the margins being rough and uneven; the texture is closely granular, and the surface looks as if it was covered with little fragments of broken glass, while the colony has a shining appearance. When liquefaction commences, an ill-defined halo is first seen to surround the granular colony, which by transmitted light has a peculiar roseate hue.

In gelatine needle cultures development occurs all along the line of inoculation, but liquefaction of the gelatine occurs at first only near the surface. On the second day, at 20° C., a short funnel is formed that has a comparatively narrow mouth, the upper portion containing air; just below this is the whitish viscid mass. At the end of from four to six days, the funnel, having increased in depth and diameter, may reach the walls of the test-tube. In from eight to fourteen days the upper two-thirds of the gelatine is completely liquefied. Owing to the slight liquefaction occurring along the line of growth the first three or four days, the central mass that has formed along the line of inoculation settles down as a curved or irregularly bent yellowish-white thread, in the lower part of a slender tube filled with liquefied gelatine, the upper part of which widens out, and is continuous with the funnel above.

On the surface of nutrient agar a moist, shining, white layer is formed along the line of inoculation. Blood-serum is slowly liquefied. On potato in the incubator, a rather thin semi-transparent brown, or grayish-brown layer is developed.

In nutrient bouillon, the development is abundant and rapid, especially in the incubator. The fluid is only slightly clouded, but the spirilla accumulate at the surface, forming a wrinkled membranous layer.

Sterilized milk is also a favorable culture-medium.

In general this organism grows in any fluid containing a small quantity of organic material and having a slightly alkaline reaction. An acid reaction of the culture-medium prevents its development as a rule, but it has the power of gradually accommodating itself to the presence of vegetable acids, and grows upon potatoes (in the incubator only) which have a slightly acid reaction. Abundant development occurs in bouillon which has been diluted with eight or ten parts of water, and the experiments of Wolffhügel and Riedel show that it also multiplies to some extent in sterilized river- or well-water, and that it preserves its vitality in such water for several months, but in milk or water containing other bacteria it dies out in a few days. This organism is destroyed, in recent cultures, in nutrient gelatine at 52° C., as determined by Sternberg, the time of exposure being four minutes. A few colonies only develop after exposure to a temperature of 50° C. for ten minutes. In Kitasato's experiments ten or even fifteen minutes' exposure to a temperature of 55° C. was not always successful in destroying the vitality of the spirilla, although in certain cultures exposure to 50 C. for fifteen minutes was successful. The low resisting power to heat, desiccation, and chemical agents, indicates that this organism does not form spores, and many bacteriologists agree that this is the case.

Hueppe has described a mode of spore formation which is different from that occurring among the bacilli, that is, the formation of so-called arthrospores. These are said to be developed in the course of the spiral threads, not as endogenous, refractive spores, but as spherical bodies with a somewhat greater diameter, and somewhat more refractive; but this method of spore formation has not been observed by others who have investigated the question, and cannot be considered as established.

The test for the presence of the cholera spirilla originated by Bujwid and by Dunham consists in the reddish violet color produced in the bouillon cultures containing peptone, or in cultures in nutrient gelatine, when a small quantity (five to ten per cent.) of sulphuric acid is added to the cultures. According to Fraenkel this test serves to distinguish it from the ordinary bacteria of the intestine, and from the Finkel-Prior spirillum, but not from Metschnikoff's spirillum. The reaction is shown by bouillon cultures which have been in the incubator for ten or twelve hours, and by gelatine cultures in which liquefaction has occurred. The sulphuric acid should be quite pure. The color quickly appears, and is reddish violet or purplish red. According to Salkowski, the red color is due to the well-known indol reaction, which in cultures of the cholera spirillum is exceptionally intense and rapid in its development.

The most satisfactory method for obtaining the "cholera-red" reaction,—as we have had lately abundant opportunity to verify,—is that of Beyerinck (Cat. f. Bact. ü. Parasit. Bd. xii. S. 715) in which cultures are made in filtered neutralized one-half per cent. solution of commercial peptone, at 37° C. After twelve to twenty-four hours the cultures are cooled, and from two to five drops of C. P. Sulphuric Acid are added. If the spirillum be present, a very marked and beautiful rose-violet color is produced in the course of a few moments.

A test which is said to distinguish cultures of the cholera spirillum from the spirillum of Deneke and that of Finkler-Prior has been suggested by Cahen. This consists in adding a solution of litmus to the bouillon, and in making the cultures at 37° C. The cholera

Fig. 25.—Cholera Vibrio. Bouillon Culture, Three Weeks Old. Involution Forms. Cover-glass Preparation, Stained with Fuchsine. (Fraenkel.)

cultures show on the following day a decoloration which does not occur at this temperature with the other spirillum named. For determining as promptly as possible whether certain suspected excreta contain the cholera spirilla, a little of the material may be used to inoculate greatly diluted bouillon, gelatine plates being made at the same time. At the end of ten or twelve hours the cholera spirilla, if present, will already have formed a characteristic wrinkled film upon the surface of the bouillon. A little of this should be used to start a new culture in bouillon, and a series of gelatine plates made from it, after which the cholera test may be applied. The result of this, in connection with the morphology of the micro-organisms forming the film, and the character of growth in the gelatine plates, will establish the diagnosis, if the cholera spirillum is present in considerable numbers; if but few are present in the original material it may be necessary to make two or more series of plates and bouillon cultures before a pure culture can be obtained, and a positive diagnosis made.

Pfeiffer has just published (in 1892) his researches upon the cholera poison. He finds that recent aërobic cultures of the cholera spirillum contain a specific toxic substance fatal to guinea-pigs in extremely small doses. This substance stands in close relation with the bacterial cells, and is perhaps an integral part of the same.

The spirilla may be killed by chloroform, thymol, or

by desiccation without apparent injury to the toxic character of this material. It is destroyed, however, by absolute alcohol, by concentrated solutions of neutral salts, and by the boiling temperature, and secondary products are formed which have a similar physiological action, but are from ten to twenty times less potent.

Similar toxic substances were obtained by Pfeiffer

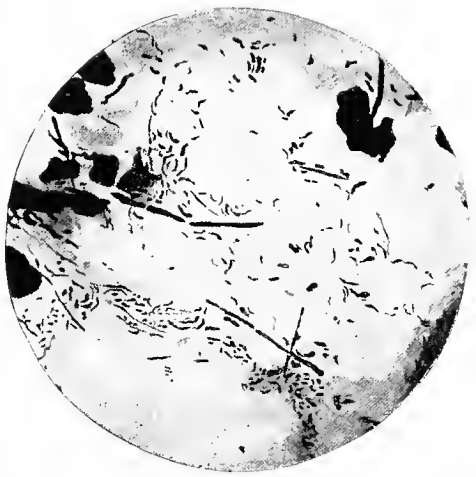

FIG. 26.—Tooth-scraping. Curved Bacilli, Spirochaëte and Leptothrix. Cover-glass Preparation, Stained with Gentian Violet. (Fraenkel.) · 1000.

from cultures of Finkler-Prior's spirilla, and from the spirilla of Metschnikoff.

The spirillum is not found in the blood, nor in the various organs of individuals dead of cholera, but is always found in the discharges during life, and in the contents of the intestines examined immediately after death, frequently in almost a pure culture in the colorless rice-water discharges. It is evident, therefore, that the morbid phenomena must be ascribed to the absorption of toxic substances formed during its growth in the intestine. In cases which terminated fatally after a very

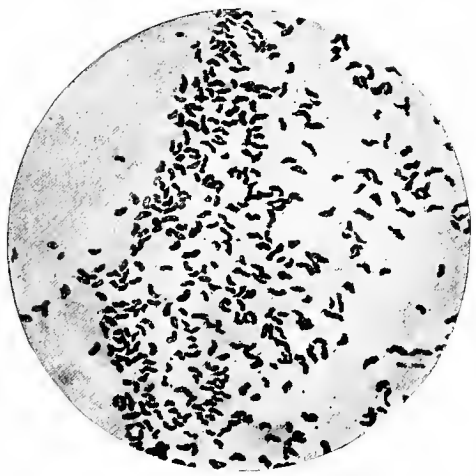

FIG. 27.—Finkler-Prior's Vibrio. Gelatine Culture. Cover-glass Preparation, Stained with Fuchsine. (Fraenkel.) · 1000.

brief sickness Koch found but very slight changes in the mucous membrane of the intestine, which was slightly swollen and reddened; but in more protracted cases, the follicles and Peyer's patches were reddened about their margins, and an invasion of the mucous membrane by the organisms was observed in properly stained sections. They penetrated especially the follicles of Lieberkühn, and in some cases were seen between the epithelium and the basement membrane. As a rule, the spirillum is not present in vomited material, but Koch found it in small numbers in two cases, and Nicati and Rietsch in three. All observers have found the organism always present in cases of true cholera; on the other hand, very numerous control experiments fail to show its presence in the intestinal contents of healthy persons, or in that of those dead from other diseases.

Nicati and Rietsch observed a certain degree of attenuation in the pathogenic power of the spirillum, after it had been cultivated for a considerable time at from 20° to 25° C., and the observation has since been made that cultures which have been kept up from Koch's original material have no longer the original pathogenic power.

Cunningham in his recent publications gives the following conclusions as the result of his own bacteriological studies:

1. In many undoubted cases of cholera he has failed to find the "comma bacilli."
2. In one case he found three different species.
3. From sixteen cases in which he made cultures he obtained ten different kinds of curved bacilli, the characters of which are given in his report.

It is possible that in India, which appears to be the

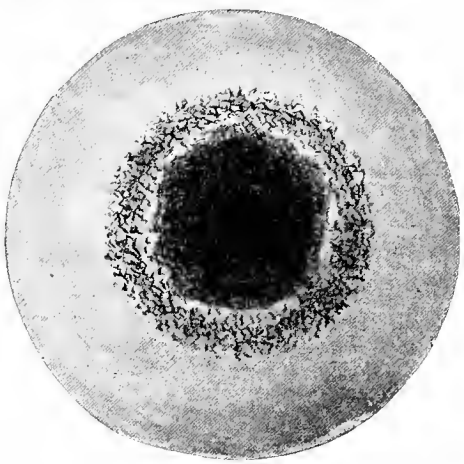

FIG. 28.—Finkler-Prior's Vibrio. Colony on Gelatine Plate, Twenty-four Hours Old. (Fraenkel.) · 100.

permanent habitat of the cholera spirillum, many varieties of this micro-organism may exist, but extended researches made in the laboratories of Europe show that Cunningham is mistaken in supposing that spirilla resembling "comma bacilli" are commonly present in the intestines of healthy persons. Sternberg says that in very extended researches, made in the United States and in Cuba, he has never found any micro-organism resembling Koch's cholera spirillum, in the dejecta of patients with yellow fever, or of healthy individuals, or in the intestinal contents of yellow fever cadavers.

The organism most likely to be confounded with the cholera spirillum, and from which it must be differentiated by the methods of cultivation, as well as by the aid of the microscope, is the spirillum of Finkler-Prior, otherwise called the vibrio proteus. It was obtained by Finkler and Prior in 1884, from the fæces of patients with cholera nostras, after allowing the dejecta to stand for some days. Subsequent researches have not sustained the view that this spirillum is the specific cause of cholera nostras.

Morphology of the spirillum of Finkler-Prior: It resembles the spirillum of Asiatic cholera, but the curved segments are somewhat longer and thicker, and not so uniform in diameter, the central portion being usually thicker than the somewhat pointed ends; it forms spiral filaments which are not as numerous, and are usually

shorter than those formed by the cholera spirillum. In unfavorable media other forms are common, such as large oval, spherical, or spindle-shaped cells. It has a single flagellum at one end of the curved segments, which is from one to one and a half times as long as these. It stains with the usual aniline colors—best with a watery solution of fuchsin.

Biological Characters: Is an aërobic and facultative anaërobic, liquefying, motile spirillum; spore formation not demonstrated; grows in the usual culture-media at the room temperature.

Upon gelatine plates small, white punctiform colonies may develop at the end of twenty-four hours, which under the microscope are seen to be finely granular, and yellowish, or yellowish-brown in color. Liquefaction of the gelatine around these colonies progresses rapidly, and at the end of forty-eight hours is usually complete in plates where they are numerous. Isolated colonies on the second day form saucer-shaped depressions in the gelatine, the size of lentils, having a sharply defined border.

In gelatine needle cultures, liquefaction progresses much more rapidly than in similar cultures of the cholera spirillum, and a funnel of liquefied gelatine is to be seen on the second day, so that by the end of a week the gelatine is usually completely liquefied. Upon the surface of the liquefied medium a whitish film is seen.

Upon agar a moist, slimy layer covering the entire surface is quickly developed.

The growth in blood-serum is rapid and causes liquefaction of the medium.

Upon potato this spirillum grows at the room temperature, and produces a slimy, grayish-yellow glistening layer, which soon extends over the entire surface. The cholera spirillum does not grow upon potato at the room temperature. The cultures give off a fairly strong putrefactive odor, and, according to Buchner, in media containing sugar an acid reaction is produced as a result of their development. They have a greater resistance to desiccation than the cholera spirilla.

Pathogenesis: Pathogenic for guinea-pigs when injected into the stomach by Koch's method, after previous injections of carbonate of soda, but a smaller proportion of the animals die from such injections (Koch). At the autopsy the intestine is pale, and its watery contents, which contain the spirilla in great numbers, have a penetrating, putrefactive odor.

Another organism resembling that of Asiatic cholera is the spirillum of Deneke, called the cheese, or the spirillum tyrogenum, which was obtained by Deneke in 1885 from old cheese.

Morphology of the spirillum of Deneke: Curved rods, and long spiral filaments resembling the spirilla of Asiatic cholera. The diameter of the curved segments is somewhat less than that of the cholera spirillum, and the turns in the spiral filaments are fewer and closer together. The diameter of the segments is uniform throughout, so that this organism more closely resembles the cholera spirillum than does the preceding. It stains with the usual aniline colors—best with a watery solution of fuchsin.

Biological characters: Is an aërobic and facultative anaërobic motile spirillum; spore formation not demonstrated; grows in the usual culture-media at the room temperature, more rapidly than the cholera spirillum, and less so than that of Finkler and Prior. Upon gelatine plates small pin-point colonies are developed, which on the second day are about the size of a pin's head, and have a yellowish color. Under the microscope they are seen to be coarsely granular, of a yellowish-green color in the centre, and paler toward the margins. The outlines of the margins are sharply defined at first, but later, when liquefaction has commenced, the sharp contour is no longer seen. At first, liquefaction of the gelatine causes funnel-shaped cavities resembling those formed by cholera spirilla, but liquefaction is more rapid.

In gelatine needle cultures liquefaction occurs all along the line of puncture, and the spirilla sink to the bottom of the liquefied gelatine in the form of a coiled mass, while a thin yellowish layer forms upon the surface. Complete liquefaction usually occurs in about two weeks.

Upon the surface of agar a thin yellowish layer forms along the needle-track.

Upon potato, at a temperature of 37° C., a thin yellow

Fig. 29.—Finkler-Prior's Vibrio. Needle Culture in Gelatine, Forty-eight Hours Old. Natural Size. (Fraenkel.)

layer is usually developed, but not always, and it contains as a rule beautifully formed spiral filaments.

Pathogenesis: It is pathogenic for guinea-pigs when introduced into the stomach by Koch's method; three out of fifteen animals treated in this way died.

Still another organism resembling the spirillum of Asiatic cholera is: the spirillum of Metschnikoff, obtained by Gameleia in 1888, from the intestinal contents of chickens dying of an infectious disease which prevails in certain parts of Russia during the summer months, and which in some respects resembles chicken

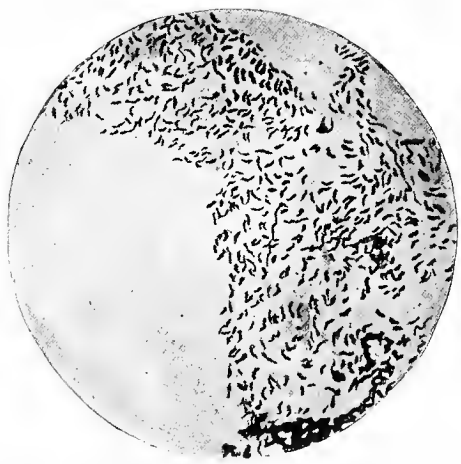

Fig. 30.—Vibrio of Metschnikoff. Gelatine Culture. Cover-glass Preparation, Stained with Fuchsine. (Fraenkel.) × 1000.

cholera. His experiments show that the spirillum under consideration is the cause of the disease referred to, which he calls gastro-enteritis cholerica.

Morphology of the spirillum of Metschnikoff: Curved rods with rounded ends and spiral filaments. The curved segments are usually somewhat shorter, thicker, and more decidedly curved than is the spirillum of Asiatic cholera. The size differs very considerably in the blood of inoculated pigeons, the diameter being sometimes

twice as great as that of the cholera spirillum, and at other times about the same. A single long undulating flagellum may be seen at one extremity of the spiral filaments or curved rods in properly stained preparations. It stains with the usual aniline colors, but not by Gram's method.

Biological characters: An aërobic, facultative anaërobic (?), liquefying motile spirillum. According to Gamaleia, endogenous spores are formed by this spirillum, but Pfeiffer does not confirm the observation, and it must be considered extremely doubtful, in view of the slight resistance to heat (killed in five minutes by a temperature of 50° C.). Grows in the usual culture-media at the room temperature.

Upon gelatine plates small white pin-point colonies are developed at the end of twelve to sixteen hours. These rapidly increase in size, and cause liquefaction of the gelatine, which takes place, however, much more rapidly with some than with others. At the end of three days, large saucer-shaped areas of liquefaction may be seen, resembling those produced by the Finkler-Prior spirillum, the contents of which are turbid, while other colonies have produced small funnel-shaped cavities filled with transparent liquefied gelatine, resembling colonies of the cholera spirilla of the same age. Under the microscope

FIG. 31.—Vibrio of Metschnikoff. Needle Culture in Gelatine, Forty-eight Hours Old. Natural Size. (Fraenkel.)

the larger liquefied areas are seen to contain yellowish-brown granular masses, which are in active movement, with the margins surrounded by a border of radiating filaments.

In gelatine needle cultures the growth resembles that of the cholera spirilla, but the development is more rapid. Upon agar at 37° C. a yellowish layer resembling that formed by the cholera spirilla is quickly developed.

Upon potato no growth occurs at room temperature, but at 37° C. a yellowish-brown or chocolate-colored layer is formed, which closely resembles that produced by the cholera spirillum under the same circumstances. In bouillon at 37° C. development is extremely rapid and the liquid becomes clouded and opaque, having a grayish-white color, while a thin, wrinkled film forms upon the surface. When muriatic or sulphuric acid is added to a culture in peptonized bouillon, a red color is produced, similar to that in cultures of the cholera spirillum, and even more pronounced. In milk at 35° C. rapid development occurs, and the milk is coagulated at the end of a week. The precipitated caseine accumulates at the bottom of the tube in irregular masses, and is not redissolved. The milk acquires a strongly acid reaction, and the spirilla quickly perish.

Pathogenesis: It is pathogenic for chickens, pigeons, and guinea-pigs. Rabbits and mice are refractory, except for very large doses. A few drops of a pure culture inoculated subcutaneously in pigeons, or injected into their muscles, cause their death in eight to twelve hours. At the autopsy an excessive subcutaneous œdema is found in the vicinity of the point of inoculation, and a superficial necrosis may be observed. The blood and the organs generally contain the vibrio in great numbers, showing that the animals die from general infection—acute septicæmia.

In spite of all that has been said since the first announcement by Koch that he considered his spirillum to be the cause of cholera, and the many assertions to the contrary, the relationship between the two to-day is practically universally admitted. The opinion to this effect is based upon a number of reasons, some of which are as follows:

1. The spirillum of Koch has never been found in any other situation, a point that has been established by innumerable observations.

2. This spirillum is found in all cases of Asiatic cholera, without exception, provided that the case is not too far advanced. In such a case there has been a secondary infection, that has killed out the true organism and masked its effects. (To this class must be assigned Emmerich's "Naples bacillus.") Ever since the first announcement of this discovery by Koch, observers have carried out his assertions in all parts of the world where cholera has been investigated at all—in France, Italy, Austria, Hungary, Germany, India, China, Japan, etc.

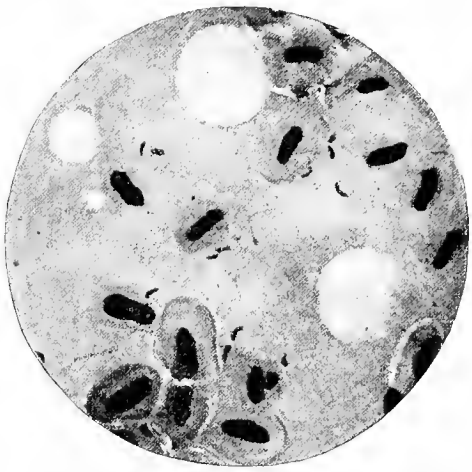

FIG. 32.—Vibrio of Metschnikoff. Pigeon's Blood. Cover-glass Preparation, Stained with Fuchsine. (Fraenkel.) · 1000.

3. This spirillum is found in slight cases as well as in severe. It is present in the beginning of the attack, and it is located in the intestine, that is to say in the region especially attacked by the disease, and in which occur the initial and essential lesions.

The attempts to add to these arguments the more decisive one of successful inoculation experiments, were at the first not satisfactory in their results. Nicati and Rietsch were the first to secure successful results, which they obtained by introducing pure cultures of the organism into the duodenum of guinea-pigs, in which animals they had previously tied the ductus choledochus. By these experiments they obtained symptoms extremely analogous to those of true cholera, and Koch also succeeded in the same direction by passing the infectious material (pure cultures) into the stomach by an œsophageal catheter. In his experiments the animals had been previously narcotized by the injection of tincture of opium, this to prevent peristalsis, and their stomachs had been made alkaline by the introduction of carbonate of soda, a solution to make the stomach alkaline being necessary, because the spirillum of Asiatic cholera will not develop in an acid medium.

Doyen has shown that by introducing alcohol into the stomach the alkaline solution and the tincture of opium may be dispensed with. But, however the experiments may be conducted, they all show one important thing—the great necessity for a healthy condition of the gastro-intestinal tract for the avoidance of infection with cholera. Dyspeptics and alcoholics have been shown in all epidemics to be especially fatally attacked by the disease. It cannot yet be affirmed that the absolute proof of the production of cholera by the specific spirillum has been obtained, because the methods employed in the experiments mentioned above leave too many loop-holes open for the occurrence of accidents, and yet the evidence is so nearly complete that there seems to be no reason for any doubt; the more especially as the exact experimental evidence can probably never be obtained, because none of the lower animals, so far as is known, are susceptible to cholera under natural conditions. The nearest approach to an actual experiment upon man is the case of one of the members of one of the cholera courses held in Berlin in the winter of 1884–85. This man, a physician, was attacked with "cholerine," and after some suffering, but no dangerous symptoms, recovered, the cholera spirillum being isolated from the discharges at various times during his illness. There seems to be no doubt that this was a case of true cholera, arising from some carelessness upon the victim's part in handling the cultures with which he had to deal in the laboratory, for there were no cases of cholera in Berlin at the time, nor had there been for a long time previous.

The entrance of the spirilla is undoubtedly effected by means of the gastro-intestinal tract, and there has not been a particle of evidence from experimental work to favor the theory of Pettenkofer that it ever enters from the air and through the respiratory region.

The acidity of the gastric juice is extremely unfavorable to the growth of the organism, and this explains the liability of the persons with functional or organic disease of the stomach to the attacks of the disease, for in these instances the reaction of the gastric juice is altered or modified so as to allow of the spirillum living until it has passed this point of danger and has reached the intestine, where there are more favorable conditions for its development.

Nicati and Rietsch, and Van Ermengen determined the toxicity of cultures of this organism when they had been deprived of the bacteria, either by filtration or by heating. In 1885, Nicati and Rietsch, by treating similar cultures with alcohol, succeeded in extracting a substance that killed guinea-pigs and rabbits, with the production of cramps and a lowering of temperature. Brieger studied the various chemical bodies that appeared in the cultures of the cholera spirillum; among the number there were convulsivants, methyl-guanidine and a base, $C_3H_8Az_2$, a febricant poison, and compounds that produced inflammation and necrosis. More recently, Brieger and Fraenkel have isolated a toxalbumin, and Petri has determined the presence of a less active substance, toxopeptine.

Hueppe and Scholl have perhaps made as important researches as any in their work upon cultures that have been deprived of free access of oxygen. From such cultures they succeeded in obtaining a peptotoxine that in a dose of 5 c.c., killed guinea-pigs in forty minutes, the animal presenting paralytic symptoms after ten minutes and convulsions after a quarter of an hour. This is a more active poison than was obtained before and was got in larger quantities: an egg after inoculation with a pure culture produced at the end of eighteen days enough to cause the death of ten guinea-pigs. The importance of this is seen when it is remembered that the spirilla are deprived of the access of oxygen when they are developing in the human intestine, and according to these experiments are therefore under the most favorable conditions for the development of this peculiar toxine.

A temperature of from 30° to 40° C. is the most favorable for the development of the cholera spirillum, but it will grow slowly at a temperature as low as 17° C. It ceases to grow at a temperature lower than this, but its vitality is not destroyed, and it grows well when the temperature is again raised; at 10° C. of cold its vitality has been retained, but, on the other hand, a temperature of as low as 56° or 60° C., is sufficient to destroy its vitality in a short time.

Inasmuch as no true spore-formation has been seen to occur in the development of this organism, it is not surprising that drying was shown, first by Koch, to destroy its vitality in a very short time—less than twenty-four hours. But conclusions drawn from his experiments may be misleading, for while this destruction of vitality by drying does occur in a very short time in the case of thin layers, it does not take place under less favorable conditions. This was shown by Kitasato, and by Berkholtz, who saw the vitality retained, the one for thirteen days, and the other for thirty-eight, in experiments in which silk-threads were used for holding the organism during their subjection to desiccation. It should be said, however, that these experiments were conducted in a desiccator, which did not permit the free access of oxygen to the bacteria, and it is undoubtedly the case that this agent is as important as any in the production of the result that it was desired to obtain.

The organism has been found in ordinary drinking-water by Koch in one of the tanks in India, in the neighborhood of which an epidemic of cholera had broken out. It does not live long in distilled water, however, as shown by Meade Bolton, Wolfhügel and Riedel, and others. Strauss and Dubarry found that it lived for fourteen days in one case, and Kraus, for two days only. Other observers have not seen it retain its vitality for anything like so long a time. In ordinary sterilized water it lives longer, according to the experiments of Wolfhügel and Riedel, as well as Pfeiffer, who found that it existed for seven, nine, and twelve months, while Hochstetter lengthened this time to three hundred and ninety-two days. Its vitality appears to be shorter again in non-sterilized water. Strauss and Dubarry found it to be thirty days in one specimen, and thirty-nine in another; while a mixture of other bacteria shortens the time still more. This latter point is one of great importance and has been studied by many experimenters. Koch determined that the organism ceased to live in ordinary drinking-water at the end of six or seven days, and that after twenty-four hours' contact with sewer-water they appeared to be dead; while Schiller, on the other hand, found that they retained their vitality in the same medium for fourteen days. Petri, in an effort to find out how long they lived in the intestine after burial, was able to demonstrate them in cultures at the end of nineteen days. Certain foods may be of great importance in transmitting the organism, as in the case of milk, in which it grows with great energy and without producing the least visible alteration; it has been shown that it will live for at least four days in milk, and forty-eight in butter.

Most of these experiments were conducted with the idea that this organism is an aërobic one, but Hueppe has shown that it is also an anaërobic, and that grown under these conditions the spirillum is possessed of a greater virulence, but it is also easier of destruction. As suggested by Proust, this may explain the comparative rarity of *immediate* infection. The bacterium coming from the intestine as an anaërobic organism is possessed of feeble resisting powers and is therefore easily destroyed, and it is only after it has taken on the conditions of aërobic growth that are furnished it in the medium in which it develops outside of the body that it finds itself possessed of the power of resistance sufficient to enable it to again enter the human body. Such observations are of especial interest in connection with the theory of Pettenkofer (*vide supra*), as seeming to show that his idea of the influence of locality is exact, in so far as this influence is extended in changing the anaërobic to an aërobic organism.

According to Koch, solutions of 1 to 400 of carbolic acid, 1 to 2,500 of sulphate of copper, and 1 to 10,000 of corrosive sublimate are sufficient for the arrest of the de-

velopment of the spirillum of Asiatic cholera. Esmarch and Eisenberg show that creolin will destroy it more quickly than carbolic acid in solutions of the strength of from 1 to 1,000, or 1 to 2,000. Liborius, Kitasato, and Pfuhl have shown the active effect of freshly prepared milk of lime, while Hueppe and Loewenthal seem to have established the important prophylactic and therapeutic value of salol in the management of cholera.

TREATMENT.—*Inoculation Against Cholera.*—Haffkine, whose first article upon the protective inoculation of animals against cholera appeared in the spring (*La Semaine Méd.*, No. 36, 1892), tried the virus upon himself (*Münch. Med. Woch.*, August 9, 1892). He injected subcutaneously in his left side a somewhat larger dose than that used in animals, of the so-called first kind of anti-cholera vaccine, prepared after Pfeiffer's method (Ueber das Choleragift, *Zeit. f. Hyg.*, xi., 393). An illness followed, lasting for twenty-four hours, made up of a rise of 1° C. in temperature, headache, dryness of the mouth, and clouding of the urine, with no disturbance of the digestive tract. There was pain, slight swelling, and glandular enlargement at the seat of the inoculation, the pain lasting five days, and the swelling diminishing gradually until the ninth day. Six days after the first inoculation the other side was inoculated with the strengthened cholera virus (Vaccine No. 2), and there was a second rise of temperature and local pain, but no swelling. The pain disappeared in three days, and the condition became normal in twenty-eight hours, with no digestive disturbances. Similar inoculations were tried in three other persons with like results. In one of these cases a slight diarrhœa which had lasted for several days stopped the day after the injection (first). The inoculation of both kinds of anti-cholera vaccine, the protective power of which in animals has been experimentally proved, is harmless to men, and Haffkine has the hope that six days after inoculation with this vaccine the human organism will have obtained complete immunity against every cholera infection (*Boston Med. and Surg. Journ.*, cxxvii., 227).

Salol in Cholera (*Deut. Med. Woch.*, August 11, 1892). —The treatment first proposed by Loewenthal (first dose of two grammes of salol, followed by hourly or half-hourly doses of one-half to one gramme [Ibid., 1889, Nos. 25 and 26]) has been reported by several authors as producing remarkable results when employed in man. Dr. Gonzales, of Salvador, has used it in fifty-three cases of cholera in one of the Philippine islands with only three deaths (and these were already in the last stages of the disease when they came under observation); the mortality under other methods of treatment being about forty-five per cent.

As a contrast to these results may be quoted those next following, and the paper upon this subject in the *Practitioner* (for November, 1892) will be of interest. It is by Dr. Hehir, of India, who was the first to recommend the use of the drug in India several years ago. After a careful experimentation with it in a large number of cases he concludes that it, like many other drugs, must be considered as having failed to justify the expectations raised in regard to it, and that it should be relegated, like its predecessors, to the limbo of oblivion as far as its special usefulness in cholera is concerned.

The following treatment of cholera was suggested by Nothnagel and Kahler (*Münch. Med. Woch.*, August 16, 1892, and quoted in the *Boston Med. and Surg. Journ.*, September 8, 1892), at the request of the Austrian Government: The use of dilute hydrochloric acid, eight or ten drops to a quarter of a glass of water after meals, the relief of constipation by enemata of boiled water, and the careful treatment of already existing gastric or intestinal catarrh are advised. Colds must be guarded against and attention given to the general hygiene of the body (baths, exercise, sleep). Every diarrhœa must be treated as if it were a choleraic diarrhœa. The patient must be put to bed, if possible after a warm bath, or a hot sitz-bath, with warm compresses on the abdomen, the nourishment limited to barley-broth, and tincture of opium, with tea, rum, or cognac given. If nausea or vomiting appear, carbonated, not alkaline, water is recommended. All drinking-water must be first boiled. Before the patient is put to bed an energetic cold rubbing down is recommended, but this must be superintended by the physician. Calomel comes into consideration only in the very beginning of the disease.

For the treatment of a well-developed cholera attack the tannin enemata recommended by Cantani are best suited, one-half to two litres (quarts) of water boiled, and at a temperature of 39° to 40° C. (102.2° to 104° F.), in which 15 to 20 grammes (3¾ to 5 drachms) of tannin are dissolved, are discharged by high irrigation. This procedure is best suited to the premonitory stage, but can be of use in the fully developed algid stage. The tannin has a limiting action on the development of the cholera spirillum, but is also supposed to counteract and favor the quick elimination of the cholera poison from the blood.

In the stage of asphyxia, in order to counteract the thickness of the blood, hypodermatic injections or intravenous injections may be used to advantage. For the first, two litres (quarts) of distilled water are boiled for half an hour in a vessel, the mouth covered with cotton, 6 grammes (1½ drachm) of carbonate of soda and 8 grammes (2 drachms) of sodium chloride dissolved in it, and cooled to 40° C. (104° F.). This fluid is injected by means of a large, hollow needle, through a fold of skin of the abdominal wall into the cellular tissue. The skin is first to be made thoroughly aseptic.

Instead of a syringe a burette is connected with the needle with a rubber tube. The whole apparatus should be previously disinfected. In the course of a half-hour, 1½ litre (quart) of the fluid can be injected. The skin of the thigh or interscapular region can also be chosen for the injection, and the resulting swelling can be reduced by massage. If after the third injection the relief is only transitory, intravenous injection is to be tried. For this the same solution can be used, or a solution of 5 grammes (1¼ drachm) sodium chloride, with 10 grammes (2½ drachms) sodium sulphate to 1,000 grammes (one quart) of water, previously boiled and thoroughly filtered as the other. In a quarter of an hour, from 2 to 2½ litres (quarts) can be injected into a vein in the arm. The first appearance of the algid stage is the indication for these procedures. For stimulants, champagne, fermented mixtures, heavy wines with the addition of ten to twenty drops of ether, tea with brandy, subcutaneous injections of camphor in olive-oil, in the proportion of 1 to 9, warm baths, energetic and long-continued rubbing with alcohol, or with cloths dipped in ice-water, and warmth to the extremities are useful.

In case of muscular cramps injections of morphine are useful. The treatment of the typhoidal condition, often observed, must depend upon the individual case. It is important to watch for and treat renal complications, and especially to bear in mind the necessity of maintaining the general nutrition.

During the time of cholera, it is well known, according to Sansom (*The Practitioner*, November, 1892), that there are many cases of simple diarrhœa, and the question often comes up as to whether these are to be treated by castor-oil or by opiates and astringents. The author quoted recommends most emphatically the use of castor-oil in moderate doses, offering the following prescription as a good one, viz.: ℞. Ol. ricini, Mucilaginis acaciæ, āā ℥ ss.; Aquæ menth. pip., ℥ ss.; Elixir saecharini, ℥ v. Mix carefully and make an emulsion. In addition to this, and during times of cholera, he recommends also a mixture containing either the sulphite or the sulpho-carbolate of sodium. He thinks he has seen evidence that the sulpho-carbolate acts certainly as an intestinal antiseptic, but if it be employed at all it must be used in much larger doses than are usually given—in children 15 to 20 grains, and in adults half-drachm doses in peppermint-water or cinnamon-water, and repeated every three or four hours. If there be much pain or griping, small doses of compound tincture of camphor (ten-minim doses for children or half-drachm doses for adults) may be added. He thinks that opium in most of its forms does harm. In the acute stages he has never

seen any real good from the use of astringents, but in the later periods, if much looseness continues, astringents, especially in the form of logwood, were useful. He prefers the sodium sulphite to the sodium sulpho-carbolate. These he considers to be the chief principles of medical treatment of cholera until, or unless, the signs of collapse make their appearance. He does not place much reliance upon the statistics in regard to the various methods of treating true cholera, because in the first place cases of simple diarrhœa are likely to be returned as true cholera, and in the second, the variations in the intensity of the disease at various periods of the outbreak must of necessity result in many false deductions. It is an established fact that the mortality of epidemics of cholera is much greater in the beginning of the outbreak, being as much as 60 per cent. and more, and that this very high rate recedes to 25 per cent. or less after the first outbreak.

It appears as if there was a sudden maximum of potential energy in the cholera bacteria that fails as the epidemic goes on, a condition of things that is ascribed by the more recent writers to the development of an acquired immunity among the population, and by others to the change in atmospheric and telluric conditions that become more unfavorable to the development of the organisms. Certain authorities assert that there is no medical treatment that is of avail in the maximum of the epidemic, that a patient in collapse must die, but it is not the part of the practitioner to adopt an attitude of helplessness in such a case.

Upon the approach of collapse it is recommended to place the patient at once either in a hot bath and keep him there, allowing the dejecta to be passed in the tub, or—much more convenient—the hot pack at 100° F. may be usefully employed, reapplications of the hot flannel being made at short intervals. The evacuations are the most difficult to deal with and the most important, because in them lies practically all the danger of the spread of the disease. If they be passed into a bed-pan they should be at once covered with a solution of corrosive sublimate 1 to 1,000, or of carbolic acid 1 to 20, or with a saturated solution of sulphate of iron; and they should be allowed to remain in contact with these solutions for at least six hours before they are allowed to pass into the sewers. But the best method of all is to destroy them by fire, and in this respect the suggestions of Sansom (loc. cit.) are of so much value that we shall quote them entire: "In hospitals receiving cholera patients a special furnace should be provided. In private houses, if possible, a scullery or a room having a fireplace should be appropriated for the purpose and the chimney swept clear. The evacuation should be received upon a large piece of oiled paper (*e.g.*, newspaper), on which layers of tow have been spread. To absorb further the liquid matters, sawdust or peat should be added. On removal from the patient more sawdust or peat should be thrown over the surface, and then a sprinkling of a mixture of powdered nitre and sulphur (proportions of 3 to 1). The whole should be then rolled up in the oiled paper and an outer cover of paper, brushed with carbolized oil, applied. The package is then ready to be taken to the furnace. If no fireplace can be used for the sole purpose, the burning might take place in the open air, care being taken that no nuisance is created. The addition of the nitre and sulphur (to which charcoal or coal-dust may be added if the matters are to be consumed in the open) is not only to promote combustion, but concurrently to disinfect by the sulphurous oxidation products.

"After any attention to the patient whereby it is possible that there may be contact with the evacuated matters, the nurse should plunge her hands into a watery solution of corrosive sublimate, 1 to 1,000, or one of thymol of equal strength, or, preferably, into a solution of thymol in methylated spirit, 1 to 1,000. Experience has abundantly shown that the attendants on cholera patients run scarcely any risks of infection if only contamination by the excreta be avoided."

If there be much pain, inhalations of chloroform may be used, and also, between these, the vapor of nitrite of amyl from the crushed capsules.

If the condition of collapse does not soon show signs of amending, the methods of Cantani, termed by him "enteroclysis" and "hypodermoclysis," may be employed. By enteroclysis is meant a copious enema of hot water, medicated by various drugs, by means of which not only may the irritating contents of the intestine be cleared away, and, perhaps, in some degree disinfected, but fluid may be absorbed from the surface of the intestine to replenish the empty blood-vessels. Long before the epidemic of 1866 Dr. Murray, in India, had recommended the half-hourly injection of a pint of a weak solution of common salt and carbonate of sodium into the rectum at a temperature of 120° F., and is said to have obtained very striking results. Similar means were employed by Sansom (loc. cit., p. 325), in 1866. Cantani advises the addition of tannin to the hot water. From 80 to 320 grains are dissolved in 3 pints or a quart of water or chamomile-infusion at a temperature of 102° to 105° F., and twenty drops of laudanum and an ounce or an ounce and a half of gum acacia are added. Instead of tannin, thymol in solution of hot water (1 to 1,000) has been recommended by other authorities. In the recommendations of the Royal College of Physicians recently (1892), benzoate of sodium, two drachms to a quart of water, has been suggested as an alternative to the tannic acid. In every case the injection should be made with much gentleness. The best position of the patient is that on the back with the hips well raised and the legs well drawn up as for lithotomy. The reservoir douche enema should be used and not the ordinary pump. There is much room for doubt as to whether the addition of any medicament to the hot water is of any special value, the favorable results being due probably to the clearing away of irritant and offensive *débris*, to the absorption of fluid from the intestinal surface, and to the relaxation of the arterial spasm by the hot and moist application. As shown by Cantani, the hot saline solution may pass through the ileo-cæcal valve into the small intestine.

If signs of improvement do not soon follow the procedure described above, recourse should be had to the second method, that specially introduced by Cantani and called by him "hypodermoclysis," and consisting in the injection of a hot saline solution into the subcutaneous tissue. About one drachm of common salt is dissolved in a quart of distilled water at a temperature of 100° to 105° F. The apparatus for this should consist of a glass funnel with a long rubber tube attached to a hypodermic needle of fairly large calibre. The needle is introduced in the gluteal, interscapular, lumbar, or ileo-costal region, the funnel being held at about the level of the patient, and the needle pushed so far in that it may be moved freely in the subcutaneous tissue. The reservoir is then elevated slowly so that the fluid runs into the tissue by the force of gravity and its distribution is aided by the manipulation of the fingers. When about half of the fluid has been introduced the needle is removed and the remainder is injected in another place. The method seems to be rational and is supported by strong evidence by Cantani, who has made extensive use of it. It is easier of application than the older method of intravenous injection that has been employed for many years, and it seems to be attended with better permanent results. Either or both of these methods must be employed earlier than is usually the case, and before the actual symptoms of death have made their appearance; to wait too long is to throw away all chances of success. It must be remembered that even if the dangers of the period of collapse have been safely passed, an ever-watchful care must be exercised, for even after the vaso-motor spasm has passed off there is in some cases the condition of paresis to be reckoned with, and the resulting typhoid state, the tendency to congestions of the viscera, and especially to pneumonia, must be most carefully watched for and guarded against.

General and Special Hygiene.—Measures of precaution in nursing cholera patients (*Brit. Med. Journ.*, September 3, 1892) are thus given by Mr. Ernest Hart, the editor of the journal from which the extract is made. He states that in the epidemic of 1885 the following rules were used and enforced at the London Hospital: The

following disinfectants were employed—the first two or three days Condy's fluid diluted and chloride of lime, subsequently carbolic disinfecting powder and carbolic acid largely diluted (1 to 40), mixed with sawdust in quantities sufficient to wet the sawdust, and sprinkled about the passages, wards, closets, etc.

None of the excreta from the patients were allowed to be emptied into the sewers; instead of this a portion of dilute carbolic acid—about half a pint—was put into each chamber-pail and the conteuts were buried in the garden. The pails had water-tight lids. Burnett's fluid was sprinkled in the cabs that brought the patients. The straw from the beds was burned in each case of death, or where they had been much soiled by excreta. The linen from the cholera wards was washed separately in the laundry of the hospital with McDougall's disinfecting soap. Hot coffee, beef-tea, etc., were recommended to be taken by the nurses at early dawn, and everyone was advised to avoid going on duty on an empty stomach, or in a depressed condition. An extra allowance of wine and of pay was made to the nurses.

Again, although cholera raged so severely in Chili in 1886–87, the doctors and uurses in a number of small hospitals were enabled to protect themselves entirely. Each of the hospitals (Russell) contained from fifty to sixty beds, and had a staff of six doctors, six students, and thirty attendants. All wore long aprons, reaching from the chin to the feet, and caps. For washing the hands and face a solution of corrosive sublimate (1 to 1,000) was exclusively used. In the dining-room all dishes before use were strongly heated by the flame of burning alcohol. The bread was sterilized by toasting. It is stated that no one of the staff sickened who adhered strictly to these precautions. The convalescents before their discharge were bathed in the corrosive-sublimate solution and their clothing was washed in a similar disinfecting solution. The floors of the hospital were made of a kind of pine parquet soaked in tar, and were washed daily with a solution either of copper snlphate or potassic permanganate (1 to 1,000). On emptying a ward it was fumigated, according to rule, by sulphurous acid gas for twenty-four hours.

Instructions of the French Committee on Hygiene as against Cholera, prepared in 1889.—*The germ of cholera is contained in the dejecta and vomited matters of patients. It is transported especially by water, linen, and clothing.*

1. Personal prophylaxis. Follow out a careful hygiene; avoid all causes of fatigue, especially cold, when the body is in a perspiration; excess of all kinds, of wine or of alcoholic liquors, and the excessive use of ice-water; abstain from green fruit. Special attention should be paid to drinking-water; it should be boiled if its origin is suspicious. Natural mineral waters, called table waters, are recommended.

2. Isolation of the sick. The person attacked with cholera should be isolated. The patient should be under constant supervision, and those who have charge of him should be the only ones to have access to him, and these attendants should be governed by the following rules: Take no drink or fluid in the sick chamber, never eat without having washed the hands with soap and a disinfecting solution, bathe the body frequently with a disinfecting solution, and wash the mouth from time to time, and particularly before eating, with a disinfecting solution.

3. The sick chamber. The chamber should be aired many times a day, and curtains, shades, rugs, and all furniture that is not indispensable, removed; the bed should be placed in the middle of the room.

4. Disinfection. The principal disinfectants that are recommended are sulphate of copper, freshly prepared chloride of lime, freshly prepared milk of lime,* corrosive sublimate.

The two following solutions should be used according to the circumstances indicated: First, *the strong*—sulphate of copper or chloride of lime, 5 per cent. solution (that is to say, 50 grammes of the sulphate of copper or the chloride of lime in a litre of water, milk of lime 20 per cent.). The other, *the weak*—sulphate of copper or chloride of lime 2 per cent. (that is, 20 grammes of these substances in a litre of water, milk of lime 7 per cent.). Solutions of corrosive sublimate are to be employed, one to a thousand, *the strong;* or one to two thousand, *the weak*, according to the case. The solutions of sublimate should be colored with fuchsine or eosine, which has been added to a litre of water containing 10 grammes of hydrochloric acid.

Wash the body and hands. For washing the hands use the weak solution.

Rinsing the mouth. For rinsing the mouth use a solution of hydrochloric acid, 4 to 1,000 (that is, 4 grammes of hydrochloric acid to a litre of water).

Dejections. All the dejections of the patient, the vomitus and fecal matters, are immediately disinfected with one of the strong solutions; milk of lime is especially recommended. A tumblerful of one of these solutions should be previously turned into the vessel destined to receive the dejecta. The dejecta are immediately turned into the cabinets, which are also disinfected twice a day with one of the strong solutions.

The cabinets. These are washed twice a day with one of the strong solutions.

Body linen. Soiled body linen is immediately collected, and placed for two hours in one of the strong solutions. It is then sent to the wash, where it is kept for half an hour in boiling water before being cleansed. The unsoiled linen is plunged into one of the weak disinfecting solutions. The same precautions are taken at the laundry. Neither of these classes of linen should be washed in a watercourse, for such water being likely to be drunk later may start a new epidemic.

Clothing. The clothing of the sick and the nurses should be placed for half an hour in a disinfecting oven, in steam under pressure, or in boiling water for half an hour. If these two procedures cannot be carried out, the clothing should be disinfected by sulphurous acid, after the manner indicated below in the disinfection of the infected lodging. Clothing soiled by dejecta should be placed for an hour in one of the strong solutions.

The furniture. Spots or soiled places on the furniture or walls of the room should be immediately washed with one of the strong solutions.

The mattresses and bed furniture. These should be placed in a disinfecting oven, or, when this is not accessible, should be disinfected by sulphurous acid.

Corpses. The corpses should be placed as soon as possible in a tight coffin, that is to say, one with good joints, and well closed and containing a layer of five to six centimetres of charcoal, in order to prevent filtration of fluids, and should be immediately buried.

Disinfection of infected lodgings. A room occupied by a person affected with cholera should not be inhabited until there is complete disinfection.

(*a*) Disinfectiou by sulphurous acid. The procedure is by the combustion of 40 grammes of sulphur to the cubic metre of space to be disinfected, in the following manner: Bands of paper are pasted over the cracks or joints that might let the sulphurous vapors escape. For half an hour water should be boiled in the room in a way to fill it with vapor. Sulphur is broken into very small pieces and placed in pottery vessels, or vessels of cast-iron, with large openings, and holding each about a litre. If of iron, they should be of a single piece, or riveted without solder. To avoid the danger of fire, the vessels containing the sulphur are placed in the centre of basins of iron, holding a layer of five or six centimetres of water. To burn the sulphur, a little alcohol is poured out on it, or it is covered with a little cotton soaked in alcohol, and a match is put to this fluid. The sulphur being lighted, the doors are closed, and paper is pasted over the joints. The room is not opened for twenty-four hours.

(*b*) Disinfection by sublimate. The disinfection of

* In order to obtain very active milk of lime, one should take good quality lime, and slack it little by little with a small portion of its weight of water. When the deliquescence is completed the powder should be placed in a carefully closed receptacle, and a dry situation. As a kilogramme of lime which has absorbed 500 grammes of water for slacking requires a volume of 2,200 c.c., it is enough to add double this volume of water, that is to say, 4,400 c.c., in order to have a milk of lime of about 20 per cent. To disinfect cholera dejecta, it is enough to use a quantity of this milk of lime equal to 2 per cent. of the materials to be disinfected.

plastered walls, or those covered with colored papers, should be methodically carried out over the entire surface of the chamber walls with the aid of a spray of a strong solution of sublimate. The atomizing of this solution should begin at the upper portion of the wall, should follow a horizontal line, and descend successively in such a way that the whole surface will be covered with a fluid layer in very fine drops. All the woodwork should be washed with boiling water, dried, and gone over with the same solution. The municipal administration will inspect the disinfection, and if the inhabitants do not carry it out, will proceed officially. It is part of its duty to see that the inhabitants of a lodging proceed to a serious purification. The room is not reinhabited until at least twenty-four hours have elapsed.

5. *Private Hygiene.* Drinking-water. Great care should be exercised in regard to the purity of the drinking-water. In case of an epidemic drink boiled water. Water coming from sources which possibly are contaminated should be prohibited, and bakers should never, in making bread, utilize such water. The washing of contaminated linen in watercourses is forbidden, as well as throwing into them any material from the dejecta.

Prodromic diarrhœa. It is proper to give special attention to the general condition of the public health, in order to prevent maladies, accidental and only slightly grave in themselves, and notably those of the digestive organs, from producing individual indispositions favorable to the development of cholera. It is therefore necessary to establish preventive medical visits. Physicians appointed for this purpose should exercise a surveillance over the health of the inhabitants of their quarter, and should insist upon the necessity for immediate treatment of intestinal derangement in all cases.

Obligatory information. Every case of cholera, or suspected case of cholera, must be at once declared at the Health Office.

Isolation. The sick person should be immediately isolated.

Inspection. In every house where a case of cholera occurs an immediate inspection is made by a physician delegated by the municipal administration, who should take at once all the necessary measures for isolation and disinfection.

Transportation to the hospital in a special ambulance. When a case of cholera appears in a room containing many inhabitants, the sick person is transported to the hospital in a special ambulance. The chances of cure in such case are greater, and the transmission is not to be feared.

Carriages. The carriages in which persons sick of cholera have been transported must be disinfected. They should be washed with one of the strong solutions.

6. *Public Hygiene.* All causes of unhealthfulness that prepare the region for an invasion of epidemics should be removed when cholera approaches; also, the general rules of hygiene applicable at all times should be more rigorously observed in time of cholera, especially what is concerned with the purity of drinking-water; with crowds of individuals, such as fêtes, fairs, and pilgrimages; with the watching over and feeding of armies; with the proper condition of the soil; with the minute control of closets, and search for possible causes of infection; with the regular removal of filth.

The proper condition of houses, and the particular surveillance over localities, flats, concert-rooms, and all such places meant for the working or industrial population; the condition and regular disinfection of public and private closets; the inspection and disinfection of outhouses; the cleansing of sewers; special inspection of the quarters and houses where cholera prevailed in previous epidemics — all these things are the special duties of the municipal authorities.

The following extracts from the "Report of the Medical Advisory Committee of the Chamber of Commerce of New York, on Certain Points Relating to Quarantine Detention of Passengers and the Disinfection of Passengers' Baggage, Merchandise, and Infected Ships" (Abstract of Sanitary Reports, September 23, 1892, No. 39, Washington) are of great interest, and express the general consensus of medical opinion at the present time. ". . . It should be distinctly understood that in formulating the opinions contained in this report we have limited the scope of our consultation entirely to Asiatic cholera, and to the circumstances of the present epidemic. We report here only the circumstances under which the germs of this disease are liable to enter our country in transatlantic ships, and certain of the measures which seem to us necessary to prevent their access. The control of other infectious diseases offers distinct problems in each case. The opinions which we have formed rest primarily upon this consideration: That under ordinary conditions there is little liability to the introduction of the germs of Asiatic cholera, either through the mails or through ships' cargoes. It is, on the other hand, through the ship's inhabitants and their personal effects that the contagium of this disease is most liable to enter.

"*Merchandise and Mails.*—In view of the facts just stated, we concur in the general conclusion adopted by the International Sanitary Conference at Rome, in 1885, namely, that disinfection of merchandise and of the mails is unnecessary. This general statement, however, must, we believe, be qualified when the merchandise is known to have been prepared for shipment in infected places, has been shipped from infected ports, or has been brought on ships in which cholera has occurred during the voyage. Under either of these conditions it is our opinion that measures of disinfection should be practised. The nature of these measures will depend upon the nature of the cargo, its form of packing, and the circumstances under which it has been placed before or during the voyage. We do not think that general merchandise prepared and packed in uninfected places, in boxes or barrels, or close packages, and which has been shipped at infected ports or brought on infected ships, would need other than such an exterior disinfection as could be practised on the ship or during the unloading without injury to the goods. . . . We believe that merchandise in bales presents greater possibility of contamination from its handling by infected dock-hands, stevedores, or ships' crews at infected ports, or on an infected vessel, than when packed in boxes, and should therefore be subjected to more rigorous inspection and disinfection processes than if it were entirely closed. We are assured by our advisers that hides can be disinfected without injury. A thorough, prolonged, intelligent exposure of rags to live steam or prolonged boiling are the only means known to us by which they may be rendered absolutely safe. . . . We are furthermore of the opinion that, at present, edibles which have either been prepared or packed in infected places should be refused entry altogether. . . .

"*The Inhabitants of Infected Ships and their Effects.*—We have in this report limited the term 'infected ship' to such ships as may have had a case or cases of Asiatic cholera on board during the voyage. . . . We believe that on arrival in port of an infected ship, its passengers should be at once removed to a safe and comfortable place of detention, where they should be isolated in groups as small as practicable and held under observation. We believe that under ordinary conditions the period of quarantine detention of healthy persons when removed, as they should be at once on their arrival in port, from *all known or possible sources of infection*, and properly placed, should be five days, in case no cholera occurs among them. We believe that the baggage of cabin passengers arriving on infected ships should be the subject of most careful investigation as to its point of shipment, its degree of protection from the possibility of contamination while on board, and as to its condition on arrival, and that such manner of disinfection should be practised as may seem necessary to the health officer in view of the facts in each particular case, special attention being paid to the baggage of those who may have taken ship at infected ports, or who have been recently staying in infected towns. We believe that the personal clothing and baggage of the steerage passengers, among whom cholera has occurred during the voyage, should be sub-

jected during their detention to reliable processes of disinfection; and furthermore, that the persons of such steerage passengers should be freed as fully as may be from all possibly infected clothing and effects before they are taken from the infected ships to the place of detention. We hold the opinion that the detention of passengers of any class on infected ships for a moment longer than is absolutely necessary is unjustifiable. . . . We believe that the disinfection of a ship, in which, during a voyage, a case of Asiatic cholera has occurred, cannot be, with certainty, accomplished while its passengers are on board. . . . We have, in this report, not attempted to lay down rules which will govern all cases, nor have we felt called upon to specify particular modes of disinfection. . . . Stephen Smith, M.D., Chairman; A. Jacobi, M.D.; E. G. Janeway, M.D.; T. Mitchell Prudden, M.D.; R. H. Derby, M.D.; Herman Biggs, M.D.; Allan McLane Hamilton, M.D., Secretary."

Harold C. Ernst.

ASPARAGIN. An alkaloid obtained from *asparagus officinalis*. It also may be obtained from marshmallow, lily-of-the-valley, and many other plants. It occurs in hard, brilliant, colorless crystals, with a faintly saline, cooling taste, soluble in water, one part in twelve.

The use of asparagus is being revived, and this alkaloid is recommended as the best means of obtaining its therapeutic properties. It is administered in doses of one to one and a half grain three times a day.

Asparagus has long been known to possess therapeutic properties, but it has not received much attention. The roots and shoots are official in the French Codex, and at many European watering-places it occupies an important position in the articles of diet in lithiasis and in the treatment of gouty patients. It increases the flow of urine and imparts a peculiar strong odor. It may cause vesical irritation, and should be used with caution when the renal tissue is diseased. In cardiac dropsy it is recommended, as its action is said to resemble that of convallaria.

Beaumont Small.

ASTRINGENTS, VEGETABLE, IN CHRONIC INTESTINAL CATARRH. There are three drugs which, in the course of years, I have used, singly or combined, in a considerable number of chronic cases of intestinal catarrh. Each of these drugs contains more or less tannic acid and bitter extracts, but their therapeutic value I have found to be greater than that of tannic acid by itself, and they are apt to disturb the gastric functions either very little or not at all, and can consequently be given for an indefinite period, and without harm.

1. Extractum Monesiæ is derived from the bark of Chrysophyllum glyciphlæum, a Brazilian tree. It was known and used to a great extent some forty or fifty years ago, but has now been almost forgotten. Heydenreich (1839) found it to contain fifty-two per cent. of tannin and thirty-six per cent. of a sweetish substance, probably glycyrrhicin. It is sold in the shape of irregularly shaped, dark brown pieces, is soluble in water, and has a sweetish, astringent, and later rather acrid taste. In doses of five to ten grains it improves the stomachic functions, in larger doses of fifteen grains to half a drachm it is apt to disturb digestion and produce constipation.

2. The well-known Ratanhia root comes from a bush growing in Bolivia and Peru. Wittstein (1854) found in it eighteen per cent. of tannin, some resin, wax, and sugary substances. This extract has a more acrid taste than the former, has similar effects, but is not as well borne by the stomach.

3. The Colombo root derives its name from the African "Kolumb," and belongs to a large species of creeper encountered in the forests of Mozambique and Southeast Africa. Boedeker and Buchner found in it the alkaloids columbin, berberin, and a peculiar acid, some resin and wax, and much starchy substance. For many years the extract and tincture have been in medicinal use as stomachic stimulants, but the natives, and also the Hindoos, use the drug, in the form of infusion or decoction, for diarrhœal and dysenteric diseases.

For a number of years I prescribed extr. monesiæ in the form of a jelly-paste, thus: Extr. monesiæ, ʒ ss.; extr. columb., ʒ ij.; conserv. rosarum, mellis, āā ʒ iij. M. Ft. electuarium. S.: Keep in cool place, and take a teaspoonful three or four times a day. In many cases of otherwise uncomplicated chronic diarrhœa in adults there is often considerable pain and purging, and small doses of morphine or opium may have to be given between the doses of the extract for a week or so, when they may be left off and the remedy continued by itself. Later on, and up to the present time, I have discontinued the use of the paste in all cases that could take pills instead, and I prescribe them as follows: Extr. monesiæ, extr. columb., āā ʒ ss.; extr. gentian. et glycerin., q. s. F. pil. 120; two, three, or four of such pills to be taken three times a day, and to be continued until a cure is established. If it be preferred, the pills may be put up in gelatine capsules. I have the accurate record of at least twelve cases of chronic catarrh of the ileum in adults, and some among them of two or three years' duration, with intervening periods of relative well-being and exacerbation, all of which were cured by the above remedies. At least twenty cases more I have lost sight of, but I may safely say that a cure was effected in every case that was not complicated by organic disease. In children's practice these remedies have not been used by me, but in the form and combination mentioned they have been prescribed for adults alone. Monesia and columbo together act well and produce no dyspeptic symptoms, giving off their tannic acid as they proceed to absorption in the gastro-intestinal tract. And this is a point of importance, that, in the treatment of many chronic functional or simple catarrhal disorders, a positive result may be hoped for, if we are able to continue long enough the use of properly acting remedies, without disturbing by them the functions of the stomach or other organs. I have now used these remedies in so many cases, and have observed their effects for so long a time, that I feel warranted in recommending their more general use.

Leonard Weber.

AUDINAC. A watering-place in the department of Ariége, in the South of France.

Location.—Audinac is situated five miles to the south of Saint-Giron, amid attractive surroundings. Mild climate. Season, June to September. There are two springs yielding an abundance of water having a harsh, styptic taste. Temperature of water, 70° F.

Analysis.—One quart of the water contains:

	Grains.
Sulphate of lime	10.976
Sulphate of magnesia	9.739
Chloride of magnesium	5.391
Carbonate of lime	8.074
Carbonate of iron	1.096
Bitumen	0.972
Total	36.248

Indications.—These purgative and diuretic waters are employed in abdominal plethora, dyspepsia, genito-urinary disorders. They are supposed also to be rather tonic, on account of the iron which they contain.

Accommodation.—Audinac has not kept pace with modern improvements. It is a sleepy French village and no longer a fashionable resort. Still the thermal establishments are not altogether devoid of comforts for invalids, and of the power of the springs there is no doubt.

Edmund C. Wendt.

AUSSEE. A climatic and bathing resort in Steiermark, Austria. (See also Vol. I. of this Handbook.)

Location.—Aussee is charmingly situated among the hills of the so-called "*Salzkammergut.*" It is over 2,000 feet above sea-level. The saline waters are used for brine baths and hydrotherapy in all its forms. The place is also popular with mere tourists on account of its fine

surroundings and the facilities it offers for excursions. Season, July to September.

ACCESS.—Aussee is now a station on the Austrian State Railroad.

INDICATIONS.—The baths are employed with benefit in serofula and neurasthenia. Some phthisical cases and "run-down" people generally do remarkably well there. Diseases of women are largely treated in various private medical establishments, which constitute a special feature at Aussee.

ACCOMMODATION.—Many large and small hotels, sanatoria, institutions, etc. The *Kaiser Franz Joseph's Bad* is a new thermal establishment with excellent arrangements. There are concerts and other amusements, reading-rooms, bowling-alleys, etc. Among the hotels may be mentioned Hackl, Erzherzog Johann, Erzherzog Franz Karl, Sonne, Wilder Mann. Owing to its growing popularity the prices are now relatively high.

Edmund C. Wendt.

AXENFELS. A climatic station on the southern arm of the Lake of Lucerne—that part which is known as the Bay of Uri, about two and one-half miles from the town of Brunnen. The latter place may be reached either by steamboat or by railroad from Lucerne, at the eastern end of the lake, or from Fluelen, at the southern end of the Bay of Uri. From Brunnen Axenfels is reached by the old St. Gothard diligence road, which zigzags up the side of the mountain to an elevation of about two thousand five hundred feet, affording an almost constantly recurring series of magnificent lake and mountain views, such as can be seen in only a few parts of Switzerland.

The hotel (*Hotel et Pension Axenfels*) is a well-built stone structure, with large and airy rooms, all modern conveniences, and pleasant surroundings. While everything is on a more modest scale than at the Hotel Axenstein, which is scarcely a mile distant, in all that relates to the comfort and well-being of its guests, the Axenfels house is in no respect behind its more pretentious neighbor.

Edmund C. Wendt.

AXENSTEIN. A climatic station on the Lake of Lucerne, Switzerland.

LOCATION.—One of the most beautiful spots on the Lake of Lucerne, Axenstein affords a pleasant sojourn to those in need of rest, or "after-cures." It is 2,400 feet above the level of the sea, in a fairly well-sheltered position, and of easy access. The air is "Alpine" in quality. The Axenstein establishment is situated in a picturesque country, near the small village of Morschach. An extensive park surrounds it, planted with pine and fir trees. The excursions are varied and interesting. Two villas situated in the park contain billiard-rooms, baths, etc. There is a telegraph and post-office. English church in one of the villas.

ACCESS.—By the St. Gothard Railroad from Lucerne to Brunnen, thence by omnibus or carriage in one hour to Axenstein.

INDICATIONS.—Milk- and whey-cures are about the only special therapeutic measures made use of here, the place being a popular resort for invalids without serious affections.

ACCOMMODATION.—The *Grand Hotel Axenstein* is a first class Swiss hotel, with all modern comforts, and prices are not yet inconveniently high.

Edmund C. Wendt.

BACILLUS PYOGENES SOLI.[1] I isolated this organism from an abscess which formed at the seat of inoculation in a rat inoculated with an impure smear-culture from an animal dead of tetanus. The smear-culture was one of those made in the manner described for isolating the bacillus of tetanus by Kitasato's method (see this organism under heading Tetanus). It was found impossible to isolate the pyogenic bacillus by plating the pus in the usual way. This was only possible by inoculating from abscesses in animals to culture-media, and from culture-media back to animals a number of times. In this way the contaminating organisms gradually disappeared, and the pus organisms became relatively more and more numerous, until finally all contaminations were got rid of.

The organism resembles in many respects the bacillus of diphtheria. It presents the same irregularities of shape; the swollen, club-shaped extremities; the transverse, unstained, clear spaces in stained preparations; the deeply stained, often perfectly round spots, as are seen in the diphtheria organism. They stain readily with all the ordinary staining solutions, but best with Loeffler's methylene blue. With this stain the older cultures often present a very remarkable appearance, in that there appear bright-red spots in the otherwise blue rods. In some preparations the organisms look as if they had been double stained. The red color is especially evident in the swollen knobs. They have no independent motion, and do not stain by Gram's method.

The growth of the organism is slow on all media. When first obtained it could only be got to grow on gelatine and in beef-tea, but cultures which I have kept reinoculating now for about a year grow equally well on agar. The growth in all cases is scanty. Colonies in gelatine are very small, and appear as round yellowish spots under the lower power of the microscope. Stab-cultures resemble stabs of streptococcus pyogenes; along the bottom of the line of inoculation are discrete, round colonies. Growth on potatoes and on blood-serum is weak, and presents nothing characteristic. In the hydrogen tubes as described for tetanus (see under this heading) the growth is comparatively good.

FIG. 33.—Bacillus Pyogenes Soli (schematic), showing some of the various shapes often met with. × 1,000.

The bacillus is, therefore, a facultative anaërobe, indeed, it seems to grow best where there is paucity of oxygen deep in the stab.

The effects upon animals differ with the mode of inoculation. In rats, gray mice, rabbits, and usually white mice, subcutaneous inoculation of small or large amounts produces an abscess strictly confined to the seat of inoculation. These abscesses form in twenty-four hours, and run a shorter or longer course, depending upon the amount of the culture inoculated. Animals do not suffer from any general symptoms, as a rule, from subcutaneous inoculation, but white mice do sometimes have abscesses in the joints and internal organs. Injections of from one-half to three-fourths cubic centimetre of a liquid culture into the ear-vein of a rabbit produce, in some cases, multiple abscesses in the joints, kidneys, and in other internal organs; sometimes also ulceration of the intestines.

The organism is found aggregated in small and large irregular clumps, seldom separate bacilli, in and among the pus-corpuscles.

Meade Bolton.

[1] Meade Bolton: The Am. Jour. of the Med. Sciences. June, 1892.

BACTERIOLOGICAL TECHNOLOGY. This article is supplementary to that under the title "Micro-organisms" in the REFERENCE HANDBOOK. The same order in the arrangement of subjects has been followed, to facilitate reference, and the principles of bacteriology there expounded are in this article amplified by such selections from the literature of the subject as seem applicable to a work of this nature

STAINING REAGENTS.—Ziehl's Carbolic Fuchsin Solution: Fuchsin (crystals), 1 gm.; carbolic acid, five per cent. aqueous solution, 100 c.c., and add slowly absolute alcohol, 10 c.c. A permanent solution. When used cold this solution stains in a few minutes most forms of bacteria. Wurtz recommends that it should be filtered after forty-eight hours. He advises against its use for staining pathological tissues, as it stains all granular and coagulated matter, and in this way disfigures the preparation.

Kuehne's Carbolic Methyl-blue Solution: Methyl-blue (crystals), 1.5 gm.; absolute alcohol, 10 c.c.; add gradually while mixing, carbolic acid, five per cent. aqueous

solution, 100 c.c. Action is similar to that of Ziehl's solution.

Lithion-Carmine Solution: Carmine, 2.5 gm. to 5 gm.; saturated aqueous solution of lithion carbonate, 100 c.c. Stain for two to three minutes; wash for one-half to one minute in the following: Concentrated hydric nitrate, 1 part; seventy per cent. alcohol, 100 parts. Wash in distilled water, then transfer to alcohol, then to oil, and mount in balsam. Over-staining is impossible, as the color can be removed to any extent by the action of the hydric nitrate alcohol.

Fraenkel's Solution for Decolorizing and Double Staining: Hydric nitrate, 20 c.c.; distilled water, 30 c.c.; ninety per cent. alcohol, 50 c.c.; saturated alcoholic solution of methyl-blue, 66 c.c.

Czenzynski's Solution: Concentrated aqueous solution of methyl-blue, 40 c.c.; one-half per cent. eosine solution (in seventy per cent. alcohol), 20 c.c.; distilled water, 40 c.c. For contrast staining of blood cover-glass preparations.

Fixative for Dry Substances in Making Cover-glass Preparations. v. Sehlen recommends a mixture of equal parts of egg albumen and a cold saturated solution of boric acid. The dry substances are mixed with a drop of this mixture on the cover-glass, and coagulation is effected by passing three times through the flame. It filters clear, and remains unchanged for a considerable time.

Staining of Sections and Cover-Glass Preparations.—Gram's Method, Modifications: Guenther recommends the use of a three per cent. hydric chloride solution in alcohol instead of absolute alcohol, after the section has been removed from the iodine solution; also, the use of xylol, instead of the oil of cloves, for clearing sections.

Weigert suggests washing the section in water or a 0.6 per cent. sodium chloride solution after its removal from the aniline gentian-violet stain, then placing it on a slide and drying it with filter-paper. Gram's iodine solution is applied on the slide and removed with paper. The section is then moistened with aniline oil, which removes the water, and, it is claimed, produces a more marked contrast. The aniline oil is removed and replaced by xylol, and the specimen mounted in balsam.

Fibrine, hyaline matter, etc., are stained a deep blue; micro-organisms are stained a dark violet.

Botkin recommends washing the cover-glass preparation or section in aniline water after its removal from the aniline gentian violet solution and before using the iodine solution. This, he claims, removes the excess of dye from the tissues, and fixes that already taken up by the bacteria.

Staining the Bacillus Tuberculosis.—Ziehl: Cover-glass preparations of sputum or tissue-smears are rapidly and effectively stained by this method. Float the prepared cover-glass on Ziehl's carbolic fuchsin solution in a porcelain capsule, and heat gradually to the boiling-point. After boiling has continued for a few minutes, decolorize without previous washing, in a five per cent. aqueous solution of hydric sulphate, then wash in two to three alcohols (sixty to eighty per cent.) and rinse thoroughly in water. Contrast stain in a watery solution of methyl-blue.

This method is applicable to the staining of the B. tuberculosis in tissues, but the section of tissue should not be heated above 45° C., and must remain in the staining fluid for about one hour.

Ahrens: Dissolve a small crystal of fuchsin in two to three drops of ninety-seven per cent. alcohol (or a few drops of a saturated alcoholic solution may be used) and add to this 2 to 3 c.c. of chloroform. This mixture is at first cloudy, but clears by precipitation, and when clear the prepared cover-glass is floated upon it for four to six minutes. Allow the chloroform adhering to the cover to evaporate, and decolorize with a three per cent. hydric chloride (ninety-seven per cent.) alcohol. Then wash in water and contrast stain with a watery solution of methyl-blue.

In employing this method for tissues the acid alcohol is washed out with absolute alcohol.

Gabbet recommends staining the prepared cover-glass for two minutes, without heating, in Ziehl's solution and washing in water. Then decolorize and contrast stain by immersing the preparation for one minute in the following solution: Methyl-blue (crystals), 2 gm.; twenty-five per cent. hydric sulphate, 100. c.c. Wash thoroughly in water and mount in balsam. This is a simple method and gives good results.

Czaplewski: Stain the preparation in warm Ziehl's solution and after draining off the surplus coloring matter, immerse six to ten times in a solution composed of a saturated alcoholic solution of yellow fluorescin with an excess of methyl-blue and allow the stain to drain off slowly after each immersion. Then contrast stain in a concentrated solution of methyl-blue and wash quickly in water.

The especial advantage claimed for this method of staining is said to be that mineral acids may decolorize many of the tubercle bacilli, while fluorescin does not.

Fraenkel recommends that sections be stained for twenty-four hours in an aniline-water-fuchsin solution, then immersed for one to two minutes in his decolorizing and double staining solution (see above), washed in water, etc.

In cases where the tubercle bacilli are few in number a method of precipitating them in the sputum may be employed.

Biedert: 15 c.c. of sputum are mixed with about 6 c.c. of water, and with from 4 to 8 drops (never more) of a strong solution of sodium hydrate, according to the viscidity. This is then boiled, being continually stirred, and 12 to 18 c.c. more of water are gradually added until a thin fluid is produced.

This is to be stood in a precipitating glass for two days, when the upper layers of fluid are poured off and the sediment stained and examined.

It is well to preserve some of the original sputum, to cause the adherence of the sediment to the cover-glass, as the power of coagulation by heat is frequently lost by the above treatment of the sputum.

Stroschein: 5 to 10 c.c. of sputum are mixed with one to three times their bulk of the following solution: Borax, 1; boracic acid, 3; water to saturation, and thoroughly shaken for one minute. This is allowed to stand for twenty-four to forty-eight hours and the sediment is then examined.

Centrifugal Machine.—This apparatus is employed to precipitate bacteria from urine, milk, and other fluids, with satisfactory results. Its use was first suggested by Litten. (See Fig. 34.)

The apparatus consists of a perpendicular shaft, which supports a metal disk. At the periphery of the disk four test-tube holders are swung, and the disk is made to revolve very rapidly, through the agency of a series of multiplying cogs by turning a crank. One is enabled to accomplish in minutes what formerly required hours, as Professor Litten states.

Staining the Diplococcus Pneumoniæ.—This lancet-shaped bacillus stains easily by the usual methods, but the capsule by which it is encompassed, when found in the tissues, remains unstained.

Staining in Ehrlich's aniline water gentian-violet solution and decolorizing by Gram's method leaves the coccus stained. The capsule is unstained, but remains visible.

v. Kahlden recommends, for demonstrating the capsule, staining for some hours in a one per cent. solution of fuchsin in five per cent. carbolic acid water. This gives a deep red color to the coccus, and the capsule has a pale reddish tint.

Staining the Gonococcus.—In cover-glass preparations made from the suspected secretions, the coccus is easily stained by watery solutions of the aniline dyes, preferably methyl-blue. It is decolorized by Gram's method.

The cocci lie for the most part within the pus-cell, and are mostly grouped about the nucleus. Kratter states that this grouping is more characteristic than the "semmel" shape.

Schutz recommends staining cover-glass preparations for five to ten minutes in a saturated solution of methyl-

blue in five per cent. carbolic acid water. Then immersing for three seconds in dilute hydric acetate, 5 parts; water, 20 parts, and washing thoroughly in water. Contrast stain in a very dilute solution of saffranin.

v. Kahlden recommends staining two to three minutes in an alcoholic solution of eosin and warming. The excess of eosin is absorbed with paper, and the film is then stained for half a minute in an alcoholic solution of methyl-blue. Wash in water, dry, and mount in balsam.

Touton recommends that sections be stained in Ziehl's solution and washed in alcohol.

Staining Actinomyces.—In examining pus for actinomyces the characteristic whitish granules must be sought for. This is best done on a glass plate, upon a dark background. The granules are carefully crushed between two cover-glasses, which are then drawn apart; the film is dried in the air, and the cover passed three times through a flame.

A number of methods of staining have been suggested, but the results are uncertain. For diagnostic purposes double staining in hæmatoxylin and eosin suffices, giving a red color to the fungus and a blue color to the tissue.

Gram's method (staining in Ehrlich's aniline-water

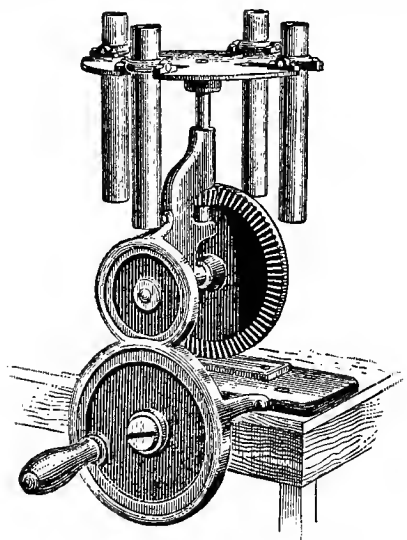

FIG. 34.—Litten Centrifugal Machine.

gentian-violet solution and decolorizing in a solution of iodine—potassium iodide) gives good results when the section is left in the staining solution for twenty-four hours, but is open to the objection that the fungus is liable to fall out when the celloidin is dissolved by the absolute alcohol.

Weigert's stain for bacteria, when preceded by the lithion-carmine stain, produces good results, giving an especially sharp outline to the edge.

Weigert also recommends staining for one hour in Wedl's orseille solution, washing in alcohol, contrast staining in a one per cent. aqueous solution of gentian-violet, again washing in alcohol and mounting in balsam. This gives a blue color to the inner parts of the "ray fungus," and to the outer parts a ruby red.

Israel stains the pear- or flask-shaped ends of the fungus a burgundy-red, by staining for several hours in a solution of orcein in water, rendered acid by hydric acetate.

Staining the Plasmodium Malariæ.—Blood obtained by puncture is quickly spread upon a cover-glass in the thinnest possible film. When dried in the air and passed rapidly three times through a flame the organisms may be stained with an aqueous solution of methyl-blue. The red blood-cells remain unstained.

Plehn recommends, after fixing the film in absolute alcohol, the following solution for double staining: Methyl-blue, concentrated aqueous solution, 60 parts; eosin, one-half per cent. solution in seventy-five per cent. alcohol, 20 parts; distilled water, 20 parts; twenty per cent. potassic hydrate solution, 12 parts. Stain for five to six minutes and wash in water.

Czenzynski's solution may be employed with excellent results for producing a contrast stain. The covers should be floated upon it for some hours at a temperature of 37° C.

Staining of Spores.—Guenther: The cover-glass, being prepared in the usual way, is floated on a solution of aniline-water fuchsin or gentian-violet, in a watch-glass, and very carefully heated to the boiling-point, when it is held entirely away from the flame for one minute. This operation is repeated five times. The cover is then plunged into a three per cent. hydric acetate alcohol, and thoroughly rinsed in water.

The bacilli may be contrast stained by an aqueous solution of the aniline dyes.

Moeller: The cover-glass preparation, dried in the air, is fixed by passing three times through a flame, or by immersing for two minutes in absolute alcohol. It is then placed in chloroform for two minutes, to remove fat-globules and crystals, and washed in water.

Chromic acid has been found so to act upon the spore-covering as to allow the stain to penetrate it. The time required to effect this change in the covering varies from one-half to two minutes. If the action is insufficient the spore does not stain; if too great, the spore is too readily decolorized. To test this action for the species under examination a five per cent. solution of chromic acid is allowed to act upon the specimen for one minute. This effect being noted, a second specimen is treated for a longer or shorter time, as may be required.

After removal from the chromic acid the preparation should be thoroughly rinsed and stained by a few drops of Ziehl's solution being heated upon it for one minute, and brought but once to the boiling-point. Without being washed it is at once immersed in a five per cent. hydric sulphate solution and then thoroughly washed in water.

A contrast stain is produced by immersing the cover for thirty seconds in an aqueous solution of methyl-blue or malachite-green.

Staining of Flagella.—Neuhaus recommends boiling the prepared cover-glass for five minutes upon black logwood ink, "Kaisertinte," and then placing it in a dilute neutral sodium dichromate solution for fifteen minutes. This process must be repeated several times.

Trenkmann stains the flagella of motile bacteria, living in water, as follows: A small drop of fluid which contains the bacteria is spread upon a cover-glass with a large drop of distilled water, and dried in the air. It is then placed, without heating, in an aqueous solution of one per cent. of tannin and one-half per cent. of hydric chloride, for two to twelve hours, and after rinsing thoroughly it is stained from one to four hours in a dilute solution of dahlia or fuchsin (concentrated alcoholic solution, 2 parts; water, 20 parts), gentian-violet, or methyl-violet (1 to 80 parts of water), methyl-blue, etc. Dahlia, fuchsin, and methyl-violet give especially good results.

As this method answers only for staining the flagella of bacteria as found in nature, and not in cultures, he recommends for the latter the following procedure:

Use as culture-medium an infusion of potato, or, if this is not suited for propagating the species of bacterium desired, broth may be employed. In the former case the growth must be diluted five to ten times, in the latter forty to fifty times, before the cover-glass preparations are made. Where it is necessary to make preparations directly from plate cultures, dilute at least one hundred times.

Dry in the air, and, without heating, the covers are placed in the following solution: Tannin, two per cent.; hydric chloride, one-half to one-fourth per cent.; distilled water, q.s., for six to twelve hours or more. After thoroughly rinsing they are placed in Gram's solution, or

in a solution of tincture of iodine, 1 drop; water, 10 c.c., for about an hour, then thoroughly washed and stained for about one-half hour in a very dilute aniline-water gentian-violet solution, as follows: Saturated alcoholic solution of gentian-violet, 1 drop; water, 20 c.c.; aniline water, 80 c.c.

Loeffler at first recommended the use of a corrosive solution before applying the stain, but modified the method by mixing the corrosive material and stain in the same solution, and adding an acid or an alkali as he found necessary.

Add a minute amount of the culture to a small drop of water on a cover-glass and mix carefully so as not to break off the flagella. A small portion of this mixture is transferred to a second, and from the second to a third cover, and dried in the air. The covers are then passed three times through the flame, being held between the thumb and finger to prevent overheating and destruction of the delicate tissue, and are stained by filtering a few drops of the following solution upon the cover-glass: Tannic acid solution (acid, 20; water, 80), 10 c.c.; saturated ferrous sulphate solution, 5 c.c.; methyl-violet, or preferably fuchsin, 1 c.c. This to be carefully warmed until vapor begins to rise. It should never come to a boil.

This solution answers well for staining the flagella of many forms of bacteria, but for certain others it requires to be modified by the addition of an alkali or an acid.

The alkali used is an exact one per cent. solution of sodium hydrate, and the acid a solution of hydric sulphate, of such strength that 1 c.c. will exactly neutralize 1 c.c. of the one per cent. solution of sodium hydrate.

The amount of acid or alkali required to produce the best results in staining the flagella is to be determined by experiment. For the following species it has been shown that to each 16 c.c. of the tannic-acid-iron solution the following additions are necessary: Spir. choleræ Asiaticæ, 1 drop of acid; Spir. rubrum, 9 drops of acid; B. typhosus, 1 c.c. of alkali; B. subtilis, 28 to 30 drops of alkali; B. of Rauschbrand, 29 drops of alkali; B. œdematis maligni, 36 to 37 drops of alkali. The flagella of the B. typhosus are found to be best developed in five to eight hour blood-serum cultures.

Staining Bacteria in Milk or Substances Containing Fat.—Ahrens: Dilute milk with an equal part of water (cream and substances containing a large quantity of fat require greater dilution), and spread in a thin layer on a cover-glass. The film is dried in the air and the cover passed three times through a flame.

Mix 12 to 15 drops of a saturated alcoholic solution of methyl-blue with 3 to 4 c.c. of chloroform, and on this float the cover-glass prepared as directed above, for four to six minutes. On removing from the staining fluid, after allowing the chloroform adhering to the cover to evaporate, wash thoroughly in water and mount in balsam. This makes an exceedingly clear preparation.

Examination of Blood for Bacteria.—For this examination blood must be spread in the thinnest possible layer on the cover-glass and fixed by one of the following methods: 1, By passing three times through a flame; 2, in absolute alcohol; or, 3, and best, by subjecting it for five minutes in an oven to a temperature of 125° C.

Staining such a film for some hours in Czenzynski's solution and washing in water produces exeellent results in contrast staining.

Guentber has suggested washing the film in a one to five per cent. solution of hydric acetate for ten seconds, to remove the normal coloring matter from the red blood-cells, thus making the bacteria more apparent. The hydric acetate is removed first by blowing it off the preparation by means of a tube, and then allowing the fumes of strong ammonia to act upon it for a few seconds. Staining is accomplished by an aqueous solution of the aniline dyes.

Sections of Pure Cultures.—A pure culture, either in agar or in gelatine, after removal from the tube may be hardened for four to eight days, exposed to the light in a one per cent. solution of potassium bichromate, then washed in water and treated with seventy per cent. and ninety-six per cent. alcohols. Gelatine cultures thus hardened are mounted on cork, kept for twenty-four hours in absolute alcohol, and then cut and stained. Agar cultures, after being hardened are to be saturated with bergamot oil, then placed in a soft bergamot oil paraffine, and then in pure paraffine, at 37° C., for twenty-four hours, when sections may be made. Sections should be stained on the slide, cleared only with bergamot oil, and mounted in balsam. Loeffler's alkaline blue and Gram's and Weigert's methods of staining give good results. Colonies from thin gelatine plates may be hardened in the same way, and are then to be treated as sections. To prevent them from folding they should be placed between two slides before immersing in alcohol, and a weight should be placed upon the cover after mounting in balsam.

Culture Methods.—*Sterilization.*—By moist heat. An apparatus known as the Arnold Steam Cooker was first applied as a steam sterilizer by Prudden. It is now manufactured as a steam sterilizer and is largely used in preparing foods for infants, sterilizing surgical instruments and dressings, and is of value for sterilizing clothing and bedding used by persons suffering from contagious diseases, and the clothing of their attendants. It also presents advantages for laboratory use. It consists of (A) a flat, shallow boiler, holding but a small amount of water, and therefore requiring but a minimum amount of heat to produce steam; (B) a reservoir, placed upon the boiler, which it constantly feeds and insures the constant formation of steam; (D) a covered steam-chest or receiving-vessel, placed above the reservoir and connected with the boiler by a cylindrical tube of large diameter (C); and (E) a hood, covering the receiver and enclosing an air-space which is constantly supplied with escape steam. The hood and the steam-jacket which it encloses prevent variations in temperature in the receiving-vessel, so long as the heat applied to the boiler remains unchanged.

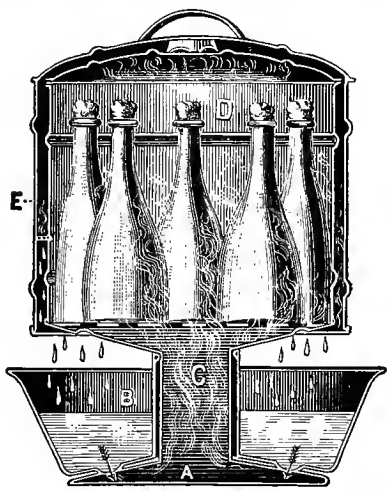

Fig. 35.—Arnold Steam Sterilizer, Sectional View.

By dry heat. A double sheet-iron or tin oven placed on a range or on a gas-stove is employed as an efficient sterilizer.

By desiccation. Koch has shown that the vitality of the spirillum choleræ Asiaticæ is rapidly destroyed by drying, and the same effect is produced upon the vegetative forms of all bacteria, the time required varying with the species. Spores have a much greater resisting power, and some forms are known to retain their vitality for several years. Spores of the B. anthracis, dried on silk threads, after five years have shown active and typical growth and proved to be pathogenic to white mice.

By sunlight. Numerous writers have shown that bacteria are destroyed by the action of direct sunlight upon

them, as well as by the action of diffused light. Vegetative forms are destroyed much more rapidly than are spores. That spores are eventually destroyed seems proven from the experiments of Arloing, Momont, and Gaillard.

The B. tuberculosis, as stated by Koch, is killed in a short time by exposure to the direct rays of the sun, and the same effect is produced by diffused light, when the exposure is continued for several days.

By electricity. Experiments in this line have been made by several writers, those made by Spilker and Gottstein seem to be the most convincing. They used an induction current from a dynamo machine, which was passed through a wire wound around a test-tube containing a culture, the tube being suspended in water. No growth occurred after resowing the culture, and repetitions of the experiment gave similar results.

The strength of the current seems to have a direct effect upon its germicidal power, but in no experiment were the bacteria destroyed in less than one hour.

Pasteurization.—Freeman has experimented in this line and offers an apparatus (now a commercial article) for pasteurizing milk and infant foods. This apparatus consists of a covered tin pail of given size, which is filled to a certain marked level with water which is actually boiling. Into this is placed a second tin vessel filled with water of ordinary temperature and holding the bottles which contain the fluid to be pasteurized. The outer pail is then covered, and the apparatus left standing for one hour, when the bottles are removed and put in a refrigerator to prevent development of any spores which are present.

The apparatus described has been found to raise the temperature of the fluids contained in the bottles to between 73° C. and 76° C., and to hold them at that temperature for a sufficient time to destroy the B. tuberculosis, spir. choleræ Asiaticæ, B. typhosus, etc. Milk treated in this manner shows no visible alteration, and if kept in an ice-box remains unchanged for several days.

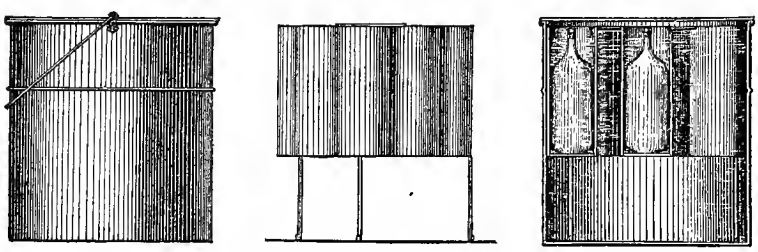

FIG. 36.—Freeman Pasteurizer.

CULTURE - MEDIA.—*Meat Extract Media.*—Liebig's Beef Extract is largely used in preparing nutrient broth, gelatine, and agar. It is substituted in the proportion of one half of one per cent. for the infusion of meat, and makes a most efficient growing medium for most forms of bacteria.

Melting Agar.—To facilitate the melting of agar, it may be soaked over night in water, but the water absorbed must be measured and taken into account.

Soaking agar in a very dilute solution of hydric acetate for some hours facilitates its melting, but this treatment causes it to lose some of its stiffness, which it does not regain.

Neutralization.—For the purposes of neutralization a solution of potassium or sodium hydrate possesses an advantage over the CO_2 salts in not giving off carbon dioxide, which, when held mechanically in the viscid fluid, may mask its proper reaction and cause the medium to be made too alkaline.

A medium, when markedly alkaline, cannot be cleared except by coagulating in it the white of egg. To facilitate this coagulation, which sometimes requires prolonged boiling in an alkaline solution, a single drop of concentrated hydric chloride may be dropped in while the fluid is boiling. This acid does not appreciably alter the reaction.

Schultz recommends the following titration method as a more simple and more exact process for neutralizing media:

Measure out 1 c.c. of the medium to be neutralized, put it in a beaker-glass, standing on white paper, and add one drop of a solution of phenolphtalein (1 to 300 in vinegar) and mix thoroughly. This forms a colorless solution. To this a 0.4 per cent. aqueous solution of sodium hydrate is cautiously added from a graduated pipette until the fluid assumes a pale rose tint. This process is performed three times, the amount of alkali used in each experiment carefully noted, and the arithmetical mean of the three results taken as the amount of alkali necessary to neutralize 1 c.c. of the medium. The figure thus obtained is multiplied by the number of cubic centimetres of medium to be neutralized and divided by ten. The quotient represents the amount of a four per cent. solution of sodium hydrate required to render the whole medium neutral in reaction.

Filtration of broth, gelatine, and agar has been much simplified by employing in the funnel several crossed layers of absorbent cotton, loosely packed, instead of filter-paper. The use of the hot funnel is not required, and the properly neutralized medium can be cleared by passing it several times through the cotton. There is but little likelihood of any of these media becoming too cool to flow during the process, as filtration is very rapid.

v. Freudenreich recommends that agar be filtered through paper in the autoclave. He claims that it is rapidly accomplished, it is thoroughly sterilized, and the medium is crystal clear. He also states that if agar be boiled for two hours at 115° C. and allowed to stand in the unopened autoclave for three hours, it will remain fluid, all the impurities will settle, and a clear medium may be obtained by carefully pouring off the upper layers.

Neisser and Jacobi suggest filtering agar under pressure through 5 ctm. of absorbent cotton, closely packed in a large titrating funnel. They state that filtration by this method requires but a few minutes.

Schultz has suggested the following rapid method of preparing nutrient agar:

To 1,500 c.c. of water, placed in an open enamelled iron vessel, add 18 gm. of agar and boil vigorously over a free flame for thirty minutes. During the boiling 2 gm. of Liebig's meat extract are added, and the thick, white scum which forms is to be removed. The fluid is now cooled to 60° C., and 10 gm. of dry peptone (Witte's) and 5 gm. of sodium chloride are added, together with the entire contents of one or two eggs, which are mixed with sufficient water to replace that which has evaporated.

The reaction, which usually is too alkaline, must be corrected and the mixture is again brought to the boiling point and boiling continued for ten or fifteen minutes.

Filtration is effected through a filter-paper, selected on account of its allowing a rapid filtration, without the use of the hot-water funnel, and may be repeated through the same paper. The process should be completed in an hour, and one litre of medium should be obtained.

The agar thus prepared may be used at once for Esmarch tube-plates, even after the addition of four per cent. of glycerine.

If it is desired to prepare the medium with meat infusion, instead of with Liebig's meat extract, the procedure is modified as follows:

One pound of finely chopped lean meat is digested in 1,500 c.c. of water at 50° C. for thirty minutes, strained through a cloth, boiled for five minutes, and then filtered. To the filtrate, in an agate saucepan, 18 gm. of agar are added, and the process is continued as described above.

Potato.—Esmarch suggests cutting potato in moderately thin slices, placing them in covered glass dishes, measur-

ing not more than 5 ctm. in diameter, and sterilizing in steam for three consecutive days. This answers well for the purposes of culture.

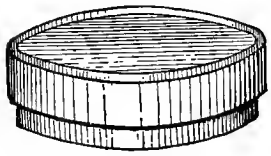

FIG. 37.—Dish for Potato Culture. (Esmarch.)

Roux first suggested placing potato in test-tubes for culture purposes. He cut a core out of the potato with a cork-borer, placed it in a test-tube, the lower end of which had been constricted to form a receptacle for water, and sterilized in steam.

Bolton used larger tubes. The method of preparation is as follows:

A potato squared off at each end, cut out by an apple-corer, and the core thus obtained divided obliquely into two equal parts. Each half is put into a test-tube measuring about 3 ctm. in diameter and 12 ctm. in length, and sterilized for three consecutive days. A small amount of water collects in the bottom of the tube and prevents rapid drying of the medium, while the oblique surface of the potato renders sowing upon it easy, and enables the culture to be readily observed through the tube.

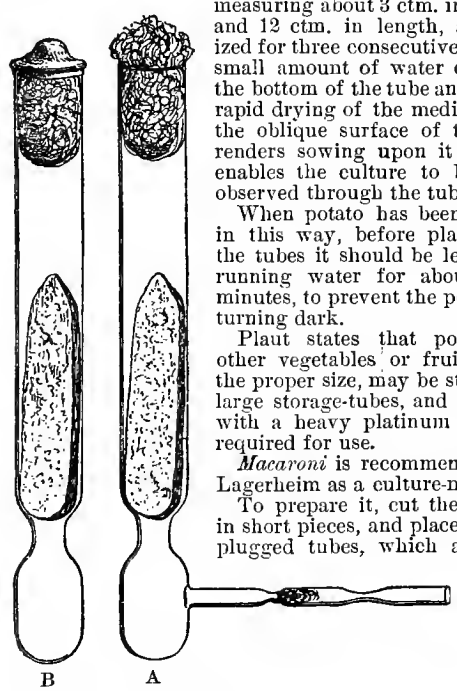

FIG. 38.—Tubes for Potato Cultures. *A*, for anaërobic growth; *B*, for aërobic growth. (Roux.)

When potato has been prepared in this way, before placing it in the tubes it should be left in cold running water for about twenty minutes, to prevent the potato from turning dark.

Plaut states that potatoes, or other vegetables or fruits, cut to the proper size, may be sterilized in large storage-tubes, and fished out with a heavy platinum needle as required for use.

Macaroni is recommended by de Lagerheim as a culture-medium.

To prepare it, cut the macaroni in short pieces, and place in cotton-plugged tubes, which are nearly filled with water. These should be boiled in the steam sterilizer for fifteen minutes, then the excess of water is poured off, and the regular process of sterilization performed.

Many species of bacteria do not grow upon macaroni, but it is useful as an additional medium.

Urine.—Heller has suggested that urine reduced to the specific gravity of 1.010 be used as a culture-medium, to which peptone, salt, gelatine, agar, glycerine, sugar, etc., may be added. He also suggests the use of diabetic and albuminous urine.

Ascitic and hydrocele fluids are used for the purposes of culture, with or without adjuvants. They are to be drawn off from the body by sterilized instruments and received in sterilized vessels. They are prepared as culture-media by the processes employed for blood-serum.

Egg.—The white of egg is an efficient culture-medium.

Schenck recommends using the outer, clear, and most fluid of the albuminous layers, mixed with equal parts of water. This is sterilized discontinuously at 65° to 70° C.

Tarschanoff and Kolessnikoff make a broth-like, a syrupy, and a solid medium from eggs by treating them with potassium hydrate.

They found that eggs in their shells, placed in a ten per cent. solution of potassium hydrate, showed an alteration in the consistence of the albumen. In four days it becomes "fluid-gelatinous-transparent," and in from five to fourteen days it becomes "solid-gelatinous" and faintly yellow, but remains transparent.

The *broth-like* medium is made by using a ten per cent. aqueous solution of the "fluid-gelatinous-transparent" albumen and sterilizing.

The *syrupy* medium is a fifty per cent. aqueous solution of the "fluid-gelatinous-transparent" albumen.

The solid medium may be either α, the "fluid-gelatinous-transparent" albumen placed in tubes and sterilized, or β, the "solid-gelatinous" albumen, cut in thin slices and used unsterilized, in small double dishes.

Blood-serum.—Abbott has suggested an improvement in the method of securing blood-serum. He recommends collecting the blood in museum jars of one gallon capacity, closed by a cover which can be tightly secured upon a rubber joint.

After the blood has stood in these jars for about fifteen minutes, or until clotting has begun, a clean glass rod is passed around the edges of the surface of the clot, to break up adhesions which have formed, and which would prevent the sinking of the clot to the bottom. The covers are then tightly replaced, and with as little agitation as possible the jars are removed to an ice-chest. At the end of about forty-eight hours the firm clot will have sunk to the bottom of the jar, and above it a quantity of dark straw-colored serum is found. This serum should be drawn off with a sterilized pipette and placed in tall cylinders and the blood-corpuscles allowed to settle by standing the cylinders in an ice-chest for twenty-four hours. The clear serum is then pipetted off into tubes or flasks and sterilized by the fractional method.

Kirchner has demonstrated that chloroform added to various fluids will prevent putrefaction in them. He recommends the use of this agent in the strength of one per cent. for preserving storage-flasks of unsterilized blood-serum and milk. Chloroform does not kill spores, but prevents their development, so that when fluids thus preserved are prepared for use the chloroform must be driven off by heat, and sterilization effected by the usual methods.

Blood-serum thus preserved in sealed flasks for more than a year has been successfully used as a culture-medium.

Loeffler mixes three parts of blood-serum with one part of beef-broth containing one per cent. of glucose. This is sterilized and used as a fluid or solid medium. It is recommended for growing the B. diphtheriæ, and Park has shown that within eighteen hours a sufficient growth may be obtained on the coagulated medium to establish a differential diagnosis between diphtheria and the other pseudo-membranous inflammations.

Hueppe combines blood-serum with agar to make plates. He mixes the sterile fluid serum with equal parts of two per cent. nutrient agar to which 0.5 to 1 per cent. of glucose has been added. The following procedure should be closely adhered to, viz., warm the serum to 37° C., melt the agar and cool to 42° to 45° C. and mix them together. The material to be studied is then added and the plate poured before the agar has become solid.

Bumm suggests collecting human blood from the placental end of the cut umbilical cord, in a sterilized vessel. The serum is collected and sterilized in the usual way. From single cases he has secured from 15 to 20 c.c. of clear serum.

Human blood-serum seems to be necessary for procuring cultures of the gonococcus.

PLATE CULTURES.—Petri suggested for plating gelatine and agar, the use of double glass dishes measuring 10 ctm. in diameter and 1.5 ctm. in height. The upper dish is a cover and the lower dish, with its perpendicular edges, serves to hold the medium, and obviates the necessity of using a levelling apparatus and cold stage. The "Petri dish" has in most cases replaced the flat plate formerly used. It seems to be adapted to every need.

"Streak-plates" are made on gelatine and agar, after the medium has been poured in the plates and become solidified, by drawing an infected needle across them in four or five parallel courses. When the number of bacteria on the needle is small, and the streaks are made with a light touch, separate colonies will be found growing along the line which the needle has travelled. This method of plating is especially adapted for use at autopsies.

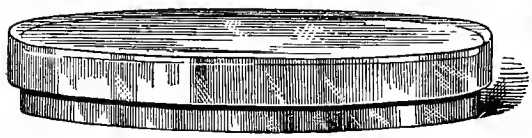

FIG. 39.—Dish for Plating. (Petri.)

ANAËROBIOSIS. — Various methods have been suggested for obtaining bacterial cultures in an atmosphere from which oxygen has been excluded. Some forms, the obligatory anaërobes, require that this condition be absolutely fulfilled, while others, the facultative anaërobes, develop both in the presence and in the absence of oxygen.

The methods described answer the requirements more or less perfectly, but the process is a difficult one to carry out, and attention is required to the minute details.

The oxygen may be removed from the culture by mechanical means, and this is the most usual procedure, or it may be absorbed and enter into chemical combinations which are not broken up by the processes required to obtain a growth of the bacteria in question.

FIG. 40.—Anaërobic Growth Obtained by Deep Puncture.

By means of the air-pump the air may be rarefied, and a large proportion of the oxygen removed, or, as was first suggested by Koch, the medium on a plate is covered with a sheet of mica, beneath which the air is excluded and the growth which occurs remains under observation.

For growth in tubes, Hesse has suggested pouring upon the medium a quantity of sterilized oil.

Librious, after boiling the medium for 20 minutes to drive off the oxygen contained in it, cooled the medium quickly, inoculated the germ to be cultivated, and then sealed the tube.

Roux, after boiling, cooling, and inoculating the medium, poured upon it a thick layer of agar, which, when cool, he inoculated with an aërobic germ, to use up any oxygen which might still be present or which might gain admission.

Deep puncture, with a long platinum needle, in a tube containing a column of nutrient medium, 8 or 10 ctm. in height, is an efficient method of obtaining anaërobic growth. The first growth appears at the lower part of the tube and extends slowly upward, sometimes reaching nearly to the surface of the medium.

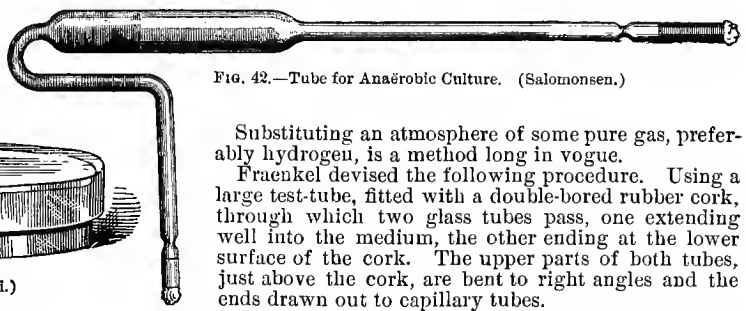

FIG. 42.—Tube for Anaërobic Culture. (Salomonsen.)

Substituting an atmosphere of some pure gas, preferably hydrogen, is a method long in vogue.

Fraenkel devised the following procedure. Using a large test-tube, fitted with a double-bored rubber cork, through which two glass tubes pass, one extending well into the medium, the other ending at the lower surface of the cork. The upper parts of both tubes, just above the cork, are bent to right angles and the ends drawn out to capillary tubes.

Through the longer tube a stream of hydrogen or other gas is passed to replace the air which is driven out through the shorter tube, and when this is accomplished both tubes are sealed, the shorter one first.

After the tubes have been sealed an Esmarch tube-plate may be made.

Salomonsen has devised a culture-tube in which the air may be replaced by hydrogen. It consists of a piece of glass tubing drawn out at both ends, leaving between them a bulb 8 or 10 ctm. in length. One of the ends is bent up upon the bulb, and at the middle of the bulb bent outward at a right angle. After the medium has been introduced, a stream of hydrogen is passed through it from below while it is still fluid. Inoculation is effected by means of a platinum needle, and after the air has been replaced by hydrogen, both ends are sealed.

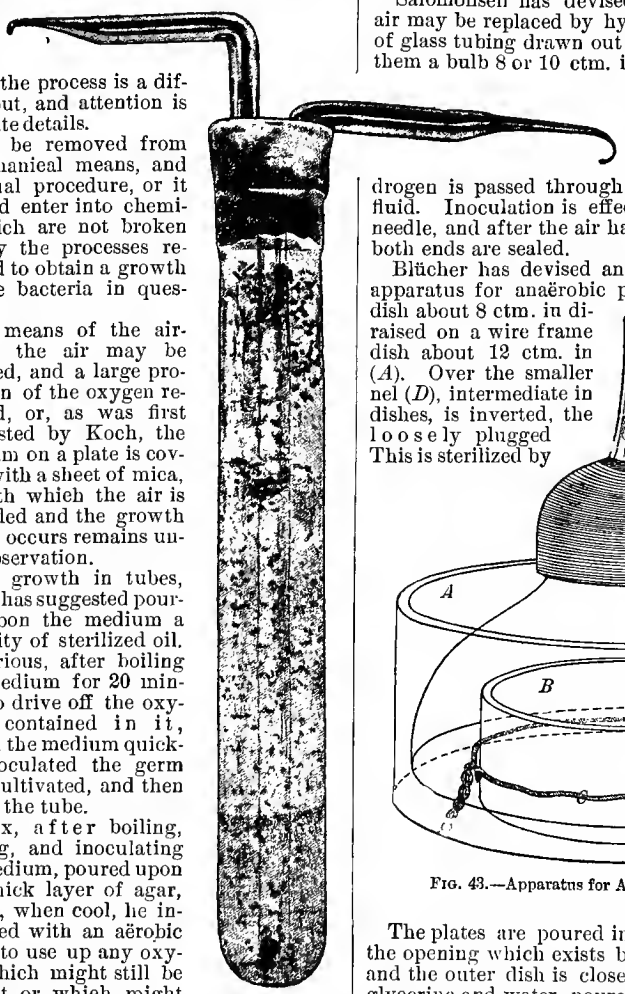

FIG. 41.—Anaërobic Tube-plate. (Fraenkel.)

Blücher has devised an ingenious and very effective apparatus for anaërobic plating. It consists of a glass dish about 8 ctm. in diameter (*B*), which is raised on a wire frame (*C*) and placed within a dish about 12 ctm. in diameter and 5 ctm. high (*A*). Over the smaller dish a tulip-shaped funnel (*D*), intermediate in size between the two dishes, is inverted, the neck of which has been loosely plugged with cotton (*E*). This is sterilized by dry heat.

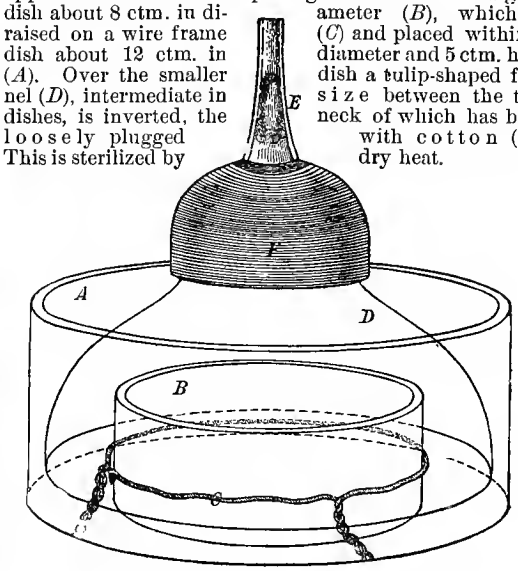

FIG. 43.—Apparatus for Anaërobic Plating. (Blücher.)

The plates are poured into the inner or smaller dish, the opening which exists between the rim of the funnel and the outer dish is closed by a sufficient quantity of glycerine and water, poured into the outer dish, and the neck of the funnel is connected with the gas generator by a piece of rubber tubing, 8 or 10 ctm. in length, which is provided with a spring clip. The gas, passing from

above, drives the air out beneath the rim of the funnel, and when this process is completed, the rubber tubing is closed by the spring clip, the connection with the gas generator is broken and a drop of glycerine placed in the lumen of the rubber tubing, above the spring clip, to effectually seal it. It is necessary to weight the funnel to overcome the buoyancy of the gas contained in it (*F*).

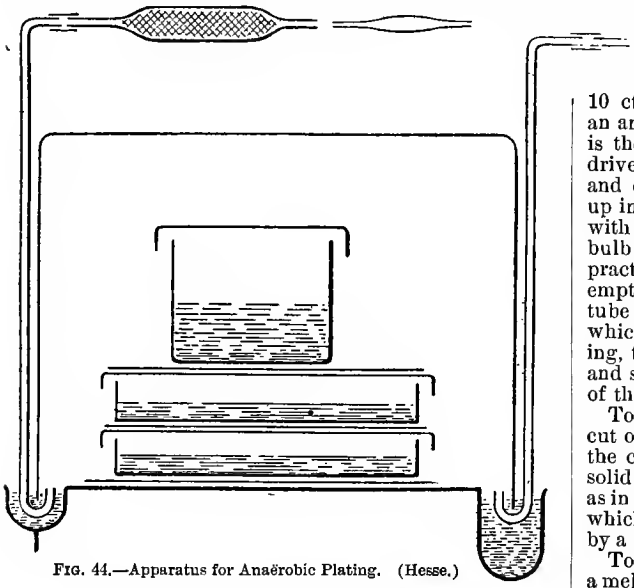

FIG. 44.—Apparatus for Anaërobic Plating. (Hesse.)

Hesse and Botkin have both devised apparatus for growing anaërobic plates.

In both cases a closed chamber is formed by inverting a vessel of considerable cubical contents, within one of slightly greater diameter. A small rack to hold several plates, one above the other, is placed within the chamber, and raised from the floor of the lower vessel.

Hesse seals the opening between the upper and lower vessels with mercury, and conducts the stream of hydrogen through a glass tube curved at its extremity to a short U-shape. The air is conducted off by a similar glass tube placed on the other side, and when the substitution of the hydrogen is completed both tubes are removed without allowing any of the gas to escape.

Botkin uses a liquid paraffine joint, 3 ctm. in height, and conducts both the gas and the air through rubber tubes. These tubes, when bent to the desired shape, retain this shape through the agency of a fine copper wire

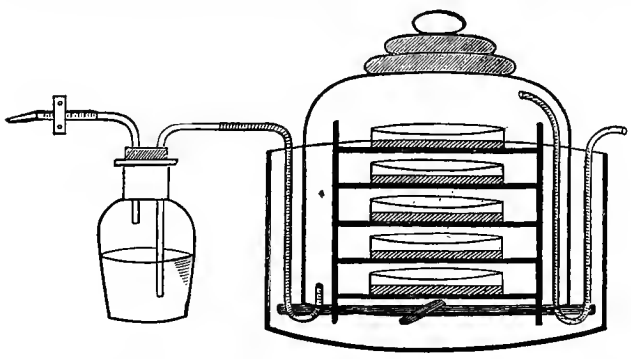

FIG. 45.—Apparatus for Anaërobic Plating. (Botkin.)

previously passed through them. They are easily removed, after steadying the upper vessel, by simply drawing them out.

Esmarch's roll tube-plates may be used for anaërobic growth by filling the tube with gelatine. In doing this it is necessary that the tube-plate already made be held in ice-water, to prevent its melting, while the gelatine, which should be as cool as it is possible to have it, is poured in.

Nikiforoff has devised a bulb for cultures, from which the air can be absolutely excluded. It is made from a moderately thin glass tubing of 1.5 to 2 ctm. diameter, sealed at one end and drawn out to a long capillary tube at the other, leaving a bulb about 5 ctm. in length. The capillary tube is broken at its middle, and at a distance of about 10 ctm. from the bulb it is curved through an angle of 160°. The end of the capillary is then immersed in sterilized water, the air driven out by heating the bulb with a flame, and on cooling some of the water is sucked up into the bulb. To fill such an apparatus with the nutrient medium the water in the bulb must be carefully boiled out, leaving practically a vacuum, and just before the emptying of the bulb the end of the capillary tube is immersed in the desired medium, which must be in a fluid condition. On cooling, the medium flows rapidly into the bulb, and sealing is effected by holding the curve of the capillary tube in a flame.

To allow of inoculation the tube must be cut off where the bulb begins to narrow into the capillary. The process of sowing in a solid medium is the same as in ordinary tubes, after which the tube is sealed by a blow-pipe.

To sow in broth, or in a melted gelatine or agar, he recommends the ingenious method of touching an end of a short, sterilized capillary tube, held in sterilized forceps, to the fluid to be examined. The capillary at once fills, and it is dropped into the bulb, where it falls to the bottom, its contents being washed out by the fluid medium

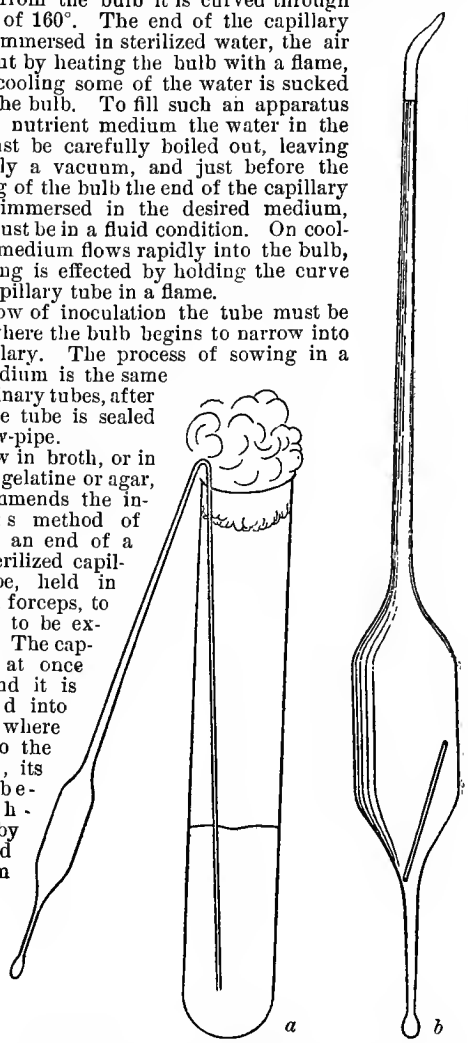

FIG. 46.—Anaërobic Culture-tube. *a*, Method of filling tube with culture medium; *b*, tube inoculated and sealed. (Nikiforoff.)

during its descent. The bulb is then sealed.

Hueppe recommends the use of eggs in their shells for anaërobic cultures.

After external cleansing and disinfection with sublimate, washing in sterilized water, and drying with sterilized absorbent cotton, the egg is thoroughly shaken and a fine opening made at its point, by a sterilized instrument, through the shell and membranes. Through this opening the inoculation is made, and it is afterward covered with sterilized paper and sealed with collodion.

Buchner absorbs the oxygen present in the tubes,

and uses for the purpose an alkaline solution of pyrogallol.

A tube inoculated in the ordinary way is placed in a large test-tube containing 1 gm. of commercial pyrogallic acid. To this 10 c.c. of a 10 per cent. potassium hydrate solution is added from a pipette, and the large tube is quickly closed with a rubber cork and sealed. In twenty-four hours, at 37° C., the contained oxygen is absorbed. At lower temperatures a longer time is required.

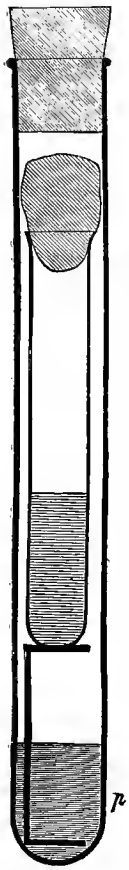

Fig. 47. — Apparatus for Anaërobic Culture. (Buchner.)

It is of advantage to raise the inoculated test-tube above the fluid in the large tube on a glass or metal support (*p*).

Kitasato and Weil have proposed adding to the nutrient medium substances which possess the power of absorbing oxygen. They believed that the good effect of sugar, as used by Liborius, upon the growth of anaërobic bacteria was due to this absorbing power, and they experimented to find a substance which would act more powerfully in this regard.

They found that sodium formate, used in the strength of 0.3 to 0.5 per cent. in nutrient agar, left a clear, transparent medium, and its presence was so beneficial upon the growth of three anaërobic species experimented with, that they recommend its use for this purpose.

They also found very characteristic appearances from growing anaërobes in agar, to which 0.1 per cent. of sodium indigo-sulphate had been added.

Before inoculation and for about twelve hours after it, this medium is bluish-black and opaque. As growth progresses the color changes to one of a greenish tint, the change appearing first in the lower part of the tube and spreading upward. Gradually the growth in the puncture-line becomes apparent, and the agar, which eventually regains transparency, also regains its original yellow or brownish color. In all cases the color of the superficial layers of the medium, to the depth of about two ctm., remains an indigo-blue.

Anaërobic Hanging-drop.—The growth of anaërobic bacteria in hanging-drop has been carried on by apparatus which allowed a stream of hydrogen to replace the air, or from which the air was exhausted by the air-pump. Two much more simple and very efficient methods have been suggested.

Nikiforoff prepares the hanging-drop as usual, upon the hollow slide, and, by slipping the cover to one side, places a small drop of a saturated solution of pyrogallol on the edge of the hollow; then by slipping the cover to the other side he inserts a small drop of ten per cent. potassium hydrate solution, and returns the cover-glass

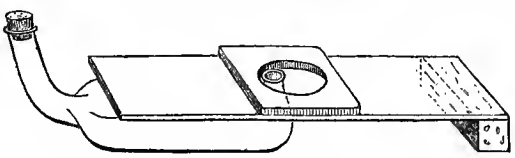
Fig. 48.—Slide for Anaërobic Hanging-drop. (Braatz.)

to its proper place. By careful manipulation the two drops may be run together, and the oxygen is then absorbed. The alkaline pyrogallol forms a dark ring around the hanging-drop.

Braatz also uses the alkaline pyrogallol solution to absorb the oxygen, but forms a retort for it beneath the slide, which is connected through a hole in the slide with its upper surface. Over this opening a glass ring is sealed. The hanging-drop is made in the ordinary way, and sealed with vaseline upon the glass ring. Through another opening in the retort the pyrogallol is first introduced, then the ten per cent. solution of potassium hydrate, and the opening is plugged and sealed.

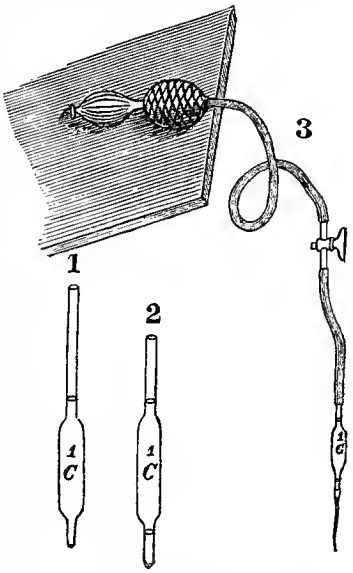

Fig. 49. — Syringe for Animal Inoculation. (Petri.)

Inoculation of Animals. — Petri has recommended an inoculation syringe which seems to present advantages over those formerly used. He employs a graduated glass pipette of 1, 2, or 5 c.c. capacity, with a short tube of exit, which is ground to fit accurately into the shoulder of a hypodermic needle. The needle and pipette are easily sterilized and are the only parts which come in contact with the fluid to be injected.

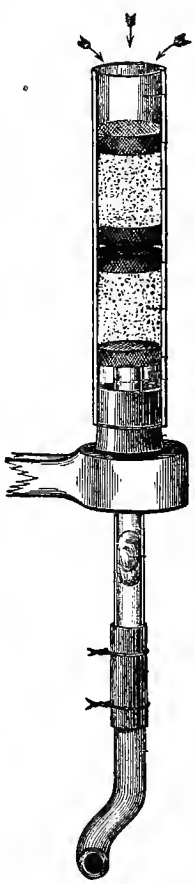
Fig. 50.—Sand Filter for Air Analysis. (Petri.)

The injecting power is supplied by a double bulb, such as is used in an ordinary hand-spray apparatus, and attached to the pipette by rubber tubing, in the course of which a stop-cock has been inserted.

The pipette being filled with the desired fluid, the stop-cock turned to cut off the air, and the bulb being inflated, the needle is introduced into the tissues and by carefully turning the stop-cock enough force can be applied to drive the desired quantity of the inoculating fluid into the body of the animal. Then by turning the stop-cock to cut off the force and withdrawing the needle the operation is completed.

Examination of Air. — It has been demonstrated that the air may be freed from the dust and bacteria which it contains by filtration through various substances and this fact has led observers to employ filtration for studies of air analysis.

After a measured quantity of air has been aspirated through the filter, the bacteria are freed from the filtering substance and grown upon plates. Cotton, glass-wool, and asbestos-wool serve as efficient filters, but the difficulty of spreading these materials in the fluid medium and their opacity have led to a discontinuance of their use.

Petri, after a series of experiments, suggested the use of a column of sand as an air-filter and has devised the following method for its use.

Grains of sand, measuring between 0.25 and 0.5 mm., are collected by means of a series of sieves, and thoroughly burned over a flame for the

purpose of sterilization. This gives them a reddish color.

A glass tube, 9 ctm. in length and 1.5 ctm. calibre, is fitted within its lumen with four disks of fine wire gauze to serve as supports, and between each two of these disks a sand-filter, 3 ctm. in length, is closely packed. Each end of the tube is plugged with cotton and the whole is sterilized in hot air. The filter is now ready for use.

When the apparatus is to be used for an analysis, the cotton plugs are removed and placed in a sterilized covered vessel, and the filter is attached to an exhaust-pump by means of rubber tubing. From 5 to 10 litres of air a minute are drawn through the sand, until the required amount has passed, when the filter is separated from its attachments, the cotton plugs are replaced and the filter preserved for plating.

The method of plating is as follows: After removing the uppermost cotton plug, the upper gauze disk is taken out with sterilized forceps and placed in a sterilized Petri dish. The sand is then poured into the same dish, the melted gelatine added, and the sand spread evenly by short, quick lateral movements of the dish.

The lower sand-filter is then treated in the same manner and the plates preserved for observation.

With the aid of a good hand-magnifier, the colonies of bacteria may be readily distinguished from the grains of sand.

Opaque areas are sometimes formed in these plates, by a grouping of the sand-particles, which may obscure certain parts of the plate. To overcome this objection the use of soluble filters has been proposed. Sedgwick and Tucker have used for this purpose a filter of granulated sugar, about 8 ctm. in length and 3 mm. in diameter, contained in a glass tube. To avoid the risk of contamination in pouring the plates they attached to the tube containing the filter, a cylindrical glass bulb, ruled in squares, into which the sugar used for filtering is to be transferred and in which the plate is rolled. Both ends of the apparatus are plugged with cotton and sterilization is effected at 150° C. in hot air.

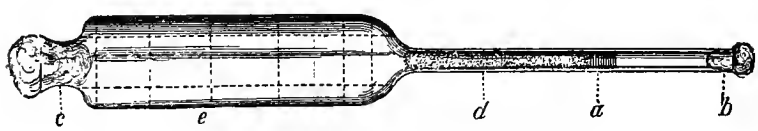

FIG. 51.—Aërobioscope. (Sedgwick and Tucker.)

These writers propose the use of an exhaust receiver of measured capacity provided with a vacuum gauge, to determine the amount of air used. To this receiver their apparatus is attached and the desired amount of air drawn in through it. When this is accomplished the sugar is transferred from the tube to the bulb by careful tapping, a sufficient amount of gelatine is then poured into the bulb, and after the sugar is dissolved a plate is rolled, under a stream of cold running water.

The sand-filter for air analysis may be simplified as follows: In a glass tube, 9 ctm. in length, about 0.3 ctm. in diameter, 6 ctm. of sand, of the size recommended by Petri, are placed, and the column supported on a roll of fine wire gauze pressed into the tube. Both ends of the tube are plugged with cotton and the whole is sterilized in dry heat. After removing the cotton plugs this filter is inserted in a rubber tube connected with an exhaust receiver, as suggested by Sedgwick, and the required amount of air is drawn through it. The plating is effected by scattering the sand used for filtering in a Petri dish and adding the melted gelatine.

The amount of sand used in such a filter is less than that used in the method proposed by Petri, which overcomes an objection to the use of his method, since a satisfactory examination of the plate can be made with a hand-magnifier or with low powers of the microscope.

EXAMINATION OF WATER.—Water for bacteriological examination, taken from the surface of a stream or a faucet, may be collected in a sterilized tube or flask. Samples taken from the deeper parts of a stream are collected in sterilized weighted bottles, fitted with an apparatus to withdraw and replace the stopper, and lowered to the desired depth.

Water should be plated as soon as possible after it has been obtained. Should it be necessary to transport it before the plates can be made, the bottle containing it should be packed in ice.

The quantity of water used for an analysis must depend upon the number of bacteria which it contains. One cubic centimetre is the amount usually employed, but less should be used if more than five hundred colonies develop from this amount. For quantitative analysis a measured quantity must always be employed, a drop, being an indefinite quantity, is not to be recommended.

The colonies should be counted on the third or fourth day. *T. M. Cheesman.*

BAD BRONN. An Alsatian watering-place, known also as Kestenholz (Ger.) and Châtenois (Fr.).

LOCATION.—Kestenholz is prettily situated not far from Strasbourg, and within sight of Schlettstadt on the river Rhine. It is an unpretentious, quiet resort, with four saline and moderately alkaline springs, flowing in great abundance, and having a temperature of about 64°F. It is chiefly frequented by ladies. Although the water contains traces of sulphuretted hydrogen, it is not unpleasant to the taste. The baths are refreshing, and the thermal establishment is modern in its appliances. There are beautiful natural promenades through chestnut-plantations and fine forests. The walks resemble those of Marienbad. Mr. Wolff writes as follows concerning this place ("The Watering Places of the Vosges, 1891"): "Apart from the use of the waters, for a cheap sojourn in foreign mountain country it would not be easy to hit upon a fitter place than Châtenois. It is easily reached, being situated on the branch-line from Schlettstadt to Markirch, at the junction of the valleys of the Leber (Lièpvre) and of Weiler (Val de Villé), both exceedingly pretty and at the same time interesting valleys, leading up to the lofty ridge which rises farther south to the high points of the Schlucht and the Hohneck."

ANALYSIS.—In 1,000 parts there are contained:

Free carbonic acid	traces
Sulphuretted hydrogen	traces
Chloride of sodium	3.200
Chloride of magnesium	0.078
Chloride of potassium	0.010
Sulphate of soda (anhydrous)	0.086
Sulphate of magnesia	0.050
Sulphate of lime	0.020
Silicate of soda / Bicarbonate of soda	0.050
Silicate of lime	0.410
Silicate of magnesia	0.270
Silicate of iron and of manganese	0.020
Basic salts of bromine and of iodine	strong traces
Organic matter, in combination with lithia silicic acid and ammonia	0.020
Fluorine, arsenic, lithia	strong traces
	4.214

INDICATIONS.—These saline waters are useful in rheumatic and gouty affections, hepatic plethora, catarrhal affections of the bowels, anæmia and chlorosis. For conditions of neurasthenia the place itself, apart from the springs, has undeniable advantages. Tuberculosis and cutaneous affections are also said to be much benefited by a course of these waters, but this statement must be taken *cum grano salis.*

ACCOMMODATION.—A new hotel is in course of construction, the older ones are mediocre, though clean. The usual sprays, douches, pine-needle baths, inhalations, etc., are provided. But everything is on a small scale. It is a cheap place—Mr. Wolff stating that one dollar a day will about cover all necessary expenditures. *Edmund C. Wendt.*

BADEN-BEI-ZÜRICH, so called to distinguish it from the other European Badens, is a popular watering-place of Switzerland, only a short distance from Zürich.

LOCATION.—This Baden was at one time the most fashionable spa of Europe. It is prettily situated in one of the most picturesque spots of the Jura Mountains. The river Limmat pierces the mountain chain here on its way down from Zürich. There are beautiful promenades with fine views of the Alps. Richly wooded hills are found in all directions. The elevation of Baden above sea-level is less than twelve hundred feet. There are a number of sulphurous springs, rich in chloride of sodium, and having a temperature of 118° F. They furnish about one million litres a day. It is a quiet place now.

The climate is bracing, and the temperature on the whole equable. It is an all-the-year-round resort, but is largely frequented only during the warmer months.

ACCESS.—Baden is a station on the railroad from Zürich to Bâle, thirty minutes from Zürich.

ANALYSIS.—One quart of Baden mineral water contains:

	Grains.
Sulphate of soda	2.218
Sulphate of magnesia	2.442
Sulphate of lime	10.860
Chloride of potassium	0.711
Chloride of sodium	13.042
Chloride of magnesium	0.566
Carbonate of lime	2.599
Carbonate of magnesium	0.152
Carbonate of strontium	0.005
Fluoride of calcium	0.016
Chloride of calcium	0.719
All other ingredients	0.013
Total of solids	33.343

INDICATIONS.—Baden was known to the Romans, and has a good reputation in the treatment of gouty and rheumatic affections, motor disturbances after fractures and dislocations, metallic intoxications, and all digestive and respiratory troubles on a lithæmic basis. It is also a "*Terrain-Kurort*" for the Oertel method of treating cardiac affections and obesity.

The baths have all modern appliances and comforts.

There are opportunities for milk-, whey-, and grape-cures. Inhalation-rooms, massage, etc., are not wanting to meet the requirements of certain cases.

ACCOMMODATION.—There are numerous "bath-hotels," such as the Bären, Blume, Limmathof, Hirsch, Schwan, etc. There is a fairly good *Kurhaus*, with salons, reading-room, etc. An orchestra plays from April to October, and there are two theatres. The proximity to the University town of Zürich is an advantage. Not many English and American visitors go there now.

Edmund C. Wendt.

BADENWEILER. A popular watering-place and climatic station in the Black Forest, known to the Romans as *Aquæ Villarum*.

LOCATION.—Badenweiler is pleasantly situated in the southern part of the Black Forest, in the Duchy of Baden, near the university town of Freiburg. It has only about six hundred inhabitants, but is annually visited by over five thousand patients and tourists. It is one thousand three hundred feet above the sea-level, and the pure air, impregnated with the balsamic odors of the surrounding pine woods, is a factor which adds greatly to the popularity of the place as a health-resort.

Dr. C. W. Allen, of New York, recently spent some time there, and has given his impressions in the *St. Louis Courier of Medicine*. There are interesting remains of the old Roman baths, still showing the usual *atrium*, *vestibulum*, *frigidarium*, *calidarium*, *tepidarium*, etc. The new baths are equipped with all the modern appliances of a complete establishment, such as douches, showers, sprays, inhalation-cabinets, etc. The waters of the springs are earthy and slightly alkaline, having a temperature of 80° F. and flowing at the rate of 1,140 litres per minute. It is a peculiarly pleasant water to swim and bathe in, according to Dr. Allen's personal experiences.

The higher peaks of the Black Forest shut in the little village from the northeast and partly from the south, while it is open toward the Vosges Mountains on the west. Sharp and raw winds are unknown, the ground dries quickly after rains, and even in the woods no unpleasant dampness is felt. The temperature is even, the night and day variations being slight. The place is very healthy, the mortality (exclusive of the first year of life) being only about fourteen per thousand. There are excellent facilities for many highly picturesque excursions. From near-by mountains fine views of the Alps, Jura, Vosges, and the Valley of the Rhine are obtained. Season, May to October.

ACCESS.—From the station Mühlheim, on the railroad, between Bâle and Freiburg, by omnibus or carriage.

INDICATIONS.—Diseases of the chest, nervous and catarrhal affections, neuralgia, rheumatism, female diseases, neurasthenia, anæmia, protracted convalescence, are all treated with happy results at Badenweiler. There are plenty of amusements—concerts, theatre, "Italian nights," etc. Cows', goats', and donkeys' milk. A special feature is made of the grape and whey cure. Badenweiler is also a so-called "*Terrain-Kurort*" (Oertel) for cases of heart disease.

ACCOMMODATION.—There are good hotels, chief among which are the Hotel Sommer, Römerbad, and Sonne. Apartments in villas are also found, and there are quite a number of good boarding-houses. The *Kurhaus* is elegantly fitted up with a ball-room, reading-rooms, etc. It is a commodious structure and under good management. There is a moderate "cure-tax" for visitors and patients.

Edmund C. Wendt.

BAD HEILBRUNN. A popular watering-place in Bavaria, Germany.

LOCATION.—Heilbrunn (healing spring) is prettily situated near the Bavarian Alps. It is two thousand five hundred feet above sea-level. Attractive scenery and abundant vegetation add to the charm of the little village.

ACCESS.—By way of Munich to station Tölz, thence by omnibus.

ANALYSIS.—The waters of the spring called Adelhaid's quelle are rather rich in bromides and iodides. In 1,000 parts of water there are contained:

Sodium chloride	4.758
Sodium carbonate	0.777
Calcium carbonate	0.073
Magnesium carbonate	0.018
Sodium iodide	0.027
Sodium bromide	0.046

The spring has a temperature of 50° F. The water is limpid and sparkling, and something like 60,000 bottles are exported annually.

INDICATIONS.—Cutaneous and syphilitic affections, scrofula, also anæmia and catarrhal affections of the air-passages, are chiefly treated at this place. But obesity, goître, and diseases of women are said to do well there also.

ACCOMMODATION.—Rather primitive and not over clean. There is a *Badehaus* and a number of boarding-houses. Summer season only.

Edmund C. Wendt.

BAGNOLLES.—A watering-place in the Department of Orne, France.

LOCATION.—Bagnolles (not to be confounded with Bagnols-les-Bains), is situated in a picturesque valley, surrounded by hills, and about five hundred feet above the level of the sea. This region of the country is known, on account of its mountainous character, as the "Switzerland of Normandy." The springs are mildly mineralized and have a temperature of 65° F.; 10,000 parts contain only 1.309 of solids. There are also several cold chalybeate springs in the place.

ACCESS.—From Paris to Domfort, thence to the village of Couterne, which is about six miles from the springs.

ANALYSIS.—Besides chloride of sodium, small quantities of arsenical salts, sulphides, silica, lithia salts, and

baryum are contained in these waters; also a moderate proportion of carbonic acid gas.

INDICATIONS.—Chronic sores, phlebitis, skin diseases, scrofula, chlorosis, rheumatism, abdominal plethora, and gastralgia, are the diseases said to be beneficially affected by a course of these waters.

ACCOMMODATION.—Modern bathing establishment, with the usual appliances. Moderately good lodgings at boarding houses. *Edmund C. Wendt.*

BAGNOLS-LES-BAINS.—A watering-place in the Department of Lozère, France.

LOCATION.—Bagnols-les-Bains is situated in a narrow valley at an elevation of about two thousand six hundred feet above the level of the sea. The climate is rather trying on account of sudden atmospheric changes. There are six hot sulphurous springs with temperatures ranging from 50° F. to 105° F. Season, June to September.

ACCESS.—Paris to Mende, on the Paris, Lyons & Mediterranean Railroad (fifteen hours). From there by stage to Bagnols in three hours.

ANALYSIS.—The springs are only slightly mineralized, the chief ingredients being sulphate of soda, carbonate of soda, and sulphides.

INDICATIONS.—The diseases usually treated here are cutaneous affections, scrofula, rheumatism, chronic ulcers, etc. But it is at least open to question whether cardiac and pulmonary complaints, for which the springs are also recommended by French physicians, would not be made worse there, on account of the known uncertainties of the climate.

ACCOMMODATION.—There are two thermal establishments, with the usual facilities for douches, sprays, inhalations, etc. Hotels moderately good and cheap. *Edmund C. Wendt.*

BAINS-LES-BAINS, a quiet watering-place in the Vosges Mountain district, with springs highly prized by the Romans.

LOCATION.—Bains-les-Bains is pleasantly situated in a wooded district of France, near the town of Epinal. Elevation above sea-level, nine hundred feet.

Mr. Wolff, in "The Watering-places of the Vosges" (London, 1891), thus speaks of it: "Thanks to the meeting of two different geological formations—the granite of the Vosges on one side, and the calcareous stretch of Champagne on the other—the climate of this intervening sandy belt is also said to be all that could be desired, inimical to disease, and remarkably conducive to longevity. Proceeding to more minute local features, the new hotel seems, in respect of construction, tolerably perfect. There are airy, good-sized rooms. And I was surprised to find of all places this retired and old-fashioned oasis taking the lead among Vosges watering-places in the adoption of the electric light, which is laid on all over the house. The glories of Bains are now obscured, but it has had its halcyon days. In the Roman period it was in its own country, fairly rich in thermal waters, the 'Balneum' *par excellence*, of the bath-loving conquerors. There is a *Bain Romain* still in use, modern of course, but built upon the site of the origiual old Roman *balneum.*"

Dr. Bailly considers the waters of Bains, Plombières, and Luxeuil almost identical in effect, their main constituents being sulphate of sodium and chloride of sodium.

At Bains-les-Bains there are eleven springs in all, by far the most productive and most important—and also the hottest—of which is the *Grosse Source*, which is the property of the State. The next in importance is the *Source Tiède de la Promenade*, which indicates from 82° to 86° F.; and the third is the *Robinet de Fer*, a very weakly mineralized water, having but 0.35 gramme of solids in the litre, which is almost, if not quite, as hot as the *Grosse Source.*

ACCESS.—From Paris, viâ Mulhouse to Epinal, thence by omnibus or carriage.

ANALYSIS.—In one thousand parts:

	Grosse Source. Parts.	Source de la Promenade. Parts.	Source de la Vache. Parts.	Source Savonneuse. Parts.
Sulphate of lime.....	0.110	0.075	0.102	0.160
Chloride of sodium....	0.083	0.058	0.136	0.163
Carbonate of soda....	0.010	—	—	—
Carbonate of lime....	0.028	0.018	0.018	0.045
Silica.....	0.069	0.047	0.093	0.221
Oxide of iron..... ...	0.002	0.002	0.002	0.002
Organic matter.....	Trace.	Trace.	Trace.	Trace.
	0.302	0.700	0.351	0.491
Temperature.....	122° F.	88–95° F.	99° F.	99–107° F.

INDICATIONS.—There are two thermal establishments, with the usual appliances for douches, sprays, etc. The complaints for which the waters are prescribed are, above all things, articular rheumatism, chronic and acute, and sciatica, and then gout, rheumatic gout, liver complaints, obstruction and tumors, paralysis, cutaneous diseases, fractures, contusions, and the like. Constantin James—referring, it is to be presumed, more particularly to the tepid *Source de la Promenade*, which is especially credited with this effect—speaks of them as at the same time tonic and soothing to the nervous system. It should be borne in mind, however, that the climate of Bains is decidedly variable.

ACCOMMODATION.—The newly built *Grand Hotel* is comfortable and commodious. There is a *Casino* under the same roof, a theatre, concert-room, card-rooms, etc. There are many pleasant shaded walks in the vicinity. Season, May to October. There are also several less pretentious and more moderate hotels, as well as a variety of lodging-houses. *Edmund C. Wendt.*

BALARUC-LES-BAINS.—A watering-place in the Department of Hérault, France.

LOCATION.—Balaruc is near Cette and Montpelier, not far from the Mediterranean Sea, and on a peninsula projecting into the Talu. It is only slightly elevated above the sea-level, but the little valley is healthy and enjoys an agreeable climate. There is a saline spring having a temperature of 116° F., and flowing very abundantly.

ACCESS.—From Paris to Cette on the Paris, Lyons & Mediterranean Railroad, thence by carriage to Balaruc.

ANALYSIS.—In 10,000 parts of the water there are found:

	Parts.
Chloride of sodium.....	68.02
Chloride of magnesium.....	10.74
Sulphate of potassium.....	0.53
Sulphate of magnesium.....	0.43
Sulphate of lime.....	7.55
Carbonate of lime.....	3.05
Bromide of sodium.....	0.03
Bromide of magnesium.....	0.32
Silica.....	0.13
Total solids.....	90.80

Taken in quantity this water acts as a purgative, and it has even been observed that the bowels may remain loose for some time after the termination of a course of treatment. The water is also largely exported.

INDICATIONS.—Scrofula, struma, paralysis, rheumatism, metallic intoxications, anchylosis, and chlorotic conditions are said to be quite successfully treated at Balaruc. Patients suffering from paralytic conditions dependent on hysteria should, however, not be sent there. Although the place is a warm one, the principal thermal establishments are closed during the winter season. There is a large military bathing-place, maintained by the French Government.

ACCOMMODATION.—The thermal establishments are not as perfectly comfortable and modern in appliances as could be desired. But the usual douches, sprays, etc., are administered. Amusements are only sparingly provided, and "bath-life" is decidedly dull at Balaruc. Fashionable throngs avoid it. *Edmund C. Wendt.*

BARÈGES. A much-frequented watering-place in the *Hautes-Pyrénées*, France.

LOCATION.—The village of Barèges is situated in a narrow valley, formed by the Bastan. It is 4,000 feet above the level of the sea, and is thus the most elevated of the spas in the Pyrenees. The surrounding mountains are barren, and the spot has no particular natural charms to recommend it. There are, however, some nine or ten mineral springs, which have given the village its great reputation as a health-resort. The French maintain a military thermal establishment there. Harsh climate.

ACCESS.—The village is thirty miles from Tarbes, and is reached by a tedious road. Pierrefitte is the nearest station on the Bordeaux Railway.

ANALYSIS.—According to Louchamp, one quart of the waters contains:

	Grains.
Sulphate of sodium	0.649
Sulphuret of sodium	0.771
Chloride of sodium	0.618
Silica	1.034
Lime	0.030
Magnesia	0.005
Caustic soda	0.077
Caustic potash	traces
Ammonia	traces
Total solids	3.184

The temperature of the ten springs varies from 85° F. to 112° F. The water is clear, but has a disagreeable odor and taste, often producing nausea and vomiting.

INDICATIONS.—Barèges enjoys an excellent reputation in the treatment of chronic diseases, such as indolent ulcers, caries, necrosis, skin diseases, syphilis, and old rheumatism. The waters, being stimulating and exciting, should not be used in acute troubles, in debilitated people, in cardiac troubles, and anæmia. Season, June to September.

ACCOMMODATION.—Only passable, owing to the fact that the number of foreigners visiting the springs is not large. Hôtel des Princes is the principal hotel.

Edmund C. Wendt.

BARMOUTH. A popular English sea-side resort, said to be suitable even in winter (?) for phthisis. The place is situated on Cardigan Bay, and with Aberystwith (farther south), belongs to a group of favorite British resorts on the west coast of Wales. The climate is alleged to be equable, dry, and mild, and while it is exposed to westerly breezes, there is good protection from the harsh north and east winds. The proximity to the splendid mountain scenery of Wales contributes to the popularity of these places. The bathing is good, there being a fine sandy beach, with a gradual descent. Good drinking-water, and sanitary arrangements. Season in the early summer. The place is reached from London (Euston) in about eight hours. *Edmund C. Wendt.*

BENZANILIDE (Phenyl-benzamide). This is one of the three anilides that have proved active medicinally. The others are salicylanilide and acetanilide. In benzanilide the salicylic acid or acetic acid of the others is replaced by benzoic acid. It is obtained by the action of benzoyl chloride or of benzoic acid on aniline, in chemically equivalent proportions, at the boiling-point. It occurs in small, white, shining scales, tasteless, odorless, insoluble in water, soluble in alcohol, 1 in 60. It is chemically and therapeutically allied to acetanilide. Kahn and Hepp, when investigating antifebrine, used it in a number of cases and found it to possess similar properties. Dose, two to ten grains. The advantages claimed for it are that it possesses less toxic properties and after its use the rise of temperature is more slow.

Beaumont Small.

BERTRICH. A spa in Rhenish Prussia, often spoken of as the "mild Carlsbad on the Moselle."

LOCATION.—The "Königliches Bad Bertrich" is insufficiently known outside of Germany. Dr. Greenwood appears to be about the only English author who has hitherto mentioned the place. Dr. Rieth, who is the Royal Bath Physician at Bertrich, informed the writer, at San Remo, that only quite recently were the claims of this spa to an assured place among the continental resorts being recognized beyond the limits of Germany. In the *British Medical Journal*, August 8, 1891, Dr. Greenwood has briefly alluded to this watering-place as follows: "Bertrich is about five miles from Alf, on the Moselle. It is situated in a deep ravine among richly wooded hills. The valley of the Alf, with its numerous side branches, is one of the most beautiful on the Moselle. Bertrich is now becoming more than a local health-resort, as it is more accessible than formerly. It possesses two thermal springs, giving a large supply of water (92° F.), and having a composition similar to that of Carlsbad. It is, however, much less concentrated, not altogether a disadvantage, as in the opinion of Dr. Lauder Brunton the amount of water consumed is a very important factor in the treatment of certain diseases. Particularly is this the case in biliary concretions, a class of diseases which derive marked benefit from treatment at Bertrich. The town possesses good hotels and boarding-houses, the charges being exceedingly low. There are daily open-air concerts. Reunions and other entertainments are also freely provided." From Dr. Rieth I gather that the mountain air of Bertrich is pure and bracing, although the place is only 500 feet above the level of the sea. The climate is equable.

ACCESS.—The interesting towns of Trier and Coblenz are only a little over one hour's ride by rail from Bertrich. The station for Bertrich on the Moselle Railway is Bullay, and a good carriage road leads in less than one hour to the spa. Steamers also ply between Alf, Trier, and Coblenz.

ANALYSIS.—For purposes of comparison the analysis of the Bertrich thermal water is placed side by side with those of Carlsbad and Marienbad.

In 1,000 parts of Water:	BERTRICH. Trink-oder Bergquelle (R. Fresenius and E. Hintz, 1890).	CARLSBAD. Mühlbrunnen (Ragsby, 1862).	MARIENBAD. Ferdinandsbrunnen (Kersten).
Sodium sulphate	0.886009	2.3387	5.0477
Sodium carbonate	0.728315	2.0024	1.8228
Sodium chloride	0.217757	1.0246	2.0047
Lithium carbonate	0.001843	Trace	0.0143
Ammonium carbonate	0.000720	.....	.....
Calcium carbonate	0.167511	0.3794	0.7839
Strontium carbonate	0.002773	0.0011	0.0009
Magnesium carbonate	0.152230	0.0524	0.6899
Iron protoxide	0.002564	0.0041	0.0849
Manganese protoxide	0.000232	0.0009	0.0216
Potassium sulphate	0.031828	0.2236	0.0423
Sodium bromide	0.000599	?	Trace
Sodium iodide	0.000009	?	.....
Calcium fluoride	.....	0.0035	Trace
Sodium phosphate	0.000130	.....	.....
Calcium phosphate	.....	0.0002	0.0019
Aluminium phosphate	.....	0.0003	0.0017
Sodium arseniate	0.000213	.....	.....
Sodium nitrate	0.003489	.....	.....
Sodium borate	0.001448	Trace	.....
Organic compounds	Trace	.....	Trace
Silicic acid	0.049100	0.0806	0.0964
Total	2.246770	6.1118	10.6130
Amount of free carbonic acid in 1,000 c.c. water	43.13	180.304	1127.74
Temperature of the water	32.9° C.	52.5° C.	9.0° C.

(See Chemische Untersuchung der Trink-oder Bergquelle des Königl. Bades Bertrich. Wiesbaden, 1891.)

INDICATIONS.—Most diseases of the stomach are said to do well at Bertrich. The following morbid conditions are also treated with good results there: Abdominal plethora, hepatic affections, lithæmia, diabetes mellitus, obesity, and, finally, various nervous affections of the neurasthenic type. Catarrhal affections of the upper air-passages are also included in the rather large category

of complaints treated at Bertrich. Season, May to the end of September.

Accommodation.—There are a number of hotels managed on the German plan, and a few apartment and boarding-houses. There are pleasant walks and drives, and the management is now liberal in the way of providing amusements. Nevertheless Bertrich is still rather "quiet and dull." There is a *Kurhaus*, and the thermal bathing establishments are excellent. For patients of limited means, who need a mild Carlsbad treatment, a course at Bertrich may be advised. *Edmund C. Wendt.*

BETA-NAPHTHOL BENZOATE ($C_{10}H_7O$, C_7H_5O). Obtained by the reaction that takes place between beta-naphthol and benzoic acid. It is a whitish, crystalline powder, very slightly soluble in water, freely soluble in chloroform and alcohol.

It is recommended as a substitute for betol, having the advantages that benzoic acid possesses over salicylic acid. When introduced into the intestines it breaks up into beta-naphthol and benzoic acid. The former remains in the intestines until excreted by them; the latter is absorbed and eliminated with the urine.

The dose is from four to seven grains, frequently repeated. *Beaumont Small.*

BETOL. The beta-naphthol ether of salicylic acid, analogous to salol, which is the phenyl ether of salicylic acid. It is obtained by the reaction between beta-naphthol and salicylic acid in the presence of a dehydrating agent. It forms in small, white, brilliant crystals, almost devoid of taste and odor. Insoluble in water, soluble in alcohol and oils. Betol possesses antiseptic and antipyretic properties. It is not acted on in the stomach, but when it reaches the alkaline fluids of the intestines it breaks up into beta-naphthol and salicylic acid. It is recommended as a substitute for salol in rheumatic affections, cystitis, intestinal catarrh, etc. It has the advantage over salol of being composed of less toxic constituents. The dose is from five to eight grains. In combination with salicylate of bismuth it is particularly recommended in the treatment of the summer diarrhœa of children and in typhoid fever. *Beaumont Small.*

BEX. A popular thermal and climatic station in the Canton of Vaud, Switzerland. Famous "*salines.*"

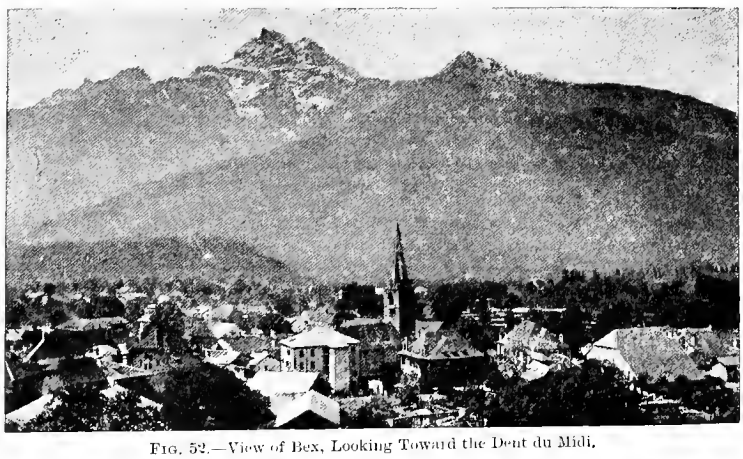

Fig. 52.—View of Bex, Looking Toward the Dent du Midi.

Location.—Bex is beautifully situated in an expansion of the Rhône Valley, and at no great distance from Vevey, on the lake of Geneva. It is 1,400 feet above sea-level. The little village is well known in Europe, but only very slightly in America. The writer, having spent several seasons at this resort, knows it to deserve greater recognition than has been hitherto accorded to it in our country. The "salines" themselves are of no mean importance, and the principal bathing establishment is a modern and commodious one. As for milk-, whey-, and grape-cures, there are few places where these can be more advantageously taken than at Bex. Invalids have also rare opportunities there for beautiful walks through a charming landscape, and, for the more hardy, distant mountain excursions offer strengthening recreation.

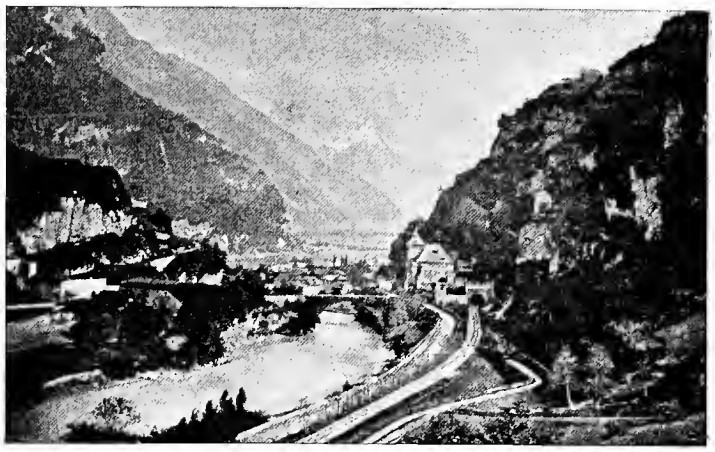

Fig. 53.—The Valley of the Rhône, near Bex.

Access.—Bex is a station on the railroad running through the valley of the Rhône. The village and Grand Hotel des Salines are reached by carriage or stage in fifteen minutes. From Paris the route is *vid* Geneva.

Analysis.—The brine is conducted to the bathing establishment from the distant salt-mines. Ten litres of the brine contain (Bischoff) 1,703 gms. of solids.

The principal ingredients, in ten thousand parts, are:

	Parts.
Chloride of sodium	1567.0
Chloride of potassium	26.5
Chloride of magnesium	10.8
Sulphate of lime	67.6

Ten to twenty quarts of this brine are used for a bath. The diluted brine is also employed internally, after having been charged with carbonic acid gas. It contains, in addition to the salts mentioned above, a small proportion of iodides and bromides.

Indications.—Apart from its advantages as a climatic resort, specially emphasized by the late Professor Lebert, Bex is now recognized to be an important bathing station. The climate is about that of Montreux, although, in spite of its mountain-protected position, harsh blasts occasionally sweep through the valley. The annual mean of the temperature is about 50° F.

The following class of cases do well at Bex: Scrofula in all its manifestations, rheumatism in its subacute forms, catarrhal affections of the air-passages, paretic and paralytic states after diphtheria and other infectious diseases, asthma, neurasthenia of the milder type, and the earlier stages of phthisis. Certain uterine affections, such as metritis, subinvolution, etc., are also benefited by a mild course of the baths. All patients in whom even moderate stimulation of the nervous system is liable to do harm should be warned

against using the Bex treatment. The thermal establishment is thoroughly equipped with inhalation cabinets, sprays, douches, and the usual outfit for hydrotherapy. The quality of the grapes used for the cure is excellent.

ACCOMMODATION.—The *Grand Hotel des Salines* is an excellent establishment of its kind, situated at some distance from and about 150 feet above the village proper. In the latter very reasonable and fairly good board is obtainable. The *Pension du Crochet* is a popular family hotel on a small scale. *Edmund C. Wendt.*

BILIN. A watering-place in Bohemia, where the famous "Sauerbrunn," or "cold Vichy," is found.

LOCATION.—Bilin is only two miles south of Teplitz-Schönau, the oldest watering-place in Bohemia. It is situated in the fertile valley of the Bila. The town has 6,000 inhabitants. The famous castle of Lobkowitz is located in this place. Over three millions of bottles of this saline water are annually exported, but it is not a largely frequented resort.

ACCESS.—Bilin is now a station on a branch line of the Bohemian Railway.

ANALYSIS.—In one thousand parts of the Bilin water there are contained:

	Parts.
Sodium carbonate	3.363
Sodium chloride	0.381
Sodium sulphate	0.719
Magnesium carbonate	0.171
Lithium carbonate	0.010
Carbonate of lime	0.410
Total solids	5.054
Free carbonic acid gas	1.409

The springs have a temperature of 53° F.

INDICATIONS.—Catarrhal conditions, Bright's disease, gravel, gout, diabetes, obesity, hemorrhoids, dyspepsia, and many affections of the genito-urinary system are said to derive benefit from a course of these waters.

ACCOMMODATION.—There is a *Kurhaus*, several hotels and boarding-houses. *Edmund C. Wendt.*

BISKRA. A new winter resort, in the province of Algiers, Africa. According to Dr. Madison Taylor (the *Climatologist*, November 15, 1891), Biskra is an oasis at the north edge of the desert of Sahara. The author named gives the following account of this new place: "Here the fashionable world, especially the French-speaking *monde* and those who follow in their wake, claim that they have found the most charming place wherein to spend the winter. They have already stimulated capitalists to build handsome, thoroughly equipped hotels there, and the tide of fashion is steadily setting that way. It may be briefly described as the terminus of the railroad running south from the great ports on the North African coast, the chief of which are Algiers and Philippeville. From either harbor railroad communication is to be had, *viâ* Constantine, to the very edge of the desert, Biskra. Here is the centre of the various caravan routes across the Sahara." Among the attractions "the charm of Oriental scenes" is mentioned.

"As to the climatic advantages of all this region, it need only be said that it is sufficiently high, being practically on the sides of the Atlas Mountains, to enjoy all the atmospheric charm of elevated table-land. Near by, on many sides, are snow-capped mountains throughout the bulk of the year. Southward the enormous expanse of sand absorbs and retains the heat of the tropical sun, over which almost no cloud passes throughout the entire year. In the immediate neighborhood of the mountains, however, local vapor condensations occur, and showers are numerous enough at certain times; but the characteristic of the climate is steady, uniform, dry warmth. The elevation of the place modifies this to just about the proper degree. There is, then, a practically uniform climate throughout the year. It is not only dry, but bracing, at no time cold, and only in midsummer unbearably hot as the equatorial rays become completely vertical. The season is, therefore, a long one; the possibility of malaria almost *nil*, because of the intensely drying properties of the vast volume of sun-heated, sand-reflecting desert air. In the valleys there is a little verdure in some places, very charming to behold, the sight of which, seen here and there on looking down upon the desert oases, inexpressibly gladdens the eye. Among the charming possibilities of the place are visits on horseback to other oases lying near by."

ACCESS.—Biskra is now accessible from Gibraltar, from Marseilles, or from Genoa. The North-German Lloyd steamers sailing to Genoa stop at Gibraltar. From Marseilles the voyage to Algiers is only a little over twenty-four hours. *Edmund C. Wendt.*

BLACKPOOL. A popular seaside resort in Lancashire, England. It is situated to the north of the estuary of the Ribble, about sixteen miles west of Preston by rail. It can be easily reached from Manchester and Liverpool. Dr. Yeo ("Climate and Health Resorts") gives the following account of this place: "Blackpool has no protection to speak of, and lies fully open to the westerly winds which prevail on this coast. It has a fine seaport, bracing air, and miles of good sands for bathing." The sanitation, drinking-water, and provisions for amusements are quite satisfactory. Season, May to October. *Edmund C. Wendt.*

BLOOD-STAINS. In the examination of stains upon weapons, clothing, or other objects, in medico-legal cases, the objects have often been partly washed or subjected to influences which render identification difficult and sometimes impossible, especially when the quantity of material for examination is small. The methods of examination by the guaiacum test and by the spectroscope have been fully treated in the article on Blood-stains in Vol. I. of the HANDBOOK.

The micro-chemical examination of stains to produce *hæmin crystals*, or crystals of hæmatin, or Teichmann crystals, when only minute stains are to be examined, is so important that we deem it desirable to give the following directions, which we have translated from "Précis de Médecine Légale," by Ch. Vibbert:

"The Teichmann crystals are so characteristic that when once seen they are afterward easily recognized. The operations for obtaining them are exceedingly simple, but require great care and patience. To avoid failure, persons but little accustomed to these minute investigations should follow carefully the methods here described, especially if, as often happens, only minute portions of the suspected material are available for these researches.

"(*a*) *Solution of the Stain.*—If the stain is small and no speck or clot to be removed can be seen, cut out the stain, following the edges of the stain, with scissors; place the stained piece of cloth on a glass slide, and put on it a few drops of water, just enough to moisten it, for it is better to get a solution somewhat concentrated After maceration till the liquid is considerably colored, press out the liquid with a scalpel or a needle, and remove the cloth, leaving the colored fluid on the slide. Avoid spreading the liquid, but dry it slowly so that it shall make a small, deeply colored spot on the glass, not entirely opaque but somewhat transparent, so that the preparation can be examined with the microscope.

"If the stains are very small several may be taken and macerated together to obtain sufficient coloring matter for the subsequent manipulations. If the stain is on wood, a thin layer of the wood may be removed with a sharp knife or lancet, and treated as directed for a fragment of cloth, only the maceration should be continued much longer.

"If it is not possible to lift the stain from the object, a ring of wax may be formed around it, making an enclosure that will hold a little water, which may be applied to absorb the stain. When the water has absorbed the coloring matter, it may be transferred to a slide by means of a pipette.

"(*b*) *Evaporation of the Liquid.*—We may allow the liquid to evaporate spontaneously, but it may be hastened by heat, only it is necessary to heat it very moderately, not exceeding a temperature of 60° Centigrade; for if the

heat is sufficient to coagulate the albumin it will interfere with the production of crystals. We generally warm the slide over the flame of an alcohol lamp, being careful that the temperature does not exceed that which is not uncomfortable when the slide is laid upon the back of the hand. It is important to heat the liquid around the borders and not in the centre, so as to prevent the liquid spreading over the slide, which would much interfere with subsequent operations.

"(*c*) *Action of Reagents.*—To the evaporated residue a little common salt should be added. Too much is injurious. It is better to make a solution of 1 part of chloride of sodium with 500 or 1,000 of distilled water, and add one or two drops of this solution. It is *more convenient to use this solution in the first place for dissolving the stain*, instead of using simple distilled water. It saves time and nothing is changed. Sometimes crystals can be obtained by treatment with acetic acid without the addition of salt, there being sufficient chloride of sodium in the blood, but it is better to add the salt than risk a failure in an important case.

"In whatever part of the process the chloride of sodium has been added, the preparation must be thoroughly dried afterward before the acetic acid is applied. This acetic acid monohydrate is called glacial or crystallizable. (It solidifies at the freezing-point, or zero Centigrade, and does not again liquefy until the temperature is raised to 17° Centigrade.) The addition of a small quantity of water transforms it to acid hydrate, which interferes with this reaction.

"Place a drop of the acetic acid monohydrate on the preparation and evaporate with heat, which may be increased and continued, but which succeeds better if it does not quite reach the boiling-point. When there is but a small quantity of the suspected material, it is especially important to use all these precautions. The acid should be taken up with a tube drawn out to a fine point, so that only a very small drop may be added at a time; place the droplet in the centre of the red deposit on the slide, and allow it to spread a little, but not to spread beyond the limit of the stain; for this purpose the heat of the lamp should be applied around the borders at various points, tipping the slide as may be necessary to retain the fluid on the red deposit only; a red line is thus formed about the borders when the coloring matter becomes thickened, and the acid remains on the stain till evaporation is completed. It is on this border that the crystals are commonly formed, and they are to be looked for by aid of the microscope.

"It is not common to find crystals after adding only a single drop of acid, but it is generally necessary to add drop after drop, evaporating each with the greatest care, examining the specimens from time to time where the red lines are formed one after the other as it is repeatedly treated with acid and dried. When this experiment is performed under favorable conditions, a multitude of distinct crystals are found. Often, however, we find only irregular masses of brown or dark coloring matter, and the remainder of the preparation filled with coagulated albumin and foreign bodies, which have become mixed with the stain. If we have added solid particles of chloride of sodium to the coloring matter, we are apt to find crystals of this salt formed in cubes, in stars or small, colorless globules, and even lance-shaped crystals of acetate of sodium may be formed. All these crystals, arranged together in beautiful forms, may often be found.

"In such cases, we select a point where the coloring matter is collected in considerable quantity, and there apply another small drop of acid and let it evaporate as before. By repeating this operation we sometimes obtain a large collection of very small crystals mingled with other matter, but when we find crystals in the form of a cross or in stars, it is very certain that they are chlorohydrate of hæmatin, and we may perfect the preparation by the addition of small drops of acetic acid.

"If doubt still remains in regard to the nature of the crystals, the specimen should be examined by the aid of polarized light. The albuminous or saline substances allow the field to remain dark, but the crystals of hæmatin appear bright on a dark field.

"By carefully following the precautions stated above, one can almost always obtain crystals of hæmatin, even with a very minute quantity of blood. The reaction is successful with very old stains. Many experts have obtained crystals of hæmatin from stains of blood ten, fifteen, and even forty years old. It sometimes happens, however, that it is impossible to obtain crystals when the stains are only a few months old. This is especially the case when the blood has been allowed to putrefy before drying. Contact with perspiration, grease, or tannin also appears to interfere with the formation of crystals.

"*Two sources of error* are to be noticed in connection with this test for blood. Crystals of murexide (purpurate of ammonia) have a form very similar to crystals of hæmatin, but they are of a bright red, and they acquire a violet color by contact with a solution of potash; but it is very difficult to imagine how it can be possible to obtain crystals of murexide by treating a stain with common salt and acetic acid. A mistake may easily occur with crystals formed from indigo. Cloth colored with this material will sometimes furnish a deposit of crystals, which will not dissolve in acetic acid and which have a form very similar to crystals of hæmatin. Their color is blue, it is true, but when the color is very deep it can scarcely be distinguished from brown. Descoust, by simply washing with water a piece of flannel of blue-violet color obtained crystals of the form and reddish-yellow color almost exactly like crystals of hæmatin. This is a more serious cause of error than is generally admitted in books on legal medicine.

"When a stain to be examined is found on clothing colored with indigo, it is important before examining the stain itself to examine pieces of the garment which are not stained to see whether they will deposit crystals of indigo. The comparison between these crystals and those obtained from the stain may remove all uncertainty if, for example, the crystals obtained from the stain are very numerous, and those obtained from the unstained cloth are very few and of a blue color. If the similarity of the two species of crystals is very close we may try the guaiacum test. The crystals of hæmatin will color the guaiacum blue, while the indigo has no effect upon it.

"When the crystals of hæmatin have been obtained they may be preserved for an indefinite period by adding a little glycerine and covering the preparation with thin glass. The expert should preserve the preparation with care as a proof of the correctness of his conclusions."

Microscopic Examination. — In the examination of blood-stains it is found that some of the corpuscles are more easily separated from the clot than others. Where the stain shows specks of dried clot which can be separated from the fabric they are more likely to resume their normal form and size than when the stain is thinner; yet single corpuscles can often be found here and there on threads or on fibres of wool, cotton, or silk. If a few drops of a solution of iodine or of eosine are added to the solvent the corpuscles are more likely to remain visible. The chief difficulty is, that any solvent which will liberate the corpuscles from the fibrin will at the same time dissolve the coloring matter of the corpuscles and render them so transparent that they are practically invisible.

Stains upon weapons of iron or steel are often so mingled with rust that great difficulty is encountered in recovering the corpuscles. If the colored substance, supposed to consist of rust mingled with blood, is placed upon a slip of glass and a drop of dilute hydrochloric acid added, the acid will dissolve the rust and sometimes bring to view the blood-corpuscles, which may be measured before they are destroyed by the acid.

It often happens, where the stain is old or very minute, that while corpuscles may be identified, the hæmoglobin is so changed or decomposed that no absorption bands can be seen in the microspectroscope, and no hæmin crystals can be obtained by treating with acetic acid and chloride of sodium. So also the stain, if old, will gener-

ally be so changed that the number of corpuscles to be seen and measured is small compared with what might otherwise be expected from the extent and color of the stain.

Since my article on blood-stains was written, in 1885 (see vol. i., pp. 575–589), increased attention has been given to this subject by medico-legal writers, and modernized views have been published, mingled with much that was written before the great improvements in the microscope revolutionized the work of medical experts. Professor John J. Reese, M.D., in the second edition of his "Text-Book of Medical Jurisprudence," 1889, says, p. 132: "Given a skilled and careful microscopist, with a good instrument of proper amplification, it will generally be possible to diagnosticate a human blood-stain from that of any of the lower animals, with the possible exception of the guinea-pig and opossum. (We exclude, of course, those few animals, more rarely met with, whose corpuscles are larger than the human, viz.: the elephant, great ant-eater, walrus, whale, sloth, and capybara.) It will always be possible absolutely to distinguish between human blood and that of the ordinary domestic animals—the ox, pig, horse, sheep, and goat—with which it is most likely to be confounded."

In apparent opposition to the above quotation from the Professor's book we find in the *Medico-Legal Journal* of New York, for September, 1892, a letter from Professor Reese, addressed to the editor, Clark Bell, Esq., in which he says:

"Certainly (as stated in Taylor's) there is no difficulty in detecting corpuscles much smaller than $\frac{1}{4000}$ of an inch, as, *e.g.*, those of the horse, sheep, and goat. The present general idea seems to be that while it is admitted that a skilful microscopist can certainly distinguish between a human corpuscle and one of a horse, cow, pig, sheep, and goat (domestic animals with which it would be likely to be confounded), still, in a murder trial, where human life is at stake, the expert is hardly warranted to swear that the blood is anything more than that of a mammal."

The proper bearing of the above statement we shall consider below.

In "The Law of Expert Testimony," by H. W. Rogers, A.M., LL.D., St. Louis, Mo., 1891, we find much that is interesting on the subject of blood-stains. Brief abstracts of testimony in the famous Cronin case are given.

The most important for our purposes are the views of Professor Marshall D. Ewell, M.D., who testified in that case, giving his opinion "that in the present state of science it was impossible to determine in the case of a specimen of dried blood by the measurement of the blood-corpuscles anything more or further than the mere fact that it was the blood of some mammal." He said: "I am very decidedly of the opinion, judging from my experience, that in the present state of science it is impossible to determine certainly, even under the most favorable circumstances, that any given specimen of fresh blood is human blood."

In the *Medico-Legal Journal*, September, 1892, p. 178, Professor Ewell claims that the possible imperfections of micrometers which have not been carefully tested by a common standard may account for the different average dimensions of blood-corpuscles as reported by different observers. Also that the personal equation of the observer causes a difference in the results as shown by samples reported. Third, that measurements by the Jackson micrometer, when low powers are used, are less accurate than measurements by the filar micrometer, but that with high magnifying powers there is little difference in accuracy between the Jackson micrometer and the filar micrometer.

Next, Professor Ewell shows that there are appreciable differences in the average dimensions of blood-corpuscles taken from the same person on different days, and in different circumstances; and, further, that the average diameter of the human blood-corpuscle is greatly affected by different diseases.

Lastly, that when blood has been dried on weapons, clothing, or other objects, and exposed to unknown conditions, there is no certainty that any treatment will restore the corpuscles to their normal diameter, so as to allow an expert to determine from what animal the blood was derived.

From the above considerations, illustrated by careful observations reported in his paper, Professor Ewell formulates the following conclusions:

Summary (by Professor Ewell).—"(1) The only proposed methods of identifying blood that are worthy of discussion are (a) Teichmann's process of obtaining hæmin crystals; (b) the guaiacum test; (c) the spectroscopic test; (d) the microscopic identification of red blood-corpuscles; and (e) the micrometric test. The last method only will be here discussed.

"(2) In the use of the micrometric test no confidence can be placed in the result, unless the errors of the micrometer used, with reference to some authentic standard, are known.

"(3) Where the subject continues during a *short* period in substantially the same condition of good health, there appears, in the hands of the same observer, to be an average size of the *fresh corpuscles*, provided at least one hundred corpuscles are measured.

"(4) There are such large discrepancies between the averages obtained from the measurement of the *fresh* blood-corpuscles of animals of the same species, and between measurements of the same objects by different observers, as to throw doubt upon the published results. Several tables of measurements are given (by Professor Ewell) to prove this statement.

"(5) There is no advantage in using very high power in such investigations.

"(6) Drying the blood-corpuscles in a clot multiplies the difficulty of identification. It has never been proven that dried corpuscles can be restored to their normal proportions.

"(7) The mean size of the red corpuscles of very young animals is larger, and their size varies between wider limits, than in adults.

"(8) Many diseases alter the size of the red corpuscles; especially is this so in microcythæmia.

"(9) Fasting diminishes both the size and number of the red blood-corpuscles. So also in the case of various drugs.

"(10) In view of the foregoing it is impossible in the present state of science to say of a given specimen of blood, fresh or dry, more than that it is the blood of a mammal."

As the paper by Professor Ewell, of which the above are his conclusions, has been largely quoted in the third edition of Reese's "Medical Jurisprudence," and as Professor Ewell is now the most prominent opponent of medical experts on blood-stains, the above conclusions will be examined in detail.

As a general proposition Professor Ewell's statement (it will be readily admitted) that no certainty of accurate measurement can be claimed unless we have micrometers graduated and tested by some acknowledged standard, is true, yet it is a remarkable fact that the measurements of human blood given by Gulliver, in 1875, $\frac{1}{3200}$; Wormley, in 1885, $\frac{1}{3260}$; Schmidt, in 1848, $\frac{1}{3300}$; French Medico-Legal Society, in 1873, $\frac{1}{3267}$; Masson, in 1885, $\frac{1}{3267}$; Hans Schmid, in 1878, $\frac{1}{3412}$; Woodward, in 1875, $\frac{1}{3092}$; Formad, $\frac{1}{3200}$, made at distant intervals and without comparison by a common standard, differ by less than one-sixth of the difference between the blood of man and that of the pig.

This objection does not apply to comparative measurements of blood of different animals, where the expert, using always the same micrometer, bases his diagnosis on his own measurements alone. At present, however, it is easy for the expert to obtain micrometers made by skilful workmen and carefully rated by comparison with a reliable standard.

In regard to the discrepancies noticed by Professor Ewell between the measurements of blood-corpuscles made by different observers, it is to be noticed that the different writers fail to state whether they measured from outside to outside of the dark border of the corpuscle, or

whether, like Dr. Woodward, they measured from the centre of the dark border on one side to the centre of the dark border on the other side, or whether they rejected the whole of the dark border on both sides, considering that as only a shadow and not a part of the corpuscle. We claim that the whole of the dark border on both sides is to be measured. This we have proved by grinding glass disks in the form of the corpuscle, with rounded edges, and examining such disks with the microscope. We have also studied the blood-corpuscle by reflected light, by means of Beck's patent illuminator, measuring it with the micrometer when no dark border was shown, and then with transmitted light again measuring the same corpuscle. In both conditions the measurement was the same.

Another source of difference in measurement is in the mode of obtaining and preparing the blood for measurement. If a string is tied around the finger or the circulation is impeded in any other manner, and the blood is obtained by pricking with a needle, and is then spread upon a slide, the corpuscles, deprived of a portion of serum, will measure less than if obtained from a cut with a lancet where the circulation is not obstructed.

So also, if the blood is drawn from the prick of a needle in a warm and dry atmosphere, the corpuscles begin to contract before they can be spread upon a slip of glass.

None of these considerations enables us to reconcile all the discrepancies noticed by Professor Ewell in the writings of different authors; but the great fact is shown, by the unanimous consent of all microscopists, so far as we can ascertain, that less than three thousand five hundred (most writers say less than three thousand three hundred) corpuscles of human blood are required to measure an inch, when placed side by side; while more than four thousand corpuscles of the pig are required to measure an inch, and for the horse, ox, cat, sheep, and goat still more are required. Hence all authors agree that there is a remarkable difference between the average diameter of the human blood-corpuscle and that of any domestic animal except the dog.

Taking the pig as the representative of domestic animals, because its corpuscles are larger than those of the ox, horse, cat, sheep, or goat, the following comparison between the blood of the pig and human blood is very significant.

To determine the extent of the possibility of mistaking the blood of the pig, ox, horse, sheep, or goat for human blood, we will examine the table of measurements made by J. B. Treadwell, M.D., using a $\frac{1}{25}$-inch objective made by R. B. Tolles, and Jackson's Eye-piece Micrometer, made by Tolles, ruled by Professor Rogers, and a stage micrometer ruled, tested, and rated by Professor Rogers.

In this table the measurements of 3,000 corpuscles are given, 200 having been taken from each of fifteen different persons. The measurements are given maximum and minimum by tens, by twenties, by fifties, and by one hundreds, and by two hundreds. Six hundred corpuscles from pigs were measured, 200 from a pig three weeks old, 200 from one of two months, and 200 from a pig three months old.

As the corpuscles of the pig have a larger average than those of the ox, horse, sheep, or goat, we make our comparison between the blood of man and the blood of these three young pigs.

	Mikrons.		Mikrons.
Man, smallest ten	7.658	Largest ten	8.298
Pig, " "	5.418	" "	6.520
Man, smallest twenty	7.662	Largest twenty	8.191
Pig, " "	5.757	" "	6.466
Man, smallest fifty	7.768	Largest fifty	8.079
Pig, " "	5.880	" "	6.246
Man, smallest hundred	7.852	Largest hundred	8.046
Pig, " "	6.028	" "	6.169

	Mikrons.
Smallest ten from man	7.658
Largest ten from the pig	6.520
Difference	1.138

This equals 0.000045 of an inch = $\frac{1}{22222}$ inch.

	Mikrons.
Smallest twenty from man	7.662
Largest twenty from the pig	6.466
Difference	1.196

This equals 0.000047 of an inch = $\frac{1}{21276}$ inch.

	Mikrons.
Smallest fifty from man	7.768
Largest fifty from the pig	6.246
Difference	1.522

This equals 0.000060 of an inch = $\frac{1}{16666}$ inch.

	Mikrons.
Smallest hundred from man	7.852
Largest hundred from the pig	6.169
Difference	1.683

This equals 0.000066 of an inch = $\frac{1}{15151}$ inch.

We thus see that where only ten corpuscles are measured in man, taking the smallest average of ten consecutively measured, this average for an adult man is one-sixth larger than the largest average of ten consecutive corpuscles measured from a young pig only three weeks old; while the average of the smallest one hundred from man, taken consecutively, is about one-fifth $\frac{1}{7\frac{6}{8}}$ larger than the largest one hundred taken from the young pig.

I fully agree with Professor Ewell that there is no advantage in using very high powers in measurement of blood-corpuscles. By this is meant that for actual work and careful measurements a magnification of 1,000, or at most 1,500, diameters is quite as good as the use of higher powers. Beyond this limit increased enlargement is obtained at the expense of clearness of outline. Mathematical demonstration proves that the apparent thickness of the object increases as the square of the apparent diameter increases. (See Naegeli and Schwendenef on the Microscope; also Carpenter on the Microscope, edited by Dallinger.)

I have no controversy with those who have used powers of 3,000 or 4,000 diameters; I have myself photographed blood-corpuscles with about 4,000 diameters linear, but the results are no better than with an enlargement of 1,500 diameters.

Gulliver's measurements were made with powers of about 600 diameters and yet they present but insignificant variations from the work of the latest observers, who have used magnifying powers of 2,000 to 3,000 diameters.

Professor Ewell's sixth proposition is apparently, more than all the others, the one on which he depends for support of his final conclusions. He says: "Drying the blood-corpuscles in a clot multiplies the difficulty of identification. It has never been proven that dried corpuscles can be restored to their normal proportions."

I would call attention again to the table on p. 587, Vol. I. of the HANDBOOK, giving the measurements of 3,000 corpuscles of fresh human blood, including males and females, of all ages, from infants at birth to the man of seventy. The measurements are in mikrons.

Number of individuals.	Number of corpuscles.	Average.	Max. Min.	By 10s.	By 20s.	By 50s.	By 100s.	By 200s.
15 persons as stated.	3,000	7.938	4.233 10.160	7.658 8.298	7.662 8.191	7.768 8.079	7.852 8.046	7.913 7.983
Blood-stains, human.	1,000	7.910	5.570 9.687	7.700 8.184	7.723 8.010	.....	.....	.....
3 young pigs.	600	6.101	3.849 8.391	5.418 6.520	5.757 6.466	5.880 6.246	6.028 6.169	6.069 6.144

Here we see that the average of 1,000 corpuscles restored and measured from stains of human blood is 7.910 mikrons, all probably being stains from the blood of adults; while the average from fifteen persons (three being infants) is 7.938 mikrons. The maximum, where infants are included, in fresh blood is a little more widely separated from the minimum than in the restored stains from adults. So also the range, when taken by

tens or by twenties, is a little less for restored blood than for fresh blood, for the same reason. No closer similarity of results could have been expected had all the measurements been taken from fresh blood; one set including infants and the other being taken from adults alone. The fact that there is this difference given above goes to show the great accuracy and perfect restoration of dried blood-corpuscles to their normal dimensions.

As a further confirmation of the possibility of restoring dried blood-stains to a condition in which their dimensions can be properly compared with fresh blood-corpuscles, I copy by permission the following table from Professor Wormley's "Micro-Chemistry of Poisons."

Examination of Old Blood-Stains.

Animal.	Age of stain.	Remarks.	Average.	Fresh blood.
			Inch.	Inch.
(1) Human	2 months old.	Stain, unknown.	1-3358	1-3250
(2) Human	2½ " "	Stain.....	1-3236	1-3250
(3) Human	3 " "	Stain.....	1-3354	1-3250
(4) Human	19 " "	Clot.....	1-3290	1-3250
(5) Elephant...	13 " "	Clot.....	1-2849	1-2738
(6) Dog.....	4 " "	Trace of stain unknown	1-3626	1-3561
(7) Rabbit	18 " "	Clot.....	1-3683	1-3653
(8) Ox	16 " "	Stain.....	1-4544	1-4219
(9) Ox	32 " "	Stain, unknown.	1-4495	1-4219
(10) Ox	4½ years "	Clot.....	1-4535	1-4219
(11) Buffalo	18 months "	Clot	1-4312	1-4351
(12) Goat	17 " "	Stain.....	1-5897	1-6189
(13) Ibex	18 " "	Clot.....	1-6578	1-6445

"In the case of the human blood No. 1, two months old, the deposit was in the form of a thin stain on muslin, and its nature, other than that it was mammalian blood, was unknown at the time of examination. The corpuscles were readily found, and two series of thirty corpuscles were measured. In the human blood two and a half months old, fifty corpuscles ranging from $\frac{1}{3125}$ to $\frac{1}{3448}$ of an inch, were measured.

"The blood-stain of the dog, No. 6, was prepared by Dr. Frankenberg, and consisted of a single stain so minute as to be barely visible to the naked eye; its nature at the time of the examination was unknown. In this instance only fifteen corpuscles were measured. In the ox blood four and a half years old, the corpuscles were rather readily obtained, and two closely concordant series of measurements were made."

Another table, quoted by Clark Bell, Esq., in his article on "Blood-Stains" in the *Medico-Legal Journal*, September, 1892, p. 157, is worthy of careful study in this connection. It shows results of examinations of blood dried on knives, glass, wood, cloth, paper, and stone, with measurements corresponding very closely with measurements of fresh blood.

I take great pleasure in acknowledging my obligations to Professor Ewell, from whose valuable articles on micrometric study of 4,000 red blood-corpuscles, published in the *Medico-Legal Journal* for September, 1892, I have compiled the following table:

Source of Blood.	Number of corpuscles.	Mean in Mikrons.	Maximum.	Minimum.	By hundreds Maximum.	By hundreds Minimum.
Robust man.....	650	8.03	9.98	5.03	8.28	7.95
Boy thirty-six hours old.....	200	8.86	11.39	5.70	9.06	8.65
Adult man.....	100	7.85	9.32	6.73	....	....
Purpura hæmorrhagica	200	8.26	10.87	3.45	8.28	8.25
2 cases pseudo-leucocythæmia.	400	8.04	11.04	6.56	8.55	8.42
Tuberculosis anæmic	100	8.35	10.70	5.35	....	....
Plumbism	100	8.65	10.10	5.18	....	...
Gastritis.....	100	8.32	10.18	6.22	....	...
2 cases syphilis.....	200	8.11	9.32	3.97	8.11	8.11
Erysipelas	100	7.83	9.15	6.90	....	....
Pernicious anæmia	100	7.69	9.93	6.04	....	....
Menstrual blood	100	7.71	8.80	5.76	....	....
Whole number measured...	2,350	8.14	11.39	3.45	9.06	7.95

If we take $\frac{1}{3200}$ of an inch or 7.937 mikrons as the generally accepted average diameter of human blood-corpuscles, and with it compare the average obtained by Professor Ewell from blood in disease, we find his largest average in plumbism, or lead-poisoning, is 8.65 mikrons, or one-twelfth part larger than the normal average.

Now, if we take the young pig, which, excepting the dog, is the domestic animal having the largest corpuscles, and to the normal average, 6.101 mikrons, add one-twelfth its diameter, or 0.508 mikrons, we shall obtain for a possibly diseased pig an average diameter of 6.609 mikrons; smaller by 1.318 mikrons than the average human blood-corpuscle. Certainly no microscopist of ordinary skill would be in any danger of confounding blood of such a diseased pig with human blood recovered from a stain.

The only remaining possibility of mistaking stains from blood of a pig, ox, horse, sheep, or goat for human blood, when fifty or one hundred corpuscles have been measured and found to average 7.9 mikrons, or even 7 mikrons, is to suppose it possible that the expert has *wickedly* and *purposely* measured only the largest corpuscles and has not done honest work. With a magnifying power of 1,000 diameters, a Jackson's micrometer measures with great certainty to $\frac{1}{50000}$ of an inch. Professor Ewell's filar micrometer, as he states, is graduated to one millionth of an inch, and is certainly reliable to $\frac{1}{50000}$ of an inch. Hence, no expert can have any difficulty in recognizing with absolute certainty differences of 1.3 mikrons equal $\frac{1}{200000}$ of an inch.

Professor Ewell says that, "by selecting the corpuscles, it would be possible for a dishonest observer to make the average much larger or smaller than the above given (in his table) without the possibility of detection; a fact, the bearing of which upon the value of expert testimony upon this subject is so obvious as to need no comment." I have never claimed, and shall not now claim, that it is any more difficult for a witness to swear falsely in regard to blood-stains than in regard to any other subject. But it would be quite possible on cross-examination to ask the expert whether, in measuring the corpuscles obtained from a stain, he had measured all the well-defined corpuscles in the field of the microscope, or whether he had selected the large corpuscles and rejected others which were smaller.

In treating blood-stains with solvents of fibrin, to liberate the corpuscles for measurement, it has been found in many cases that the corpuscles were smaller than in fresh blood unless maceration was long continued, old stains requiring several weeks before the corpuscles were in a condition to be measured. When a biconcave blood-corpuscle is placed in water, the coloring matter (hæmaglobin) is dissolved out, the corpuscle swells up, thickens at the edges, becomes transparent and spherical. In this condition the diameter of the corpuscle becomes less than normal. It thus happens in examining blood-stains that all corpuscles which have lost their color or have become spherical are by some experts rejected and not measured. Some corpuscles in fresh blood have much more coloring matter than others, and these corpuscles retain their color and form (as we think) much longer than paler corpuscles. We are not aware that any fluid used or likely to be used for softening blood-stains will cause the corpuscles to become larger than normal.

If the corpuscles obtained from a stain do not recover their normal dimensions it is almost absolutely certain that their average measurement will be less than normal and *never* greater than normal. Thus, in the language of Professor Wormley, we may confidently say: "*Thus, then, while the blood of man might on account of contraction in diameter of the blood-corpuscles be confounded with that of some animal having smaller corpuscles, the reverse could never occur.*"

From this discussion I claim that it has been proved beyond any reasonable question:

(1) That in favorable cases blood-stains can be so treated that reliable measurements and credible diagnosis of their origin can be given, as shown in the tables given and in others which might be referred to.

(2) That if error occurs on account of imperfect resto-

ration of the form and diameter of the corpuscles obtained from a stain, proved (by, *a*, the guaiacum test; *b*, the spectroscope; *c*, by the production of hæmin crystals) to be blood, the error, if any, will be to make human blood appear like that of one of the inferior animals, and never to mistake the blood of the ox, pig, horse, sheep, or goat for human blood.

(3) In general, when a stain has been proved to be blood by the above tests, it may be decided certainly whether it is or is not mammalian blood. So, also, a stain from the blood of the ox, pig, horse, sheep, and goat may be distinguished from human blood, thus confirming the claim of an accused person in many cases that his clothes are *not* stained with human blood. This negative testimony is certainly quite as important in many cases as testimony inculpating a prisoner.

Lastly, the expert can say, when the average of a suitable number of corpuscles from a blood-stain corresponds with the average of fresh human corpuscles, that the stain is certainly not from the blood of the ox, pig, sheep, or goat.

Such testimony by a skilled microscopist is of untold importance in saving the lives of the innocent, and often in overthrowing the plea of those who are guilty. Such testimony is quite as reliable and important to the welfare of society as that of the chemist who testifies to the presence or absence of poison that might have some resemblance to the many recently discovered ptomaïnes.

The testimony of the expert might take the following form, as recommended by C. H. Vibbert, "Précis de Médecine Légale:"

"This stain is *not* composed of the blood of such an animal (ox, sheep, horse, pig, or goat) as the accused claims. It is like the blood of man, or some animal having corpuscles very nearly the same size as those of man, as the dog or rabbit."

Or the declaration may take the reverse form, thus: "This stain is *not* composed of human blood; it might be the blood of a horse, ox, pig, sheep, or goat, as claimed by the accused."

Such declarations are justified, then, and then only, when the examination has been conducted with great care and the measurements have been made with reliable instruments. *Moses C. White.*

BOCKLET. A thermal station near Kissingen, Bavaria, much frequented by patients from Kissingen.

Location.—This little village is only a few miles, in a northerly direction, from Kissingen. Its strong chalybeate springs are often used by patients taking at the same time a course of treatment at the larger spa. Its climate is mild, and it is a simple little village, affording more quiet and cheaper comforts than are obtainable at the crowded spa of Kissingen.

Access.—By carriage or on foot from Kissingen. Stages run between the two places.

Analysis.—In one pint there are contained:

	Grains.
Carbonate of iron	0.67
Carbonate of lime	0.54
Carbonate of magnesia	3.60
Chloride of magnesium	4.43
Chloride of sodium	6.55
Sulphate of sodium	4.54
Sulphate of magnesium	3.23

The spring is also very rich in free carbonic acid gas.

Indications.—Anæmia, chlorosis, neurasthenia, diseases of women, especially when associated with tendency to constipation. Diabetics are also said to be benefited there.

Accommodation.—There is a *Kurhaus*, small hotels, and a number of boarding-houses, all moderately good. *Edmund C. Wendt.*

BONE TRANSPLANTATION. One of the most interesting of the various fields opened up since the advent of aseptic and antiseptic surgery is that of grafting and transplanting tissues from one part to another of the same or different animal or person. The success with which this can be done in the case of the skin is well known. Failure is the exception. Far different is the result when other tissues are made use of. Experiments with muscle, nerve, and tendon transplantation are, in almost all cases, failures; very few successful cases have so far been reported. As regards the results, osseous tissue occupies a position midway between these two groups; the skin on the one hand, and muscle, nerve, and tendon on the other. While in the case of certain bones the results are so favorable that bone transplantation is constantly employed, in others only isolated successful cases are reported. As a result of a large series of experiments, Adamkiewicz (*Centralblatt für Chirurgie*, 1889, Nos. xi. and xxxviii.) reaches the following conclusions: Pieces of bone, from one-half to three-fourths centimetre in diameter, unite perfectly well when they are replaced after having been removed, as by trephining. The pieces can lie exposed to the air or in a two to three per cent. carbolic acid solution, five or ten minutes without impairing the result. Larger pieces, over one centimetre in diameter, also unite perfectly well, even when the edges are not entirely smooth. Bony union takes place where osseous structures come in contact and the interstices are filled with a fibrous tissue. There is no need of taking any special care that the edges fit accurately. The surfaces of the transplanted bone retain their original form and smoothness. He claims that the periosteum takes no necessary part in the process; that the same results are obtained by transplanting pieces entirely stripped of their periosteal covering. The highly cellular connective tissue filling in the interspaces later becomes ossified, either by separate centres of growth, or by the ossification proceeding from the periphery inward, until union is complete. The amount of space which may thus be bridged over is not stated, but probably it is not very great.

These results hold good, not only for the same individual or another of the same species, but also when the bone is taken from entirely different species.

Moisson ("Thèse de Paris," 1892), from a very thorough study of the literature of the subject, comes to practically the same conclusions as Adamkiewicz. Both of these authors base their conclusions on studies and experiments connected chiefly with the cranial bones, and so far as those are concerned there is no doubt as to their correctness. The great activity in brain surgery the past few years has furnished large numbers of cases for clinical experimentation in this line. If the disk removed be small it may be replaced entire, and in the great majority of cases bony union will result. When the chisel is used, the chips may be strewn over the dura, and they usually adhere and live. Large buttons may be cut up and used in the same way. In case there is too large a defect to be covered by the bone in hand, pieces may be taken from the front of the tibia, or even from animals, with a very fair prospect of success. In some cases, however, the implanted bone is absorbed after a time, and in others it becomes necrosed and has to be removed.

Ollier read a paper before the International Medical Congress in Berlin, in 1890 (*British Medical Journal*, August 16, 1890), giving the results of his very extensive experience in this branch of surgery. He divides these operations into three classes, first, the autoplastic, in which the same bone is used to repair some deficiency in itself, and the bone is only partially severed from its connections; second, the homoplastic, where the graft is taken from the same individual but not from the same bone; and third, the heteroplastic, where the bone is taken from another individual or animal. He says the first and second methods are all but failures, and the third quite so, that is to say, the implanted bone could never grow. He further says it is perfectly hopeless to expect any permanent or complete growth of bone, unless the periosteum surrounds it. It is, indeed, true that if the parts were aseptic for a time the new bone or implanted bone, as the case might be, seemed to grow, but this was only for a time. Within six months necrosis takes place and the dead bone if loose, is thrown out, or

it may remain encysted in some instances, and while it may do no harm it is certainly of no advantage to its possessor. Notwithstanding what has been said to the contrary, he says there is no exception to this rule. These statements, coming as they do from such an authority as Ollier, carry great weight with them, yet they are at variance with the experience of most surgeons. As regards trephining, as we have seen, the mass of evidence is against them, and aside from these there are a large number of isolated cases of bone transplantation reported which tend to refute at least his final remark that there is no exception to the rule of failure. P. Berger (*Gazette des Hôpitaux*, January 14, 1892), reports a case where he successfully covered the defect due to spina bifida by a piece of bone taken from the shoulder-blade of a young rabbit. Almost every surgeon has had one or more successful results from re-attaching ends of digits entirely severed.

For the purpose of replacing the loss of the nasal bones or cartilages, transplantation of animal bone is sometimes successful. I have under observation now one case where two years ago I elevated the nasal bridge by the introduction of four cat-ribs under the skin. Thus far the bridge is solid and firm, and has not sunk in.

In another case where there was a sinking in from loss of the alar cartilages, a perfect elevation was procured by splitting the alæ and introducing flat pieces of bone taken from the front of the tibia. In a third case, to obtain the desired result, part of the shoulder-blade of a cat was used. All of these operations were done over a year ago, and the bone is still retained and is firm and solid, and there is no irritation. In only one case have I had to remove the transplanted bones. Necrosis in this case was, I think, due to the pieces being kept in a 1 to 1,000 bichloride of mercury solution by mistake. However, even then it was found that at the ends they were so firmly united as to require considerable force to extract them. That the bone was living and healthy at the ends, was shown by the shreds of living tissue adhering to them, and by the healthy pink color of the transverse section.

A very interesting experiment is reported by Phelps (New York *Medical Record*, February 21, 1891). In order to repair an ununited fracture of the leg of a boy, he inserted a portion of the leg bone of a dog, which was kept in connection with the animal until union had taken place. There was primary union of the soft parts, but unfortunately he was obliged to sever the graft on the eleventh day, owing to its becoming loosened from the muscular twitching. There was free oozing of blood from the cut surfaces, showing that circulation had become established between the patient and the dog. At the end of five weeks, no union having taken place, the graft was removed. It showed on its surface new formation of bone, and the medullary cavity was partially filled with new bone. The operation was a failure, and yet it seems as if more extended experiments in the same direction might lead to useful results.

In conclusion, it may be said that while, with few exceptions, the results obtained by bone transplantation are by no means satisfactory, yet they are such as to encourage a more extended trial. The most rigid asepsis rather than antisepsis should be employed in all these operations. The pieces of bone should be as small as will serve the purpose, several small pieces doing better than one large one, and where it is possible bony contact should be secured. If it be impracticable to replace or transplant the pieces immediately, they should be kept in a warm sterilized salt solution rather than in antiseptic fluids.

It is only by the most careful attention to all the details that a successful result can be secured.

William Barnes.

BORMIO. An ancient thermal station in the upper Valtellina district of Lombardy, Italy, now chiefly patronized as a climatic resort.

Location.—Bormio is situated near the river Adda, surrounded by massive rocks and precipices, and something like 4,000 feet above the level of the sea. The thermal waters are indifferent gypsum springs, and have been described by Pliny. The season is a short one, being restricted to the months of July and August, although the climate of Bormio is possibly a trifle more equable and mild than that of the Engadine, near which the place is situated. There is a barren and sombre look to the landscape at Bormio, but the village leads to some points where grand mountain views may be enjoyed.

Access.—By railroad as far as Botzen, then on through Meran, and over the Stelvio Pass; or by way of Como, and up the valley of the Adda; or through Coire, and then by "diligence" up the mountains.

Analysis.—There are eight springs, issuing from the calcareous precipices, near the foot of the Monte Brauglio. There is an abundance of water, something like 300 gallons a minute. The springs are hot, up to 120° F.

Analysis of the San Martino Spring at Bormio.—Ten thousand parts of water contain:

	Parts.
Chloride of sodium	5 112
Sulphate of sodium	0.604
Sulphate of potassium	0.181
Sulphate of magnesium	2 520
Sulphate of lime	4.863
Carbonate of lime	1.735
Carbonate of iron	0.025
Carbonate of manganese	0.014
Silicic acid	0.207
Total solids	10.261
Carbonic acid gas	0.474

Indications.—Gout, rheumatism, cutaneous affections, hepatic and splenic disorders, hysteria, and scrofula are the principal diseases treated at this mountain resort.

Accommodation.—The old thermal establishment *Bagni di San Martino* is rather primitive, but the new building, lower down and near the village, is a modern institution, where all the appliances for inhalations, massage, hydro-therapy, gymnastics, etc., are found. Milk- and whey-cures. Terms moderate. The old road over the Stelvio Pass into the Tyrol passes through Bormio.

Edmund C. Wendt.

BOULOGNE-SUR-MER. A French sea-side resort, largely frequented by the English.

Location.—Boulogne-sur-Mer is a fortified seaport of the Department Pas de Calais. It is on the shore of the English Channel, at the mouth of the river Lianne. It consists of two parts, the Old Town, located on the hill, and the New Town, along the water. Daily communication by steamboat with England, *viâ* Folkestone. The beach is fine. The town is a fishing centre, and is dirty but interesting. There is also a chalybeate spring not much used. Bathing is on the French system. The town is half English.

Accommodation.—Several good hotels, and a vast number of poor ones. There is a *Casino*, where plenty of gambling goes on. Also a theatre, concert-halls, etc. It is no longer a fashionable resort, being mostly frequented by the middle classes. It is a favorite place for excursions from England, and resembles our own Coney Island in many respects. *Edmund C. Wendt.*

BOURBONNE-LES-BAINS. A watering-place in the Department of Haute Marne, France, the Aquæ Bormonis of the ancients.

Location.—Bourbonne is an attractive little place, surrounded by hills and mountain spurs of the Jura formation. Mr. Wolff says of it, in his interesting work on the Vosges watering-places: "As in its geological position, so of course in the character of its waters does Bourbonne differ very materially from the other 'Watering-places of the Vosges.' Its springs are strongly mineralized, containing over seven grammes per litre of solid matter, and very hot—much hotter than anyone could bear their application. People who have accidentally dropped into this water, in which an egg is thoroughly boiled in fourteen minutes, are reported to have become in a few minutes so thoroughly flayed as to bring on death. Of the medicinal effects of the waters there has

never been any doubt. It seems a veritable bank of Bethesda. Along it hobble and limp, and are wheeled and carried, halt, lame, and cripples, people bent double with rheumatism, palsied with paralysis, misshapen with deformity—scrofulous, pale, and delicate children. Bath-chairs and crutches and sticks appear to be the rule rather than the exception."

Bourbonne is 850 feet above sea-level. Its climate is not equable and rather relaxing. Dr. Macpherson has called it the French Wiesbaden. Dr. Yeo says life is simple and cheap there. The French State maintains a thermal establishment here, chiefly used by military invalids. Few foreigners make use of the baths, although the place is attracting more attention now than formerly.

Access.—From Paris there are through trains in seven hours. From other places the local branch line and omnibuses are used, but are inconvenient.

Analysis.—In 1,000 parts :

General Analysis.

Silica	0.0604
Carbonate of lime	0.0751
Carbonate of magnesia	0.0035
Carbonates of iron and manganese	0.0038
Fluoride of calcium	tracea
Sulphate of lime	1.3550
Chloride of calcium	0.1340
Chloride of magnesium	0.0483
Chloride of lithium	0.0826
Chloride of sodium	5.2034
Chloride of potassium, rubidium, and cæsium	0 1925
Bromide of sodium	0.0671
Iodine, arsenic, and ammonia	tracea
Total of solids	7.2257
Free carbonic acid	0.0097
Carbonic acid in combination	0.0726

Temperature 122° to 149° Fahrenheit.

Source Puisard Romain.

Carbonic acid (free)	0.0703
Carbonic acid (in combination)	0.0263
Silica	0.0748
Carbonate of lime	0.0743
Carbonate of magnesia	0.0032
Carbonates of iron and manganese	0.0023
Fluoride of calcium	tracea
Sulphate of lime	1.3980
Chloride of calcium	0.0785
Chloride of magnesium	0.0538
Chloride of lithium	0.0887
Chloride of sodium	5.2020
Chloride of potassium, rubidium, and cæsium	0.1992
Bromide of sodium	0.0644
Iodine, arsenic, and ammonia	traces
Total	7.3358

Temperature 149° Fahrenheit.

Indications.—The waters being hot bromo-iodurated saline ones are useful in rheumatism, scrofula, paralysis, engorgement of abdominal viscera, and certain forms of neuralgia. Dr. Macpherson holds them to be curative in rebellious malarial fevers. Mr. Wolff says that bathing combined with douches, and often electricity, forms the basis of treatment. Massage is not held in excessive estimation, and the local doctors consider that their *douches de haute pression*—for which the water is pumped up to a height of 54 feet—are fully equal in effect to any rubbing and shampooing. Electricity, is however, much resorted to, especially in the Military Baths—which form an entirely distinct establishment, locally separated from the general *Thermes*—where, in the officers' annex, model appliances for its use may be seen. Of their douches the Bourbonne people are exceedingly proud, and they employ them in every form, from the finely divided *pulvérisation* up to the heavy jet which, one would think, would have sufficient force almost to knock a man down. Drinking is not prescribed for everyone, and rarely exceeds a daily dose of two or three tumblers. A course of treatment at Bourbonne lasts from three to four weeks.

Accommodation.—The Hotel des Bains is a good hotel. The bathing establishments are fitted up with the usual requirements. There are luxurious private baths and cheap general baths. There are amusements in moderation, but the place is not in any sense a fashionable spa ; real invalids intent on being made well are its chief visitors. There is a typical French *Casino*, adjoining the Civilian Thermal Establishment. Numerous French officers and soldiers enliven the scene by their pretty uniforms. *Edmund C. Wendt.*

BOURBOULE (*La*). One of the most important spas in France, although less frequented than the more neutral but fashionable resorts. The springs are strongly arsenical.

Location.—La Bourboule is in the Department of Puy de Dôme, in one of the prettiest regions of Auvergne. The district is very mountainous and the village is situated about 2,700 feet above the level of the sea. It is only five miles from Mont Dore ; it is less shut in than that resort. The hills in the immediate vicinity are of comparatively gentle slope. The mountain climate is on the whole mild, though rather changeable. The springs furnish hot arsenical waters.

Access.—From Paris, on the Paris, Lyons & Mediterranean Railroad, *viâ* Clermont, to Laqueille ; thence, in an hour and a half, by carriage to Bourboule.

Analysis.—One litre of the water contains :

	Grammes.
Arseniate of soda	0.0284
Chloride of sodium	2.8406
Chloride of potassium	0.1623
Chloride of lithium	traces
Chloride of magnesium	0.0320
Bicarbonate of soda	2.8920
Bicarbonate of lime	0.1905
Sulphate of soda	0.2084
Peroxide of iron	0.0021
Oxide of manganese	tracea
Silica	0.1200
Alumina	traces
Organic matter	traces
Carbonic acid (free)	0.0518

Indications.—La Bourboule has a wide range of applicability and enjoys a growing reputation, probably in part due to an energetic and intelligent management. The springs are now controlled by a stock company.

Dr. Yeo states that the waters may be taken with advantage in the following conditions :

1. In anæmic and chlorotic girls and weakly children with scrofulous tendencies, or who are convalescing slowly from surgical operations, especially when undertaken in connection with scrofulous diseases of the bones or other organs, and particularly in those cases in which the preparations of iron prove inefficacious or unsuitable.

2. In herpetic eruptions of the skin and in eczema and psoriasis.

3. In affections of the throat and respiratory passages, especially when found associated with a tendency to cutaneous eruption. In granular pharyngitis, chronic laryngitis, and asthma. In slow forms of chronic phthisis, associated with a tendency to glandular affections ; but it is not to be recommended in cases with a tendency to hæmoptysis or to troublesome dyspepsia.

4. In certain forms of intermittent fever which resist the ordinary forms of treatment.

5. In chronic rheumatism, especially in those very troublesome cases known as cases of "arthritis deformans."

6. In the gouty dyscrasia when there is no tendency to acute attacks.

7. In diabetes, especially in emaciated subjects in whom the waters of Vichy or Vals have been inefficacious, and particularly if the disease be associated with eruptions.

Accommodation.—There are good hotels and private lodgings. Besides the large *Établissement des Thermes*, used by the better class of patients, there are three other bathing establishments, thoroughly well fitted up and ably managed. They offer all the appliances of modern times, such as single, sitz-baths, general baths, steam-baths, inhalation and spray rooms, douches of every description, *buvettes*, etc.

All the springs are hot, the Perrière spring having a

temperature of about 125° F. There is a good *Casino*, and the ordinary amusements of French spas. Season, June to October. *Edmund C. Wendt.*

BOW-LEGS. The simplest and most effective brace for the correction of those cases of bow-legs in which the bones may still be bent, consists of a strip of flat bar-iron along the concavity of the curve, an inch longer than the distance from the garter-line to the sole of the shoe. The lower end is forged round, bent at a right angle, and passed into a hole, or a tube, in the heel of the shoe. At the garter-line a padded band is riveted, reaching two-thirds around the leg, and just above the malleoli a like band is attached. The splint applied, the leg is firmly bandaged to the bar.

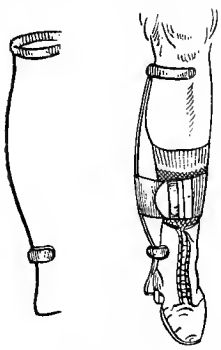

FIG. 54.—The Thomas Bow-leg Brace.

When the deformity has been corrected a broad leather strap may be used in place of the bandage. In cases where the deformity is due in a measure to the laxity of the external ligaments of the knee-joint the brace is carried above the knee, and a posterior bar is added, as in the splint for knock-knee. *John Ridlon.*

BRAIN.* GROSS OR MACROSCOPIC ANATOMY.—§ 1. The primary object of this article is to indicate briefly the principal additions to our knowledge of the subject since the preparation of the article having the same name in Vol. VIII. of the REFERENCE HANDBOOK. But the writer desires first to supply certain omissions in that article, and to correct the errors that have been detected therein. Some of these are obvious and perhaps of no great importance, but others are serious and due to the writer's imperfect observation or interpretation of specimens at that time.†

§ 2. Fig. 4684.—A. Many of the boundary lines are too faintly indicated, *e.g.*, that of the section of the chiasma. A continuous line representing the pia should have surrounded all the cut surfaces in close contact therewith. Another line representing the arachnoid should follow the general contours, as stated more fully in connection with Fig. 4711.

B. The segmental name, *diencephal*, hides most of the oval area indicating the medicommissure ; this last should have been named and should not be dotted ; although it may contain some fibres it consists mostly of cells.

C. The heavy black line representing the endyma should extend farther into the stem (infundibulum) of the hypophysis, as in Fig. 4711. At the second *e* of the abbreviation *mesen* the endymal line should not be interrupted. The interruption opposite the *n* of the abbreviation *meten* represents the metapore (Foramen of Magendie), and should have been so designated as in Fig. 4711.

§ 3. Fig. 4689.—A. On the right (left of the figure) the words *torus* and *lura* should be transposed. The former is the mononymic substitute for *tuber cinereum*, the elevation ; the latter designates the orifice, *foramen infundibuli*, left by the removal of the hypophysis.

B. On the opposite side from the word *preoperculum* a line should extend to the brain parallel with the line from *olfactory crus*.

C. The two crura should be equal in width.

D. The word *vallecula* should be *vallicula*, although the former is commonly used.

§ 4. Fig. 4698.—On the left the numbers 4 and 5 should be transposed.

§ 5. Fig. 4702.—In the upper figure the endymal line should be continuous in the roof of the mesocœle.

§ 6. Fig. 4703.—The area surrounded by the dotted circle should be marked 2 instead of 1. Since it represents the medicommissure, a bar crossing the diacœle (Fig. 4727), it might well have been left blank in this figure of the cast. In the description, near the middle, *top* should be *tip*.

§ 7. Fig. 4711.—In the description, first line, 8 should be .8 ; second line, for *subfalcial*, read *falcial* ; fourth line, for *falciculu*, read *falculu*.

§ 8. Fig. 4715.—A. Near the tip of the temporal lobe, just under the end of the line from *postoperculum*, there is really an independent triradiate fissure, consisting of a stem directed toward the tip of the lobe, with branches extending respectively dorso-caudad and ventro-caudad. The intermediate branch, a continuation of the stem from the place of radiation into the tip of the supertemporal fissure, should be erased.

B. This will leave the supertemporal fissure with a long spur extending caudad and slightly ventrad ; the shorter, darker portion of this spur represents a true branch of the fissure ; the longer, fainter part represents an artificial crack and should be erased.

C. The ventral end of the exoccipital fissure presents a branch extending cephalad and another (12) extending ventrad and slightly caudad. At the point of divergence enters the fissure marked 13 ; the junction of this latter is not deep, as appears, but shallow.

D. Just dorsad of the insula is an apparently simple junction of the subfrontal fissure with the precentral. Really there is a branch from each fissure, and they overlap slightly midway, the subfrontal branch being dorsad ; there is thus a narrow isthmus, as in Fig. 4777, between the branches of the central and precentral fissures.

E. In the explanation, after 14, the word *presylvian* should be *subsylvian*.*

§ 9. Fig. 4728.—At the end of the lowest line, indicating the most dorsal portion of the inverted region, should be the word *postgeminum*.

§ 10. Fig. 4729.—*Proplexus* should be *paraplexus*, and *hypocampa, hippocamp*.

§ 11. Fig. 4731.—The line A, B, C, should have been merely dotted to indicate the planes of section on Fig. 4730.

§ 12. Fig. 4740.—In the explanation, eighth line, for *precornu* read *paracœle*.

§ 13. Fig. 4742.—A. In the explanation, fourth line, for *precornual* read *lateral* or *paracœlian*.

B. In view of the claims of some that natural outlets exist from the paracœle into a subarachnoid space (§ 55, T), perhaps the word *presumably* should be inserted before *artificial*.

§ 14. Fig. 4746.—Compare Fig. 51 and the accompanying commentaries.

§ 15. Fig. 4748.—At the upper left-hand corner, *fossi* should be *fossa*.

§ 16. Fig. 4750.—At the left, second name from the top, for *endyma* read *paratela*. See § 53.

§ 17. Fig. 4751.—A. From the word *medicommissure* a line should reach the light strip just ventrad of the diacœle.

B. Near the tip of the lower line from B the outline of the thalamus is defective.

C. Between the left paraplexus and the tenia the membranous floor of the paracœle is the paratela.

§ 18. Fig. 4760.—On the temporal lobe, just dorsad of the pons, the apparent fissure is an artificial crack.

§ 19. Fig. 4767.—A. The short, vertical fissure between the word *operculum* and the number 1 is merely a notch or superficial branch of the presylvian fissure, the main portion of which lies ventrad of 2 ; hence the

* Exclusive of the Membranes of the Brain, which are treated of in a separate article under the title MENINGES.

† The writer ventures to advise that the changes and corrections indicated be marked in the text or upon the illustrations. A suggestion as to the desirability of prompt or periodical self-correction is offered in his paper, The Morphological Importance of the Membranous or other Thin Parietes of the Encephalic Cavities, *Jour. of Comp. Neurology*, i., p. 201.

* Fig. 4723, the word crus should be prepeduncle.

triangular area (1) is part of the operculum. The preoperculum is (2) and the subsylvian fissure is probably represented by a short indentation, visible only when the postoperculum (3) is removed. From the name *presylvian f.* a line should reach the dark space dorsad of (2). In this connection it may be added that corresponding changes should be made in § 208, D, § 234, E, and § 241, L.

§ 20. Fig. 4778.—The two fissures named *presylvian* and *subsylvian* are probably to be regarded as branches of the former, and the latter is represented by a short one concealed, as in Fig. 4767, by the overlapping postoperculum. The number of the specimen should be 318.

§ 21. Fig. 4779.—As in Figs. 4767 and 4778, the presylvian is to be regarded as having a dorsal branch; the true subsylvian as concealed.

§ 22. Fig. 4784.—The fissure named *supercallosal* is the paracentral; here, as often, the two are continuous.

§ 23. The following verbal changes should be made in the same article:

A. In § 80, *callecula* should be *vallicula;* after it should be added Figs. 4689 and 4716.

B. In § 82, C, *typical* should perhaps be *simple;* seldom, in adult brains, has the writer observed the conditions represented in Fig. 4715.

C. In § 218, the interparietal fissure of Ecker was first called by Turner *intraparietal*, and this name should be used unless, as held by the writer, it is admitted to consist of two integers, the parietal and the paroccipital.

§ 24. *Subfrontal Gyre.*—By an inexcusable oversight the more common name of this functionally important region, *viz., Broca's gyrus*, is not given; but it is employed in other articles, *viz.*, II., 34, and VIII., 206. Since the article was prepared there has appeared Hervé's monograph, "La Circonvolution de Broca," Paris, 1888.

§ 25. *Encephalic Variations.*—In § 63 mention should have been made of the brief account of anomalies of the brain in Krause's "Anatomie," pp. 192–195.

§ 26. *Order of Treatment.*—This will follow the series of definitive encephalic segments from the myel (spinal cord) cephalad.

I. General matters of nomenclature and structure; § 27–29.

II. Metencephal (postoblongata and caudal part of "fourth ventricle"). For convenience the metapore (foramen of Magendie) will be considered in the article Meninges.

III. Epencephal (cerebellum, pons, and preoblongata). The cerebellar ectocinerea (cortex) and entocinerea (dentatum and tectal "nuclei"); §§ 30–38.

IV. Mesencephal (crura and gemina or optic lobes).

V. Diencephal (thalami, etc.).* The medicommissure, conarium, paraphysis, and mesal eye; §§ 39–41.

VI. Prosencephal (cerebrum and olfactory lobes). Rhinocœle or olfactory ventricle, § 42; fornix, § 44; hippocamp, § 45; pseudocœle (fifth ventricle), § 46; indusium of the callosum, § 47; incallosal brains, § 48; relations of thalamus to paracœle (lateral ventricle) in the sheep, etc., § 49; in apes, § 52; in man, §§ 53–55; transitory fissures, §§ 56–59; permanent fissures, §§ 60–78; brain weight, § 79.

VII. Bibliography.

§ 27. *Neuraxis or neuron.*—It has now become a serious question which of these short mononyms shall be employed as a substitute for *cerebro-spinal axis, myelencephalon, etc. Neuron* was proposed by the writer in 1884 (*New York Medical Journal*, August 2, p. 114), and employed in 1885 in addresses before the American Neurological Association (as president), "Paronymy *versus* Heteronymy as Neuronymic Principles," and before the Biological Section of the American Association for the Advancement of Science (as vice-president,) "Educational Museums of Vertebrates;" also in the second edition of "Anatomical Technology." It has been adopted in this sense by Minot, "Embryology," 1892, by Waters (*Zool. Anzeiger*, 1891, p. 362), and others.

* Respecting *thalamencephalon* and analogous terms, see Vol. VIII., p. 529, § 74, note.

But, on discovering in the "Dict. de Medecine" of Littré and Robin (1877) that *neuraxe* had been used (by whom not stated) in the same sense, the writer abandoned *neuron* in favor of *neuraxis*, the presumed Latin antecedent of the French *neuraxe*, and used *neuraxis* in the articles in the HANDBOOK. It likewise has been adopted by several writers. Furthermore, *neuron* has been taken by Waldeyer (*Berliner klin. Wochenschr.*, July 13, 1891) to represent a "nerve-entity," consisting of: (*a*) a nerve-cell; (*b*) the nerve-process; (*c*) its collaterals; (*d*) the end branching;" see the abstract by Alexander Hill in *Brain*, vol. xiv., p. 569. In this sense also it is used by C. L. Herrick, *Jour. Comp. Neurol.*, ii., 137, December, 1892.*

The writer has no prejudice, and trusts the matter

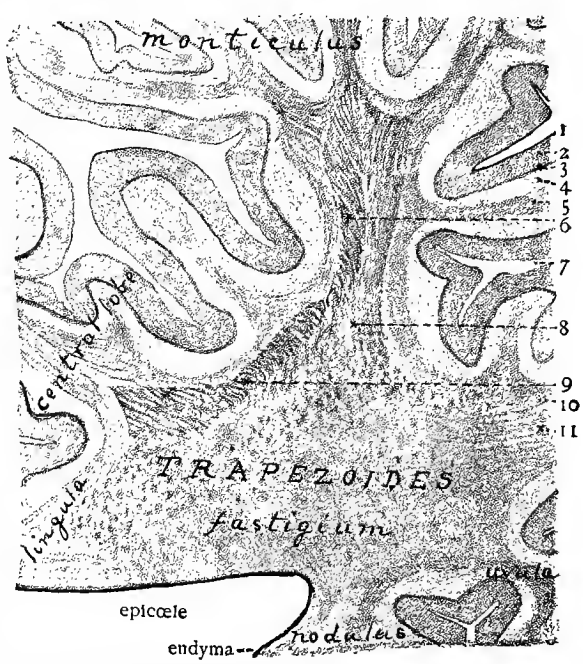

FIG. 55.—The Central Part of the Cerebellum near the Dorsal End of Its Cavity, the Epicœle. From Stilling, Fig. 57a; × 8.

This represents a part of the mesal aspect of the right half of a medisected cerebellum. The entire surface is shown on a smaller scale and without histological differentiation in Vol. VIII., Figs. 4684, 4711, 4718, 4719. In the last the organ is represented approximately erect, *i.e.*, extending dorsad from the oblongata; in the present figure, as in the other three, it is in the natural attitude, tilted caudad, so that the apex of the epicœle looks caudad rather than dorsad.

1. Pia dipping into the rimulas between the foliums; 2, ectal fibrocellular layer of the cortex, neuroglia, etc.; 3, layer of the cells of Purkinje; 4, granular layer; 5, fibrous centre, the alba or medulla; 6, 9, cephalic (anterior) decussating commissure; 7, deep rimula between lobes of the postvermis; 8, cephalic (anterior) branch of the arbor (vitæ); 10, layer designated by Stilling as composed of "guirlandenförmigen Fasern;" 11, caudal (posterior) branch of the arbor.

may be considered by some of the committees on nomenclature for an authoritative recommendation as to usage. It will probably occur to others that *neuron* is a more

* After this article was completed there reached the writer three important papers by His in the Archiv für Anat. u. Physiol., Anat. Abtb., 1892, v. u. vi. Heft., viz., Zur Nomenclatur des Gehirns und Rückenmarkes, pp. 425–428; Die Entwickelung der Menschlichen und thierischer Physiognomien, pp. 384–424; Zur allgemeinen Morphologie des Gehirns, pp. 346–383. The last is profusely illustrated with representations of embryonic brains, mostly of animals. On the first page is a list of terms employed (in gratifying conformity to the suggestion made by the writer in Vol. VIII., p. 528, § 72). The summary is as follows:

"1. Die allgemeine Morphologie des Gehirns eine notwendige Grundlage für die Deutung der Faserbahnen bilden muss.

"2. Eine solche allgemeine Morphologie nur dann endgültig zu gewinnen ist wenn wir auf die allerersten Entwickelungsstufen zurückgreifen. Nur von dieser ersten Anfangsstufe aus lässt sich der Ban sicher aufführen, dadurch dass wir die frühesten topographischen Beziehungen der einzelnen Abschnitte des Markrohres zu einander genau feststellen und dann an der Hand dieser Merkmale die Verwickelung der Formen verfolgen."

natural associate of *axon* and *enteron*, and that it is the legitimate substantive of the adjective *neural*; also that *neuraxis* might very appropriately designate the axis cylinder of a nerve-fibre. Perhaps, however, as with *cilium* (either an eyelash or a microscopic filament), the two uses are not incompatible.

§ 28. *Is there a Rhinencephalic Segment?* — The address by Professor William Turner before the Anatomical Section of the Tenth International Medical Congress, at Berlin, in 1890 (*Jour. Anat. and Physiol.*, xxv., pp. 1–53, with 42 figures), is not merely a valuable and suggestive study in the comparative anatomy of "The Convolutions of the Brain," but also is based upon a recognition of the significance of the fundamental and universal separation of the *pallium*, or strictly cerebral portion of the prosencephal, by a rhinal fissure from the olfactory bulb, crus, and hippocampal lobe, which he includes under the name *Rhinencephalon*.

As may be seen from Vol. VIII. (p. 112, § 15, A; p. 134, § 122), the writer sympathizes with this recognition of the morphological consequence of the olfactory nervous apparatus; but he deprecates the employment of a segmental term like *rhinencephalon* in what is now a third sense. Owen used it for the olfactory bulbs, actually united only in tailless amphibia; the writer (at one time adopting this view) has suggested (Vol. VIII., p. 114, note) that perhaps the bulbs, their crura, the olfactory portion of the precommissure, and a part of the aula, might be recognized as constituting a sixth definitive segment; but—unless the word *encephalon* in composition is to be shorn altogether of segmental significance—it should no more be used for a ventral portion of a region than for a dorsal portion, *e.g.*, the cerebellum, without the supporting preoblongata.*

§ 29. *The Endymal Cilia.*—In Vol. VIII., p. 118, § 43, in stating the simplest expression of an encephalic segment, the constant ental constituent of the parietes, the endyma (*ependyma* of some writers), was mentioned as a ciliated epithelium. There is considerable divergence of statement among authors as to the presence of cilia, especially in adults. P. A. Fish has described (*Amer. Monthly Micros. Jour.*, xi., p. 256, November, 1890) the ciliated cells in the encephalic cavities of the cat, both old and young. He urges the importance of thorough preservation by the injection of the preservative into the cavities; states that a magnification of not less than six hundred diameters must be employed, and intimates that the failure to recognize them in man may be due to defective methods of preparation or examination.

§ 30. *The Cerebellar Cortex.*—In none of the mediseeted brains represented in Vol. VIII. (Figs. 4684, 4711, 4718, 4719) was any effort made to show the thickness or constitution of the cortex of the cerebellar foliums; this omission is in a measure supplied by the accompanying figure (55) from the magnificent work of B. Stilling, "Neue Untersuchungen über den Bau des kleinen Gehirns des Menschen," etc. Q., pp. 357 and lxxviii.; Folio Atlas of 21 plates. Cassel, 1878.

§ 31. Points illustrated by Fig. 55.—A. The triangular form of the apex of the epicœle, whence the term *fastigium* (a gable), applied to its immediate roof.

B. The absence of a layer of cinerea (entocinerea) immediately ectad of the endyma.

C. The non-appearance, upon an accurate medisection, of any of the disconnected masses of cinerea represented in Figs. 56, 57, 58.

D. The irregularly trapezoidal outlines of the medulla (alba) forming the central cone about the apex of the epicœle.

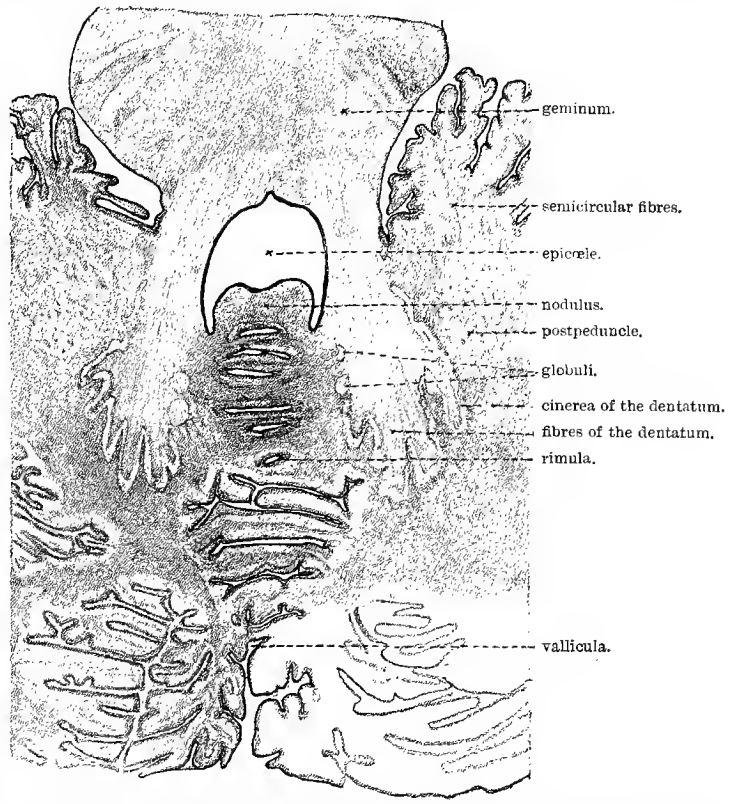

FIG. 56.—The Dentatums and Prepeduncles. From Stilling, Fig. 99, somewhat modified: ×2 –.
Preparation.—The plane of section was oblique, so as to coincide with the general direction of the prepeduncles as shown in Vol. VIII., Figs. 4721, 4722.
Defects.—By an inexcusable oversight the prepeduncles are not indicated by a line and the name; but they are readily recognized as the fibrous tracts at the sides of the epicœle, converging from the dentatums to the geminum. There is no representation of the "fleece," the layer of fibres radiating from the ectal surface of the dentatum; see Edinger's "Twelve Lectures," etc., Fig. 85.

E. The extension of the medulla as branches, whence the more comprehensive name arbor (vitæ) applied to the entire cerebellar alba.

F. The constitution of the cortex by several layers; for their microscopic structure see treatises on the subject.

§ 32. *The Cerebellar Entocinerea.*—In Vol. VIII., p. 128, § 92, brief mention is made of four pairs of masses of cinerea (gray tissue) in the central part of the cerebellum, near the apex of the epicœle; but through a misapprehension they were neither figured nor described in detail. They are commonly referred to as *roof-nuclei*, or *tectal nuclei*.

§ 33. *The Dentatum.*—This is the largest and most easily recognized of the four masses; see Figs. 56, 57, 58. It has the form of a corrugated capsule, open mesoventro-cephalad, for the reception of the fibres of the prepeduncle (Fig. 56). In any cerebellum, whether

* In this connection it may be added that the word *neuromere*, introduced by the writer (*N. Y. Med. Jour.*, 1885, p. 356, and "Anat. Technology," 2d ed., 1886, p. 400[4]) as a mononym for *definitive neural* (or encephalic) *segment*, was adopted in 1887 by Orr (*Jour. of Morphology*, I., p. 335) in the sense of *potential segment*, and this application was accepted by the writer in 1889 (HANDBOOK, VIII., 113, § 23); in this sense it is also employed by Minot ("Embryology," pp. 604–606) and other embryologists.

fresh, or hardened in chromic acid compounds, or even alcohol, it is readily recognized upon transections or upon sagittal sections begun about one centimetre either side of the meson and continued laterad for two or three centimetres.* The dentatum has received the following additional names, of which the last only is used with any frequency: *Nucleus dentatus; corpus denticulatum, s. fimbriatum, s. lenticulatum, s. ciliare;* Eng., ciliary body.

§ 34. *The Fastigatum.*—This, more often called "fastigial nucleus," is close to the meson, directly in the roof (fastigium) of the epicœle; Figs. 57, 58. It is rounded cephalad, but the caudal end presents two or three projections.

§ 35. *The Embolus* and *Globulus.*—These smaller masses of cinerea lie between the dentatum and the fastigium, and somewhat dorsad of the latter. Their forms are indicated by their names, and are well shown in Stilling's figures as reproduced in Figs. 57 and 58. More common (and cumbersome) titles are *Nucleus globosus* or *globuliformis*, and *Nucleus emboliformis.*

§ 36. Points illustrated by Fig. 56.—A. The constitution of the dentatum as a corrugated capsule of cinerea, open cephalo-ventrad.

B. The entrance of the fibres of the prepedunele through the hilum of the dentatum to connect with its cells.

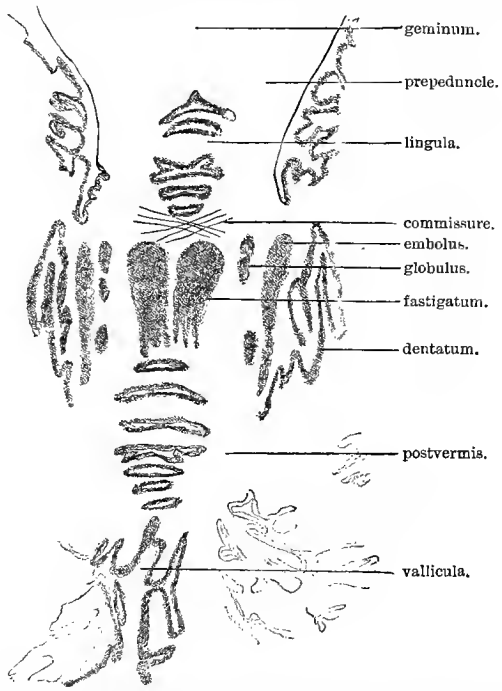

FIG. 57.—The Dentatum and other Masses of Cinerea in the Central Part of the Cerebellum. From Stilling, Fig. 98, somewhat modified; × 2 —.

Preparation.—This is commonly designated as a "horizontal" section. Really, the plane cannot be indicated in such simple terms. The central part of the figure, including the cinereal masses, is through the fastigium, the roof of the apex of the epicœle. Cephalad are parts of the lingula, the prepedunecles, and the mesencephal; caudad the foliums of the postvermis, the mesal vallicula, and parts of the lateral lobes.

Defects.—No attempt has been made to represent the fibrous constitution beyond the purely diagrammatic indication of the cephalic (anterior) decussating commissure.

§ 37. Points illustrated by Fig. 57.—A. The existence, near the apex of the epicœle, of four pair of cinereal masses, representing, perhaps, dislocated portions of the cerebellar entocinerea.

B. The lack of precise symmetry in the forms of these masses; of one set, the globuli, there are three on the left and two on the right, the more cephalic, perhaps, representing the fusion of two.

C. The form of the dentatum as a corrugated capsule with an opening or hilum toward the meson; this is shown better in the following figure.

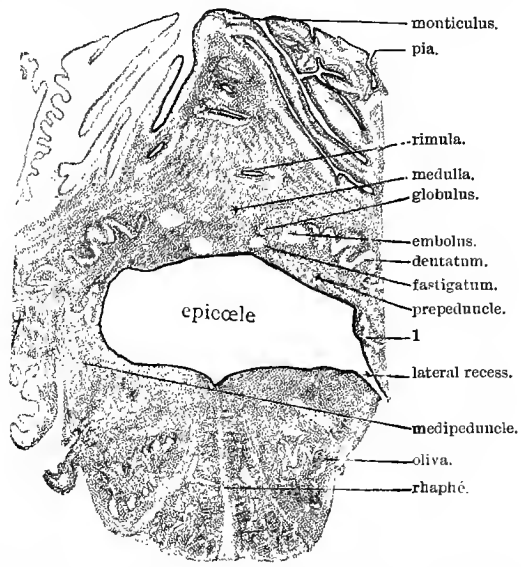

FIG. 58.—Transection of the Cerebellum and Oblongata. From Stilling, Fig. 84; modified somewhat; × 2 —.

Preparation.—The section is stated by Stilling to cut the higher part of the monticulus (see Vol. VIII., Figs. 4716-4719). It evidently passed caudad of the pons and right medipedunele, cutting the left obliquely, the lateral recess being opened on the right. This lack of symmetry is not, perhaps, a serious defect.

§ 38. Points illustrated by Fig. 58.—A. The relative positions of the cinereal masses in the epicœlian roof, as seen in transection; compare the view presented in Fig. 57.

B. The relative positions of the prepedunele and medipedunele; see Vol. VIII., Figs. 4721, 4722.

C. The resemblance of the dentatum of the cerebellum to the corrugated capsule in the oliva, which is sometimes called *dentatum oliræ.*

D. The distinctness of the rhaphé or mesal seam of the oblongata.

§ 39. *Medicommissure* (middle or gray commissure).—According to Wenzel, as stated in Vol. VIII., p. 132, § 113, this secondary junction of the thalami is absent once in six or seven individuals. With five exceptions all of the adult and late fœtal brains in the museum of Cornell University have been either medisected or so prepared as to exhibit the location of the medicommissure; out of the whole number (98) the commissure is absent in only one, a male child at term.

The writer ventures to suggest that some of the reported cases may have been based upon inadequate evidence. Unless the brain is medisected while fresh, or prepared by the injection of a preservative into the arteries or the cavities, or both, the medicommissure commonly fails to be reached; its peculiar softness causes it to break easily; and the imperfect preservation of the adjacent thalamic surfaces might lead to the non-recognition of the slight elevation indicating its existence. If the specimen is allowed to dry slightly, and is then held so that the light is reflected from the smooth endymal surface of the thalamus, then the presence of the remnant of the commissure will be indicated by the absence of such reflection from an area corresponding with its usual location. There is no other part of the brain where an error of observation is more likely to occur.

§ 40. *Conarium.*—The development of this (epiphysis

* Here and in the writer's other articles the occurrence of the termination *re* in words like *metre, fibre, centre*, etc., is in conformity with the rule adopted for the entire work; he regards it as distinctively French; see Vol. VIII., p. 527, § 66, I.

or pineal body) in various vertebrates has been studied by Heckscher of Copenhagen; the literature of the subject is also fully presented by him.

§ 41. *The Paraphysis.*—Under this name (and *Stirnorgan*) Selenka has described (*Biol. Centralblatt*, vol. x., 323–326, 1890) a second mesal appendage of the brain just cephalad of the conarium. It has been observed also by C. Hill. An abstract respecting it is given by Minot ("Embryology," p. 690).

§ 41. The mesal (parietal or conarial) eye has been recently considered at some length by Béraneck, under the title, "Sur le nerf pariétal et la morphologie du troisième œil des vertébrés," *Anat. Anzeiger*, Oct., 1892, 674–689.

§ 42. *The Rhinocœle.*—The persistence of the cavity of the olfactory crus and bulb in other forms than man (and perhaps apes) was mentioned in Vol. VIII., p. 137, § 122. In a paper, "The Partial Occlusion of the Olfactory Lobe in the Canidæ" (*Amer. Monthly Micros. Jour.*,

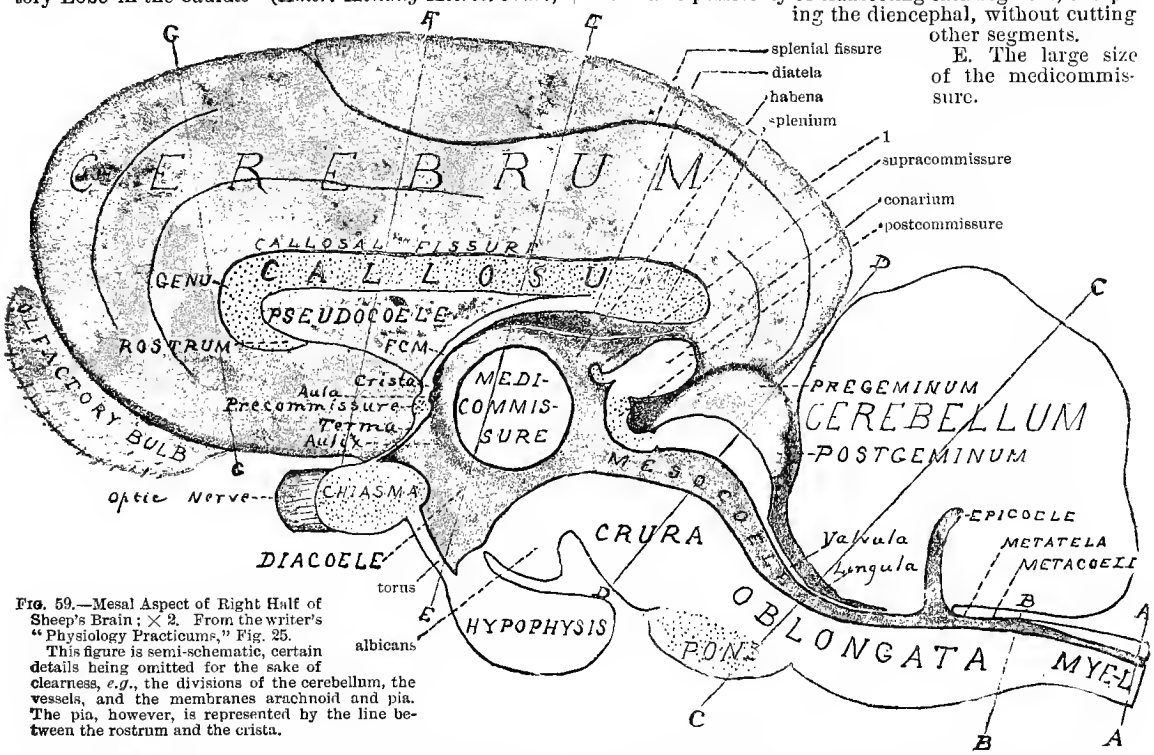

FIG. 59.—Mesal Aspect of Right Half of Sheep's Brain; × 2. From the writer's "Physiology Practicums," Fig. 25.
This figure is semi-schematic, certain details being omitted for the sake of clearness, *e.g.*, the divisions of the cerebellum, the vessels, and the membranes arachnoid and pia. The pia, however, is represented by the line between the rostrum and the crista.

xii., 49–52, March, 1891), P. A. Fish describes and figures cases of partial obliteration of the terminal, expanded portion of the rhinocœle, and complete occlusion of the narrower crural part; so far as his observations go, this is true of all domesticated varieties and of the coyote (*Canis latrans*) and the Australian wild dog, dingo. In view of the attention given to the subject by Broca and Turner (both of whom have based groupings of mammals upon the known or assumed relative development of olfaction and its organ), Mr. Fish's conclusions are here given with some modification:

1. The facts do not warrant Broca's statement as to the existence of a true ventricular axis (core of solid material in place of the primitive cavity) in the olfactory bulb, even in rat-terriers.

2. The bulb is not completely, but partially occluded, or perhaps in process of becoming entirely so.

3. The cavity of the crus, in some wild forms as well as domestic, is completely closed, thereby cutting off all communication between the paracœle and the cavity of the bulb.

4. The acuteness of the sense of smell is not essentially dependent upon the relative size of the rhinocœle.

5. Atrophy is not a necessary concomitant of occlusion.

6. Domestication, and the consequent disuse of olfaction as a means for procuring sustenance, may be a factor in promoting occlusion.

7. In the classifications of Broca and Turner the dog seems to hold an anomalous position, in that he gives every external evidence of macrosmatic power; but by the almost total occlusion of his rhinocœle he approaches structurally the conditions found in the microsmatics. Physiologically he is macrosmatic; morphologically he is microsmatic.

§ 43. Points illustrated by Fig. 59.—A. The general similarity to the corresponding aspect of the human brain as shown in Figs. 4684, 4711, 4718, and 4719.

B. The slighter encephalic flexure.

C. The smaller relative size of the cerebrum, permitting the cerebellum and even the olfactory bulbs to appear in a dorsal view of the organ.

D. The possibility of transecting each segment, excepting the diencephal, without cutting other segments.

E. The large size of the medicommissure.

F. The distinctness of the crista in the adult sheep; Vol. VIII., § 57, N.

G. The non-extension of the callosal rostrum, as a copula, to join the terma, as in man and the chimpanzee, and the consequent closure of the narrow pseudocœle by the pia only.

H. The absence, as in mammals generally, of small foliums upon the lingula; see Fig. 4719.

I. The absence, as in mammals generally, of a metapore (Foramen of Magendie).

J. The completeness of the endymal continuity or cœlian circumscription.

§ 44. *The Fornix.*—This difficult portion of the brain is monographed by Honegger in the *Recueil Suisse* (zoölogie), 1890, v., 311–434.

§ 45. *The Hippocamp.*—Variations in the form of the hippocamp and the collateral eminence are described by Howden in *Journ. Anat. and Physiol.*, xxiii., p. 283, January, 1888. The hippocamp has been treated by Alex. Hill, in a paper of which an abstract is published in the *Royal Society Proceedings*, vol. lii., p. 5.

§ 46. *The Pseudocœle.*—This cavity (the fifth ventricle, or *ventriculus septi pellucidi*) has interesting morphologi-

cal and zoölogical relations; see Vol. VIII., p. 139, § 146, and Figs. 4734, 4735, and 4833.

In the adult cat, sheep, and most other mammals, the two halves of the septum are in contact, and a pseudocœle can hardly be recognized. The rostrum of the callosum also ends in a point, as shown in Fig. 4698 and

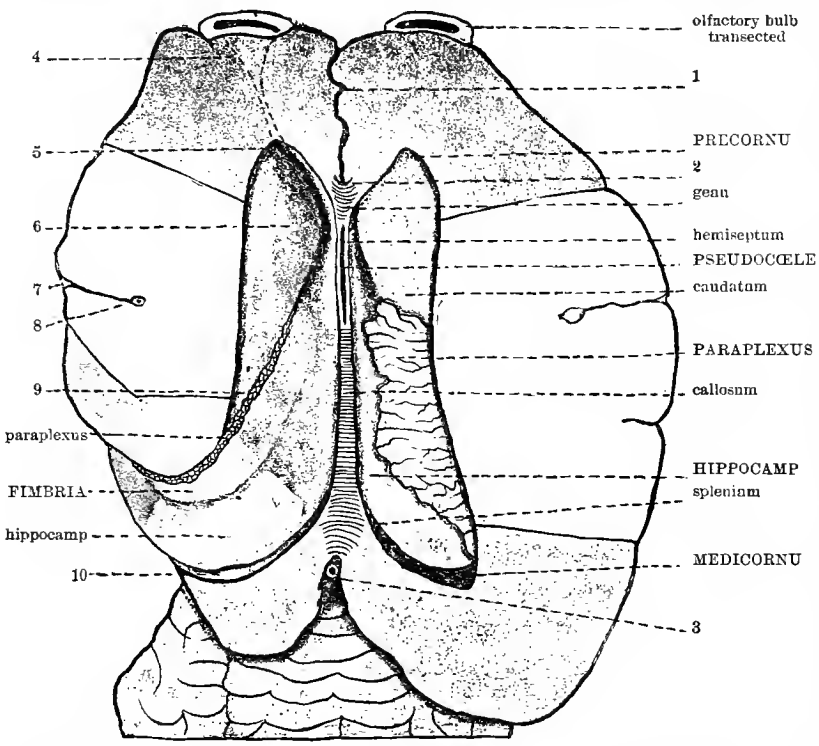

FIG. 60.—Sheep's Brain, the Paracœles (Lateral Ventricles) Exposed; × 2. From the writer's "Physiology Practicums," Fig. 29.

Preparation.—By the removal of successive slices the paracœles have been opened; the left has then been more completely exposed by oblique sections, and the paraplexus trimmed off so as to expose the wide fimbria and the furrow between it and the hippocamp. The plane of section did not coincide exactly with the callosum; the caudal three-fifths of this is represented by the transverse lines; also the cephalic end, the genu; but an intermediate portion is wholly removed, exposing the narrow pseudocœle ("fifth ventricle") and its thin lateral walls, hemiseptums.

Defects.—The cerebral cortex is not represented. The caudal half of the cerebellum is omitted.

1, Intercerebral fissure; 2, callosal fissure; 3, vessel; 4, interrupted lines indicating the continuation of the paracœle into the rhinocœle; 5, precornu; 6, caput of the caudatum; 7, Sylvian fissure crossed by arachnoid; 8, vessel at bottom of fissure; 9, cauda of caudatum; 10, part of caudal wall of paracœle.

this volume, Fig. 59. In man and in a chimpanzee brain prepared by the writer (No. 265 in the Museum of Cornell University) the rostrum continues caudo-ventrad to join the terma, and the pseudocœle is therefore completely circumscribed.

The earlier conditions in man are less well ascertained; strictly their consideration does not lie within the scope of this article, but something must be said in qualification of the account given in Vol. VIII.

According to Marchand ("Ueber die Entwickelung des Balkens im menschlichen Gehirn," *Archiv. für Mikr. Anat.*, xxxvii., pp. 298–334), the pseudocœle arises as an indentation or mesal cleft in the proton* of the callosum-fornix; by the extension of the parts this becomes longer and triangular; its sides, the halves of the septum, become *practically* portions of the mesal walls of the respective hemicerebrums, but if his account is correct they cannot be said (as in Vol. VIII., p. 139, § 145) to be *primarily* such. The complete closure cephalad is accomplished by the ventro-caudad extension of the copula so as to reach the terma at about the fifth month. Probably more remains to be done upon this region.

§ 47. *The Indusium.*—This term (coupled with the adjective *griseum*), is given by Obersteiner (p. 82) to the thin layer of cinerea upon the dorsal surface of the callosum. The presence of this continuation of the cortex upon the callosum was first noted by Giacomini (*Giornale d. r. Accad. Med. Torino*, 1883), and has since been confirmed by Blumenau (*Arch. f. Mikros. Anat.*, xxxvii., 1–15).

The indusium is not represented by Reichert, and seems not to have attracted the attention of Dalton, although some of the beautiful photographs of his transections present faint indications of it. The writer feels compelled to record, with some chagrin, that, upon a series of transections of an adult brain (1824) hardened in a mixture of ammonium dichromate and alcohol, the continuity of the cinerea upon the callosum was recognized in October, 1880; notwithstanding its significance, further examination and publication were deferred.

The ridges and lines known as *striæ mediales et laterales* are interpreted by Blumenau as associated with thickenings of the indusium. It is probable that there is considerable variation in the thickness of the layer, and that it may not always be complete at the meson.

§ 48. *Incallosal Brains.*—A case of total absence of the callosum and fornix is described and figured with un-

* This neuter noun is employed to designate the primitive, undifferentiated mass or rudiment of a part, thus in the sense of *Anlage* of the German embryologists (as adopted by Minot and others), and of *fundament*, as proposed by Mark ("Comparative Embryology"). It avoids certain obvious objections to those terms as English words, and is in harmony with the following phrases from Aristotle, kindly quoted by Professor B. I. Wheeler: τὸ πρῶτον; ἡ πρώτη ὕλη; ἡ πρώτη αἰτία.

(Fig. 61.)—1. Cut surface, extending meso-ventro-cephalad; 2, cut surface of the genu, the cephalic curvature of the callosum; part of its natural, pial surface lies just cephalad; the transverse lines on the areas 2 and 9 are introduced merely to indicate the direction of the callosal fibres, not as representations of microscopic structure; 3, point of disappearance of the pia as a result of cutting away part of the lateral convexity of the cerebrum; 4, meeting-place of the two oblique cut surfaces caused by the exposure of the medicornu; 5, point of reappearance of the pia, which was interrupted at 3; 6, is an area just caudad of the left calcarine fissure; 7, the occipital fissure; 8, the occipital eminence (see under *Defects*); 9, oblique cut surface of the splenium, of which a part of the natural surface is shown just caudad; 10, the cut edge of the paratela covering the thalamus; from 10 a line should pass mesad to the narrow area between the two lines.

Defects.—The alcohol had so bleached the cinerea as to render the recognition of its outlines somewhat difficult, so the width of the cortical zone is only approximately accurate, and the "white line of Vicq d'Azyr," shown in Fig. 4746, is not indicated.

The absence of shading upon the larger part of the surface would imply that it is all upon one level; really, however, the highest part corresponds nearly with the length of the exposed portion of the right caudatum, and from that level there are gentle slopes cephalad, caudad, and laterad. The cut edges of the hemiseptums are also at a lower level than the adjacent lateral parietes. Not all of the arteries are represented. The occipital eminence (8) is indistinct upon the right and made too small upon the left. The cut edge of the paratela (10) is made too thick and the relations of parts are indistinct: see § 55.

On the left, near the word *fimbria*, is a defective patch of shading due to a blemish in the paper.

The arachnoid is represented distinct from the pia at only two places, *viz.*, on the right, near the cephalic end, where the former crosses the wide mouth of a fissure, while the latter dips into it as a fold, and at the callosal fissures, just caudad of the splenium.

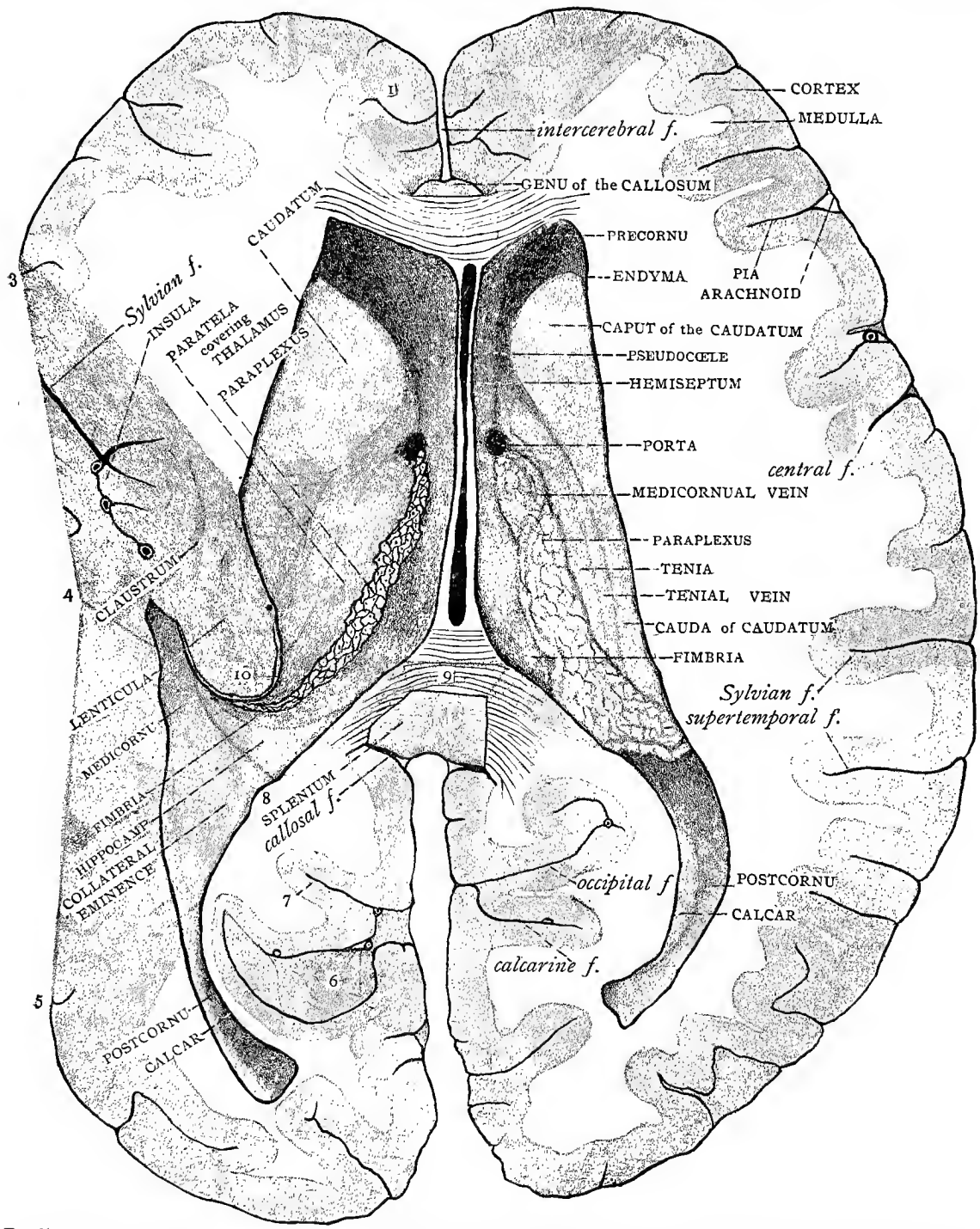

FIG. 61.—The Paracœles (Lateral Ventricles) of an Adult Male, Exposed from the Dorsal Side. Specimen 2867, Museum of Cornell University ; × 1.2.
Preparation.—The entire body (an emaciated consumptive, weighing only 37.71 kilogrammes, 83.25 lbs.) was alinjected through the femoral artery. Eight and one-half litres were introduced on the first day, and some escaped from the mouth. On the second day, and again on the fourth, another litre was injected. On the fifth day there was injected a litre of Pansch-Gage starch mixture (see article Methods, etc., in this volume, § 24). When the brain was removed, on the eighth day, the only odor was of the alcohol. The substance had already hardened somewhat and the arteries were well filled, notwithstanding some of the mass had extravasated into the thorax. The brain was transected through the mesencephal (see Methods, § 25, E), and the paracœles exposed by removing the dorsal portion of the cerebrum in thick slices down to the level of the callosum ; then in thinner slices and wedge-shaped pieces till the desired condition was reached. On the left the medicornu was exposed into the part extending cephalad ; the terminal portion extending also mesad could not be shown without cutting away an undesirably large mass. It is indicated in Figs. 4703 and 4707, although inadequately. On the left also the occipital lobe was cut to a slightly lower level than on the right ; hence, on the right appears the dorsal slope of the calcar, while on the left the plane of section coincides with the line of its greatest elevation, and the width of the posteornu is correspondingly reduced. To lessen the width of the figure a part of the lateral convexity was removed by dorso-ventral incisions between 3 and 4, and 4 and 5, so the line representing the pia ceases at 3 and 5. Finally, the left paraplexus was trimmed off quite closely. (For the rest of this explanation, see at bottom of page 104.)

usual fulness by Alex. Bruce in *Brain*, xiii., 171–190. There are included abstracts of previous cases and reduced copies of the illustrations of some.

In Vol. VIII., p. 192, the writer figured and briefly described one of three incallosal cat brains in the Museum of Cornell University. At the Boston meeting of the Association of American Anatomists, December 29, 1890, he showed the brain of a sheep lacking the callosum and fornix; but this specimen, fortunately unmutilated and thoroughly hardened, has not yet been figured or described.

§ 49. *The Relations of the Thalamus to the Paracœle.*—With the cat, dog, sheep, and all other animals examined by the writer, excepting the apes, the rima ("great transverse fissure") is just wide enough to admit the intrusion of the paraplexus, and there is no sign whatever of the entrance of the thalamus into the composition of the paracœlian floor.

§ 50. Points illustrated upon Fig. 60.—A. The close contact and even interdigitation of the mesal aspects of the frontal lobes concomitantly with the absence of a falx.

B. The width of the fimbria and hippocamp, and thence of the entire fornix, as compared with the human.

C. The apparent absence of the tenia.

D. The total exclusion of the thalamus, even in appearance, from the paracœlian floor.

§ 51. The same condition exists in man during the earlier half of gestation; Vol. VIII., Fig. 4749.

§ 52. In a chimpanzee and orang examined by the writer (Nos. 265 and 2548 in the Museum of Cornell University) the rima is widened, especially in the middle of its length, so that a narrow zone of the thalamus may be recognized, covered, however, by the paracœlian endyma; see the writer's paper, "The Relation of the Thalamus to the Paracœle, especially in the Apes" (*Association American Anatomists, Record*, 1889, p. 20).

§ 53. In the human adult, apparently concomitantly with the thickening of the subjacent thalamus, the two margins are forced apart, as seen in Fig. 4751. But this does not produce a rupture in the floor. The endyma yields or grows correspondingly, and forms a thin portion of the floor, resting upon the thalamus and adapting itself to its contour. Sometimes, as in Fig. 4749, the endyma maintains its independence and constitutes a separable paratela; in other cases the pia primitively covering the dorsum of the thalamus disappears, and the paracœlian endyma becomes so intimately united with the thalamus as to seem to belong to it. Finally, as brains are commonly removed, preserved, handled, and dissected, there is almost sure to occur a rupture along some line between the tenia and the fimbria, so that the thalamus actually appears within the paracœle as represented in most figures—*e.g.*, Fig. 4746. This subject is somewhat fully considered in the writer's paper, "The Relation of the Thalamus to the Paracœle" (*Jour. Nerv. and Mental Disease*, July, 1889, pp. 436–443), where the term *paratela* was first employed.

§ 54. Points illustrated on Fig. 61.—A. The general relation of the paracœles (lateral ventricles) to the cerebrum; although relatively much smaller than in the fœtus, they are absolutely extensive; here their natural extent has been maintained by the injection of alcohol; when examined in a fresh brain or in one hardened in the usual way their walls are often found nearly in contact.

B. The terminal dilatation and squareness of the postcornu, as contrasted with the pointed form which usually exists in brains not prepared by filling the cavities; sometimes, indeed, there has been doubt as to the extent of the postcornu, as admitted by Huxley, "Zoöl. Soc. Proceedings," 1861, p. 250; in Krause's "Handbuch," Fig. 479, the postcornua are merely linea.

C. The great thickness of most of the parietes as compared with their thinness in the fœtus, Fig. 4708.

D. The retention of the fœtal tenuity of a portion of the mesal wall, *viz.*, the hemiseptum (halves of the septum lucidum); see, however, § 46.

E. The considerable length and width of the human pseudocœle (fifth ventricle); so far as the writer has observed it is wider than in any other animal; in Fig. 60 (of the sheep) it is unnaturally wide.

F. The relation of the cortex (cerebral ectocinerea) to the medulla (alba), as an ectal layer following the fissural indentations.

G. The relation of the insula to the Sylvian fissure; the former is a typical subgyre, the latter is a typical superfissure; VIII., p. 160, §§ 260, 261.

H. The relation of the claustrum to the insular cortex ectad and the lenticula entad; see also Fig. 4785.

I. The constitution of the caudatum by two regions, a larger cephalic, the caput, and the cauda, narrow, and following the curve of the medicornu.

J. The junction of the occipital and calcarine fissures so as to constitute as it were a single bifurcate fissure; VIII., Fig. 4768, and this article, § 76.

K. The size and distinctness of the collateral eminence, an ental elevation or colliculus, corresponding to the collateral fissure upon the ventro-mesal aspect of the cerebrum; VIII., Fig. 4768, 4770.

L. The existence, on the left, of an elevation, the occipital eminence, corresponding with the occipital fissure. This colliculus is distinct in the fœtus (Figs. 4748 and 4764), and in some adults (Fig. 4736), is better marked than in this specimen.

M. The location of the portas (foramina of Monro), and their visibility in a direct dorsal view of the paracœles; by reference to Vol. VIII., Figs. 4740, 4744, it will be seen that each porta opens into the corresponding paracœle obliquely, looking laterad, cephalad, and also dorsad; hence it is visible from three different directions at right angles with one another.

N. The distance between the two portas. Deducting the slight length of the passages themselves, this distance represents the width of the aula, the mesal division of the prosocœle, which is commonly reckoned as merely the cephalic part of the "third ventricle."

O. The continuity of the hemiseptum, a part of the mesal wall of the paracœle, with the fimbria, a part of its floor; indeed, their topographical relations may be illustrated by bending a sheet of paper or metal, and holding it so that one portion is vertical and the other nearly horizontal; the former will represent the hemiseptum, the latter the fimbria.

P. The narrowness of the human fornix as measured by the distance between the lateral margins of the two fimbrias in their horizontal portions; compare the sheep, Fig. 60. It is true the word *fornix* does not occur on the figure; but, as somewhat fully discussed in VIII., p. 138, the fornix is constituted by the two hippocamps, with their fimbrias, united at the meson by the fornicommissure (Fig. 4751); in this dissection the fornicommissure is invisible, being upon a lower plane, so the fornix, as a whole, cannot be indicated.

Q. The smallness of the paraplexus as compared with its fœtal condition, Fig. 62 and Vol. VIII., Fig. 4708.

R. The formation of the free margin of the paraplexus by the medicornual vein, considerable in size and more or less contorted, by which the blood of the plexus is returned to the velar vein.

S. The considerable width of the attached portion of the paraplexus. This appears on the left side where the plexus has been trimmed quite closely. The rima is the line of apparent interruption of the parietes for the intrusion of the paraplexus, and is unusually wide in this specimen.

T. The completeness of endymal continuity and cœlian circumscription. These terms are discussed in Vol. VIII., pp. 122, 123, as exemplified upon the mesal aspect of the brain, Fig. 4711. There only the mesal cavities are visible. In the present figure (aside from the pseudocœle, which is not a true member of the series) there appear only the great lateral cavities of the prosencephal. The continuity of the endyma is represented by the uninterrupted heavy line surrounding either paracœle. Likewise is the endyma a continuous sheet upon the sides and floor of this cavity. At the margins of the rima it may be traced as a smooth surface upon the intruded paraplexus, and its cut edges are represented on

the left in this figure. The writer is aware that several authors claim or admit the existence of orifices along the medicornu whereby the cœliolymph may escape therefrom into the adjacent subarachnoid space; but he feels compelled, at present, to regard these as artifacts, like the half-dozen ruptures of the endyma near the porta in the preparation shown in Fig. 4742.

U. The *apparent* entrance of the thalamus into the composition of the floor of the paracœle. This condition is presented on the left side; on the right it is hidden by the overlapping paraplexus.

§ 55. *In what Sense does the Thalamus form Part of the Floor of the Paracœle (Lateral Ventricle)?*—So wide-spread and so deeply-rooted seems to be the notion that the thalamus constitutes a part of the paracœlian floor in the same sense as do the caudatum and the hippocamp, that, much as he would prefer to avoid criticism, the writer is induced to comment upon the current representations of this region.

Admitting, for the sake of occupying common ground, that a certain area of the dorsal surface of the human thalamus is covered by endyma; that it is continuous with the caudatum, and that therefore, like that body, it enters into the composition of the paracœlian floor; none will deny that an adjoining area of this same dorsal surface is as distinctly covered by pia; that it is continuous with the optic lobes (gemina), and like them wholly excluded from the encephalic cavity.

To represent the entire dorsal aspect of the thalamus as a smooth, unbroken surface is practically to affirm one of two things: either the whole is pial or ectocœlian, which would be in contravention of universal belief; or else the whole is endymal or entocœlian, which would involve not only the gemina but the cerebellum and oblongata, a manifest *reductio ad absurdum*.

This, nevertheless, with perhaps a single partial exception, is what we find in the accepted treatises on Human Anatomy, new as well as old.* The figures purporting to represent the natural surfaces fail to exhibit any lines of demarcation between entocœlian and ectocœlian areas either by a difference in texture or by raised edges to indicate where the reflected endyma had been divided. The extreme limits of misrepresentation are reached in Huguenin (Fig. 49), where the utter absence of distinction between surfaces which are said to be inside, and other surfaces which are said to be outside can hardly fail to mislead or at least confuse the reader who is not already thoroughly grounded in correct notions as to the general morphology of the brain.

The prevailing misconceptions as to the relations of the thalamus to the encephalic cavities are exemplified even in the recent translations of Edinger (Figs. 49 and 55) and of Obersteiner (Figs. 18 and 26). In the last, it is true, there is a semblance of demarcation between the diacœlian and paracœlian surfaces of the thalamus, a long, narrow line, just laterad of the "sulcus choroideus;" but in reality that line of reflection of the paracœlian endyma is as shown in Vol. VIII., Fig. 4751, at a considerable distance from the line of reflection of the diacœlian endyma upon the velum.

Dalton's "Topographical Anatomy of the Brain" was designed primarily to aid in recognizing the location of pathological conditions; furthermore, it is evident that the mode of removal of the brain, of handling and cutting it, would not conduce to the maintenance of membranous attachments. But in examining Series C, Plates VIII., IX., and X., for example, it is disappointing to find not only the rupture of these attachments, but also in the outline duplicates an unbroken continuity of line from the diacœle into the paracœle at either side.

With Gegenbaur's "Anatomie des Menschen," 3d ed., 1888, the case is different. This is an anatomical treatise, by a morphological leader. Yet the transections on p. 846 and the dorsal aspects on pp. 824 and 834 utterly fail to comport with the now universally admitted view of the restriction of communication between the diacœle and the paracœles to the portas (foramina of Monro).

§ 56. *The Transitory Cerebral Fissures.*—In the *Jour. of Anat. and Physiol.*, xxiv., 342, D. J. Cunningham makes the following important observation bearing upon the always interesting problem of the distinction between the ordinary mammals and the monkeys, apes, and man:

"Although I have looked for the transitory fissures in cat and dog embryos of different stages I have never seen any infolding of the cerebral wall that could be compared with those we have described in the human brain; the temporary fissures are in all probability peculiar to the primates."

§ 57. Points illustrated by Fig. 62. A. The great size

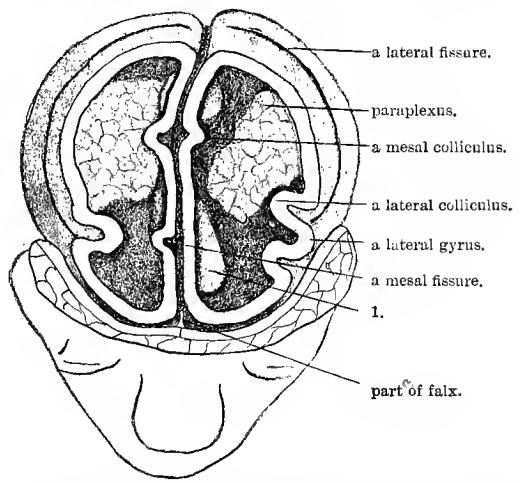

FIG. 62.—Transitory Fissures of a Fœtus measuring 5-6 ctms. from Vertex to Nates, and estimated at Fourteen Weeks; 2770; × 2.2.
Preparation.—After the exposure of the brain the frontal end of the cerebrum was sliced off so as just to clear the large paraplexuses. Of the falx all was removed excepting the fragment shown. The head was tilted so that the face is much foreshortened.

of the paracœles and paraplexuses at this stage; compare Fig. 4708.

B. The slight and nearly uniform thickness of the parietes.

C. Suggestion of a wrinkling or corrugation of the parietes as if from growth within a confined space.

D. The approximately symmetrical distribution of these corrugations.

E. The length of the fissure on either side, reaching from the Sylvian fossa nearly to the meson.

F. The absence of any indication of branching; see § 58.

§ 58. *Do the Lateral Transitory Fissures Branch?*—In none of the specimens or figures accessible to the writer do the transitory fissures on the lateral aspect present the bifurcations which are so common with most of the permanent fissures; it is to be remembered also that in the adult the total fissures (calcarine, occipital, hippocampal) are less subject to branching. The question should be carefully considered.

§ 59. In Vol. VIII., p. 148, § 188, it was stated that the writer had not yet encountered a fœtal brain in which (as said by Mihalkovics and repeated by Osborn, Vol. I., p. 640) the temporary fissures had vanished before the permanent ones appeared, leaving the surface smooth. He has since prepared a specimen (No. 2644 in the Museum of Cornell University) which measures 10 ctm. from the vertex to the nates, and 14 ctm. including the legs, somewhat flexed; the age was supposed to be about four months. Excepting the Sylvian fossa, the lateral aspect of the exposed left hemicerebrum is perfectly smooth;

* The exception referred to is Meynert's Psychiatry, where Fig. 16 includes a line marked L, crossing the thalamus, and more distinct upon the left than upon the right; upon the explanation it is named "Linea aspera," but there is no further reference to it, and its morphological significance is not mentioned: consequently, although it probably does represent a torn edge of endyma, the figure alone would not convey any definite information. It is just to add that the volume of the tenth edition of "Quain" containing the nervous system is not yet accessible.

the mesal surfaces and the right hemicerebrum have not been exposed.

§ 60. *The Permanent Fissures.*—D. J. Cunningham is preparing an elaborate account of the cerebral surface, to be published by the Royal Irish Academy as "Cunningham Memoir,"* No. vii.

In Vols. xxiv. and xxv. of the *Jour. of Anat. and Physiol.* have appeared abstracts (sometimes illustrated) of his views respecting the following: The Intraparietal (parietal and paroccipital of the writer); the Complete Fissures (the writer's transitory and permanent total); the Rolandic (central) Fissure; the Sylvian; the Insular.

The undeniably great value of these abstracts and of the work which they anticipate is somewhat impaired by a tendency toward pœcilonymy (see Vol. VIII., p. 528, § 72), *i.e.*, the employment of more than one name for the same part in the same paper (*e.g.*, "Fissure of Rolando" and "Rolandic sulcus"), and by an ignorance or neglect of American fissural literature.

mainly in the following respects: (*a*) more secondary and tertiary fissures are included; (*b*) the principal fissures are more or less sinuous as in actual brains; (*c*) a long arched fissure, practically identical with Turner's intraparietal (Ecker's interparietal), is interpreted as consisting of three portions, (1) a cephalic, retrocentralis inferior; (2) an intermediate, intraparietal; (3) an occipitalis anterior, for which is given the synonym *Affenspalte.* This, however, is certainly not the writer's exoccipital, but the transverse occipital of Ecker, which the writer has shown to be the caudal part of the paroccipital, which Eberstaller does not separate from the intraparietal.

(*d*) A needless and—in the writer's judgment—unwarrauted change of names; *e.g.*, the short fissure cutting the dorsal margin a little cephalad of the central was first described by Lussana as *solco inflesso*, and that was Anglicized by the writer as *inflected fissure;* by Broca it was called *incisure préovalaire*, and by Schwalbe *sulcus paracentralis;* disregarding priority and brevity, Eberstaller

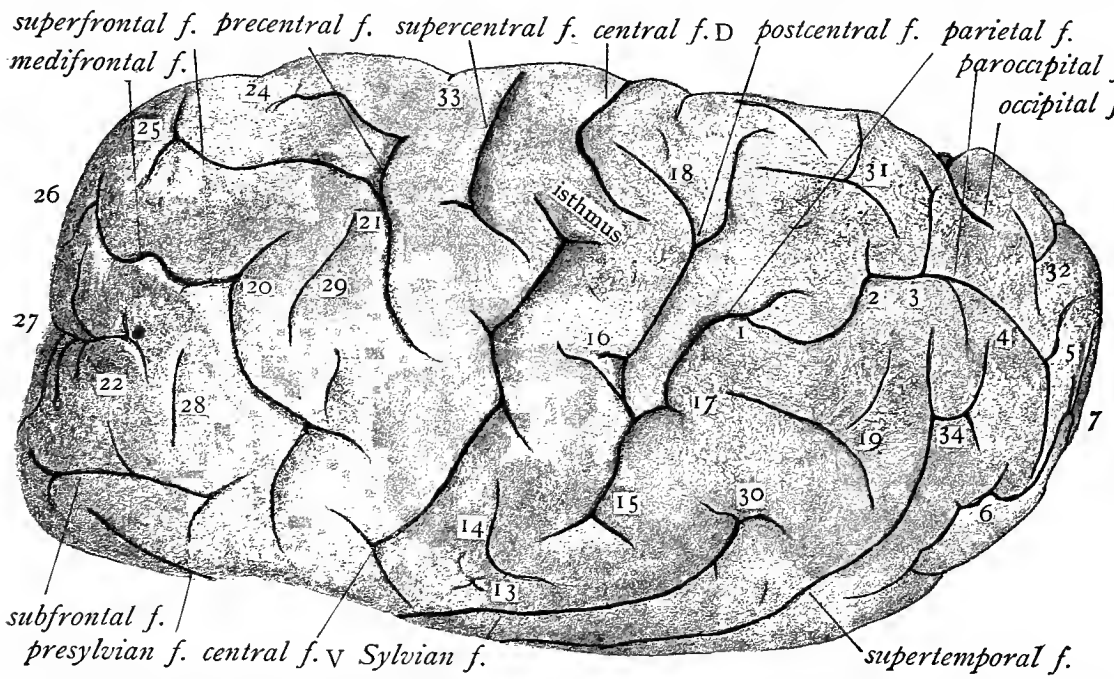

FIG. 63.—The Left Hemicerebrum of a Philosopher (Channcey Wright), from the Dorso-Lateral Aspect; × .9.
Preparation.—See Vol. VIII., Fig. 4779. The figure is based upon a photograph taken as nearly as possible at an angle of 45° with the meson, so as to present the dorso-lateral aspect. The line connecting the superfrontal and medifrontal fissures was made inadvertently.
The nnmerals 1 to 22 are at the same points as in Vol. VIII., Fig. 4779; on that figure 23 is designated the central isthmus, which here has the word printed npon it; 33 is just at the end of the short inflected fissure.

There is also in the *Brit. Med. Jour.*, August 2, 1890, an article by Cunningham discussing general questions connected with the fissures; a brief abstract is given by Hill, *Brain*, xiii., p. 552.

§ 61. Eberstaller has published an admirable account of the fissures and gyres, especially of the frontal region, under the title, "Das Stirnhirn; ein Beitrag zur Anatomie der Oberfläche des Grosshirns," O., pp. 140, with nine figures and one plate. Besides its general excellence two features will especially commend themselves, *viz.*, the Bibliography of 117 books and papers on the subject, and the Lists of Synonyms of each fissure and gyrus. The work concludes with a discussion of the homologies of the human fissures with those of the other primates and the carnivora.

§ 62. Eberstaller's plate presents what he regards as the normal fissural pattern of the lateral aspect only. From the writer's diagram (Vol. VIII., Fig. 4769) it differs

calls it *sulcus præcentralis medialis;* again, the perfect title *subfrontal*, applied by Owen and the writer to the fissure forming the dorsal boundary of Broca's gyrus, has been applied to a fissure or combination of fissures on the mesal aspect.

§ 63. Owen's names, although as a whole the best ever proposed, are in no case ascribed to him, and the considerable section of his "Anatomy of Vertebrates" treating of the fissures and gyres appears to be uuknown to Eberstaller.

§ 64. Even more specialized is the monograph of G. Hervé, "La circonvolution de Broca" [in man and apes], O., pp. 164, with 4 plates, Paris, 1888. The writer is not prepared to discuss Hervé's conclusions as to the degree of representation of the subfrontal gyre in apes; but he is compelled to dissent from the statement (p. 22) that of the two branches of the Sylvian fissure "ascending" and "horizontal" (corresponding respectively to the writer's presylvian and subsylvian) the latter is the more constant.

§ 65. In neither of these papers, nor, indeed, in any

* Since the above was written the writer has learned that the memoir has been published, but he has not yet received it.

others knowu to the writer, does there seem to have been adopted what he regards as an essential requisite to the elucidation of the subfrontal region, *viz.*, the removal of the postoperculum and of other parts in order to expose the depth and relations of the fissures.

§ 66. Points illustrated by Fig. 63 (mostly in addition to those which are enumerated in Vol. VIII., p. 158).—A. The unfamiliar appearance of a hemicerebrum when viewed from this oblique aspect.

B. The distinctness of the angles between the cephalic and the dorsal and ventral outlines; this was commented upon by the first describer of this brain, Professor Thomas Dwight, and appears in Vol. VIII., Fig. 4779, though less markedly.

C. The completeness and width of the isthmus between the dorsal and ventral portions of the central fissure; in Fig. 4779 this is marked 23, but is so much foreshortened as to be hardly visible.

D. The simple, curved form of the dorsal part of the central fissure, with no bifurcation such as exists at both ends of the ventral portion.

E. The independence of the supercentral fissure.

F. The presence of a medifrontal fissure subdividing the large area between the subfrontal and superfrontal fissures.

G. The junction of the postcentral fissure with the parietal, and the continuity of the parietal with the parоccipital; whether this junction occurs at 1 or at 2 cannot be determined at present.

H. The great length of the supertemporal fissure and the complexity of its dorsal end.

I. The absence of a distinct exoccipital fissure.

J. The presence of a long and curved fissure, 6–7, on the lateral aspect of the occipital lobe.

§ 67. *The Homologies of the Central and Cruciate Fissures.*—Upon several grounds, zoölogical, physiological, and even psychological, it is very desirable to ascertain whether the central fissure (f. of Rolando) of man, apes, and monkeys is represented in the Carnivora, and whether the carnivoral cruciate fissure is represented in the Primates.

In Vol. VIII., on pages 115 (§ 32, G, Fig. 4698), 160 (§ 258), and 134 (Fig. 4729) the question is stated and held to be unsettled. It has since been discussed by W. Turner (*Jour. of Anat. and Physiol.*, xxii., pp. 554–581), and by M. Benedikt (*Ibid.*, xxv., p. 213). The latter's views merit high consideration, and although the writer is far from ready to adopt them, they shall be here set forth, with the remark that the lack of figures and a certain vagueness of description render the original somewhat hard to interpret. For the convenience of American readers the publications necessary to cite will be indicated as follows: Broca, "Mémoires sur la cerveau de l'homme," 1888; Meynert, "Psychiatry," translated by Sachs, 1885; Wilder, "Anatomical Technology," 1882, 1886, 1892, and HANDBOOK, 1889.

A. Broca's view that the central fissure is represented in Carnivora by the presylvian of Meynert (superorbital of Wilder) is combated upon the grouud that the latter lies cephalad of the psychomotor areas and the group of giant cells of Betz; "therefore it is proved that the presylvian fissure cannot represent the central fissure; and it is not a consoling spectacle when anatomists, seduced by the error of an eminent man, have so little respect for the results obtained by physiologists and histologists."

B. Benedikt then states that the cruciate fissure lies in the "anterior limit of the psychomotor areas," and concludes that the central is represented by "a transverse fissure on the anterior end of the first primitive fissure in very many non-primate species." This is apparently the *ansate* fissure of Krueg and the writer; in *Anat. Technology*, Pl. I., Fig. 1, it is independent on the right, but on the left connected with the lateral; in the HANDBOOK, Vol. VIII., Fig. 4698, it may be recognized on the right, but is not designated. In this connection it must be noted, however, that Cunningham (*Jour. of Anat. and Physiol.*, xxiv., 153), says "it is now very generally admitted that the *sulcus coronalis* (coronal fissure of Krueg and the writer) has its homologue in the fissure of Rolando."

C. According to Benedikt the carnivoral cruciate fissure is represented in man by two short fissures, *viz.*, (1) "on the inner surface, an arcuate fissure which represents the anterior limit of the paracentral lobe; (2) a little transverse fissure on the outer surface limits generally the superior part of the anterior central gyrus from the anterior part of the frontal lobe, and represents that part of the cruciate which enters in the outer surface in animals."

It is evident that Benedikt's mesal fragment (1) corresponds to the cephalic part of the paracentral fissure, as shown in Figs. 4766 and 4768; but his description leaves one in doubt whether the lateral fragment is the inflected fissure or the supercentral or some third fissure.

It is surely unfortunate that a subject so important should be involved in needless obscurity by the lack of figures or explicit descriptions.

§ 68. In the *Revue scientifique*, vol. xlviii., pp. 555–563, 1892, Topinard discusses "Le type des circonvolutions cérébrales dans la série des mammifères.

§ 69. The cerebral fissures of a child of twelve and one-half years have been studied by Zilgien in the *Jour. de l'Anat. et de la Physiologie*, xvii., 613–621, 1891.

§ 70. Although made primarily for the determination of physiological and psychological correlations, Donaldson's careful "Anatomical Observations on the Brain and Several Sense-Organs of the Blind Deaf-Mute, Laura Bridgman" (*Amer. Jour. of Psychology*, iii. and iv., 1890–91) involved a detailed description of the fissures and gyres and the collation of much literature.

§ 71. In his study of the brain of a murderer (*Amer. Neurol. Assoc. Transactions*, 1892, 54) Donaldson adds to the mass of doubt respecting the validity of Benedikt's claim as to the significance of fissural confluence; see Vol. VIII., p. 163.

§ 72. Several Chinese brains have been described by Benedikt and by Dercum, the latter in the *Jour. Nerv. and Mental Disease*, July, 1889, and September, 1892. An Australian brain is described by A. D. Rolleston in the *Anthropological Institute Journal*, 1887, pp. 32–42.

§ 73. Sir William Turner's address, "The Convolutions of the Brain: a Study in Comparative Anatomy," *Jour. of Anat. and Physiol.*, October, 1890, 105–153, has been referred to in another connection (§ 28).*

§ 74. A case of remarkable fissural malformation and asymmetry is described and figured by W. Turner in the *Jour. Anat. and Physiol.*, xxv., 327–348. The subject was an epileptic, twenty-six years old, and the entire (alcoholic) brain weighed 1,107 grammes (39¾ oz.); the left hemicerebrum 530 grammes, the right 437. The left fissures are stated to have had a normal development and arrangement, but on the right the Sylvian fissure was wide open so as to expose the insula largely; *the central fissure was wholly absent*, together with the precentral and postcentral; the lateral surface presented three arched fissures, demarcating four arched gyres about the Sylviau fissure, a condition analogous to that in the dog and many other Carnivora. The interest and importance attaching to this case, as to the even more extraordinary malformation described by the same anatomist and referred to, with a figure, in Vol. VIII., 193, would have warranted a larger number of better figures, and a representation of the left hemicerebrum.

* Other recent publications on fissures are the following: Lussauer: Circumvolutionum cerebralium, etc., Patavia, 1888, O., pp. 19, 30 plates. Schnopfhagen: Faltungen des Grosshirns, Neurol. Centlbl., vii., p. 549. Benedikt: Beiträge zur Anat. der Gehirnoberfläche, Wien. Med. Jahrb., iii., p. 39, 1888. Eberstaller: Noch einmal die Insula Reilli, Anat. Anz., iii., 13, 1888. Mingazzini, L.: Ueber die Entwickelung der Furchen u. Windungen des menschlichen Gehirns, Unters. zur Naturl. d. Menschen u. d. Thiere, xiii., p. 498, 1888. Mingazzini, G.: Intornoci solchi e le circonvoluzioni cerebrali dei primati e del feto umano, Estratto degli Atti della R. Accad. Med. di Roma, iv., p. 48, 1888. Turner, W.: Comparison of the Convolutions of the Seals and Walrus with those of the Carnivora and of Apes and Man, Jour. Anat. and Physiol., xxii., p. 554, July, 1888. Falcone, C.: Studio sulla circonvoluzione frontale inferiore, Rendiconto dell' Accad. delle scienze, fisiche e matem., Napoli, xxvii., p. 195, 1888. Mahaudeau: Coupes des circonvolutions cérébrales, Bull. de la Soc. d'Anthrop. de Paris, x., p. 771.

§ 75. Four cases of non-union of the occipital and calcarine fissures, in white idiots, have been described by Dercum (*Jour. Nerv. and Mental Disease*, July, 1889). Among all the hemicerebrums prepared by the writer this condition exists in but one, the right of an adult female paretic (Fig. 64). Such cases are instructive on both morphological and zoölogical grounds.

When first formed the two fissures are commonly independent, and in the adult there is often a vadum or shallow at the place of junction. A complete separation, such as is shown in Fig. 64, is a retention of a common fœtal condition.

In most apes and monkeys the two fissures are separate; but usually the calcarine is the longer, and the occipital fails to reach it, a condition comparable with that in the fœtus shown in Vol. VIII., Fig. 4761. In one case, therefore, the interruption is a calcarine isthmus, in the other an occipital isthmus. Cases of occipito-calcarine independence have been observed also by H. C. Chapman (*Acad. Nat. Science Proceedings*, 1892, p. 208) and

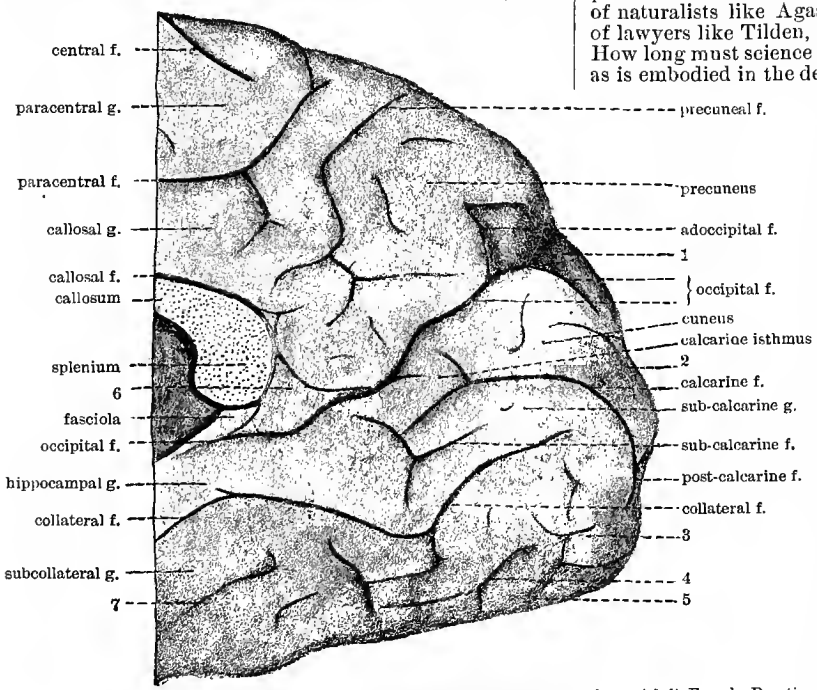

Fig. 64.—Caudal Half of the Mesal Surface of the Right Hemicerebrum of an Adult Female Paretic. No. 2358 in the Museum of Cornell University; × 1.

in the white as well as the negro. The relations of the fissures to each other and to the common stem (called *occalcarine* by the writer, VIII., p. 153, G) have been discussed by D. J. Cunningham, *Jour. Anat. and Physiol.*, xxiv., 327-334.

§ 76. Points illustrated on Fig. 64.—A. The complete separation of the calcarine fissure from the occipital by a calcarine isthmus. On the other side the two are connected as usual.

B. The bifurcation of the calcarine at each end, constituting a zygal fissure; Vol. VIII., Fig. 4773.

C. The extension of the occipital fissure so as to represent what is usually the common stem of it and the calcarine, the occalcarine; Vol. VIII., p. 153, § 213.

D. The presence of a "spur" extending caudad from the occipital toward the calcarine upon the isthmus.

E. The appearance of trifurcation of the dorsal end of the occipital. The middle extension, however, is continuous with the fissure only superficially; the cephalic branch is apparently the writer's adoccipital; the caudal, although doubtless the dorsal part of the occipital, presents an unusual curve and is invisible from the lateral aspect.

F. The extent of the precuneal fissure.

G. The considerable extension of the central upon the mesal aspect; Vol. VIII., p. 157, § 236.

H. The presence of a subcalcarine fissure.

§ 77. *The Need of Particular Brains.*—From the physiological and psychological stand-point it is clearly desirable to study the cerebrums of persons whose mental or physical powers were marked and well known. The present condition of things is illogical and unprofitable. We scrutinize and record the characters and attainments of public men, clergymen, and friends, whose brains are unobtainable. We study the brains of paupers, insane, and criminals, whose characters are unknown or perhaps not worth knowing.

It is at once a reproach and an irreparable loss to science that the community has not yet been convinced that the preservation and study of one's brain is an honor to be coveted. Who can set a limit to the results that might have been attained from the examination of the brains of soldiers like Grant, Sherman, and Sheridan; of preachers like Beecher, Brooks, and Howard Crosby; of naturalists like Agassiz, Gray, and Jeffries Wyman; of lawyers like Tilden, Conkling, and Benjamin Butler? How long must science wait for a general sentiment such as is embodied in the declaration of an eminent historian, that science is as welcome to his brain as to his old hat, and that he wishes he had ten of them?

It is encouraging to know that the brain of the late George Grote, historian of Greece, has been described by John Marshall in the *Jour. of Anat. and Physiol.*, vol. xxvii., pp. 21–68, and that the American Anthropometric Society has already the brains of Joseph Leidy (its first president), of his brother, Dr. Philip Leidy, and Dr. James W. White.*

In Vol. VIII. (§ 280), therefore, the writer urged the preeminent value of the brains of college professors for the elucidation of the correlation between the mind and its bodily organ.

§ 78. *The Greater Need of Average Brains.*—Another aspect of the matter has impressed the writer more and more during the past year, *viz.*, the need of a fissural standard, based upon the careful comparison of large numbers of average, intelligent, educated, and moral individuals, excluding the eminent as well as the immoral, the ignorant and the insane.

The first step in this direction has been taken in the acquisition of the brain of a lawyer embodying all the above-mentioned desirable characteristics. In furtherance, there have been printed numerous copies of the fissural diagrams (Vol. VIII., Figs. 4768 and 4769), with explanations,† for distribution to the classes in Physiology at Cornell University. Besides full explanations, there are the following admission and suggestion:

* In 1890, following the example of the French Société mutuelle d'Autopsie, there was formed in Philadelphia an American Anthropometric Society, in which the writer had the honor of being appointed a member of the Publication Committee. The requirement that all brains should be deposited at the headquarters of the society seemed to the writer from the first undesirable, and he withdrew in the following communication to the president, dated December 20, 1891:

"I hereby resign my membership in the society. Reflection has confirmed the views already expressed to you personally: 1. No other institution or locality is entitled to absorb or appropriate in any sense the encephalic material or reputation, present or future, of this University. 2. My own circumstances and plans for investigation would preclude any such active co-operation as might naturally be expected. With hearty good wishes for the success of the society as a local or university organization for the increase and dissemination of important and accurate knowledge respecting the brain, I remain, etc."

† These diagrams will be sent to any who ask for them.

"As is at present usual in collections, most of the specimens available for study came from ignorant, insane, or criminal persons; it must be borne in mind that the *fissural pattern of the average, intelligent, educated, and moral human being is undetermined.* Hence, although these are believed to be improvements upon previous diagrams, they must be regarded as provisional and imperfect.

"It is hoped that this and succeeding classes may include some who will recognize the desideratum above indicated and will follow the enlightened example of several graduates and professors of this University in giving written directions to the effect that their brains shall be saved for high scientific uses rather than wasted upon worms. Steps have been taken toward the formation of a Cornell Brain Association, and similar organizations might well be established at other institutions of learning and in many cities."

Those who have thus devoted their thinking organ to the service of thought with their successors are present undergraduates of Cornell University, graduates, members of the present teaching body, a former professor and an eminent non-resident lecturer. Perhaps the most interesting results are to be anticipated from the comparison of the brains of a brother and sister.*

§ 79. *Brain Weight.*—In connection with this subject (Vol. VIII., pp. 163, 164) should have been mentioned the paper by Thurnam in the *Jour. of Mental Science*, April, 1866; also Topinard's "Éléments d'Anthropologie Générale." Chaps. xv. and xvi.

§ 80. The relations between the weight of the brain and its parts and the stature and mass of the body, in man are discussed by the late John Marshall, in the *Journal of Anat. and Physiol.*, xxvi., pp. 445–500, with an interest and instructiveness that would have been still greater had he discarded the insular *ounce* and *inch* in favor of the now almost universally used metric measures of weight and length. The following significant conclusion is quoted from Donaldson's review of the paper in the *Jour. of Nerv. and Mental Disease*, xvii., 776, October, 1892: "Dr. Marshall finds that when the smaller weight and stature in the female are given their proper value in calculations, the encephalon in the female is proportionally as heavy as in the male. On this subject, see also an Editorial in the New York *Medical Record*, October 26, 1889.

§ 81. The relative weights of the two halves of the human cerebrum are discussed by W. Branne in the *Arch. f. Anat. u. Physiol., Anat. Abt.*, 1891, pp. 253, 270.

§ 82. A marked exception to the still too confidently affirmed generalization as to the correlation between brain-weight and intellect is afforded by two brains obtained by the writer in 1891; one (2870) was from a lawyer and writer, the other (2912) from an ignorant black janitor. There is little difference in respect to amount of fissuration; when fresh, the lawyer's brain weighed 1225 grammes (43.20 oz.), the janitor's 1250 grammes (44.09 oz.). The janitor was heavy and strong, the lawyer spare, though active; the former under thirty years of age, the latter in his ninetieth year.

§ 83. *Relative Weights of Body and Brain.*—In Vol. VIII., p. 163, § 287, the writer gave as the "least misleading statement," the opinion that the human brain is relatively heavier than that of any animal larger than a cat, in which the cerebrum is fissured.

This must now be qualified. Through the kindness of Director Smith of the Central Park Menagerie, the writer lately examined a male baboon (*Cynocephalus hamadryas (?)*, No. 2980). Its body weighed 5738 grammes (12.6 pounds), and its brain 171 grammes. The body is thus only 33.5 times as heavy as the brain; as stated in Vol. VIII., p. 163, § 286, in healthy human beings the ratio is probably about 1 to 45; in those dying from disease (like the baboon, which died of tuberculosis) it is variously estimated at 35.20, 36.46, and 36.50. Unfortunately the age of this baboon is uncertain; supposed at the Menagerie to be about seven years, the incomplete dentition indicates about two. Other baboons should be examined in this regard. *Burt G. Wilder.*

* They are orphans, and without other near relatives who might object; but it is understood in all cases that objections by husbands, wives, parents, or children shall be respected.

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Wilder, B. G., and Gage, S. H.: Anatomical Technology as Applied to the Domestic Cat. Third ed., from the second revised. O., pp. 600, 130 figs., and 4 lith. plates. (Chap. X., pp. 400-503, is devoted to the brain.) New York and Chicago, 1892.

The usefulness of the Anatomischer Anzeiger was mentioned in Vol. VIII., p. 164. Special records of neurological literature are made in the Journal of Comp. Neurology by the editor, C. L. Herrick (Granville, O.), and in Schmidt's Jahrbücher für in- und ausländische Medicin, by Edinger under the title of "Bericht über die Leistungen auf dem Gebiete der Anatomie des Central Nervensystems, and by Alex. Hill, in Brain.

BRAIN, METHODS OF REMOVING, PRESERVING, DISSECTING, AND DRAWING. § 1. The article under the above title in Vol. VIII. of the REFERENCE HANDBOOK (pp. 195–201) consisted largely of a series of memoranda often so condensed as to be hardly explicit. The present contribution will be in some degree an expansion of that, with additions and corrections in accordance with what has been published by others and the experience of the Anatomical Department of Cornell University.* It should be borne in mind that these methods are applicable mainly to the preparation and dissection of the brain for purely anatomical or morphological ends, such as are regarded in the articles "Gross Anatomy of the Brain," in Vol. VIII. and in the present volume. For histological and pathological purposes, in addition to the publications referred to in Vol. VIII., p. 196 (first foot-note), consult the works of C. L. Dana and L. C. Gray, named on p. 111 of this volume, and the articles by Dana and Peabody (New York *Medical Record*, January 11, 1890, p. 53) and Van Gieson (*New York Medical Journal*, July 20, 1889, and January and February, 1892); the last, on "Artifacts of the Nervous System," has been reprinted as a pamphlet of 119 pages and 17 plates.

§ 2. *Order of Treatment.*—A. Remarks on the need of more attention to the subject (§ 3); the importance of early recognition of the form and connections of the encephalic cavities (§ 4); preliminary work upon animal brains (§ 5); the utilization of infant and fœtal brains (§ 6).

B. Preservation of fœtal and infant brains (§§ 7–8).

C. Preservative liquids: alcohol (§ 10); chromic acid compounds (§ 11); Fish's liquid, a zinc chloride mixture (§ 12); dry preparations (§ 13); jars (§ 14).

D. Injection methods: entocœlian (§ 15); arterial (§ 16); starch mixture (§ 24).

* Besides the gentlemen named in Vol. VIII., § 2, note, the writer desires to acknowledge the cordial and efficient coöperation of P. A. Fish, B.S., 1890, Instructor in Physiology and Anatomy in Cornell University, and of B. B. Stroud, B.S., '91, Assistant in Chemistry.

E. Removing the brain from infants and late fœtuses (§ 25); from the adult (§ 30); removal in the dura (§ 33); weighing the fresh brain (§ 36); determining its volume (§ 37).

F. Medisecting the cerebrum (§ 25, G); storage of hemicerebrums (§ 38); removing the pia (§ 39); labelling specimens (§ 41).

G. Dissection of the brain (§§ 43–45).

H. Drawing the brain (§§ 46–58).

§ 3. *Need of More Attention to the Subject.*—In the large city schools considerable time is now devoted to the anatomy and physiology of the nervous system, and instruction is given especially in histological methods; but even there the gross anatomy is not always adequately worked out by the student himself upon good material, and it is to be feared that in some medical colleges the conditions described by the writer nine years ago* may still prevail.

Inasmuch as he is permitted to clean scrupulously the abdominal muscles before examining the vastly more important viscera, the average first-year student is at least consistent in deferring the removal of the organ of the mind until he has carefully dissected the muscle that wrinkles the forehead. With saw and chisel he lacerates the brain, tears it in the effort to save entire the sacred skull-cap; injures it yet more in the process of extraction,† and places it upon a hard, flat surface, where its own weight completes the rupture of delicate connections and hopelessly distorts its shape. Here he leaves it (having to boil or clean some bones), perhaps for a day or two, probably drying, and either freezing or decomposing according to the temperature. He then transfers it to a basin or pail, covers it with strong alcohol, notes with satisfaction that the surface hardens rapidly, feels sure of finding out all about the brain, and sees himself a future neurological expert, perhaps even an asylum superintendent. In due time, armed with his "Gray" and a big knife, he succeeds in identifying the cerebellum, the chiasma and the pons. Upon the cerebrum he recognizes the Sylvian fissure, but is doubtful about the central; moreover, the effort to detach the dried-on pia creates so many undescribed depressions and fissural confluences that he imagines, *à la* Benedikt, that it belonged to some hardened criminal. Lifting the occipital lobes, his fingers readily enter cavities which must be the "descending horns of the lateral ventricles," a triumphant refutation of the opinion of certain "theoretical" anatomists that there is no such thing as a "great transverse fissure" till artificially produced. He then slices the brain *secundum professoris artem*, and is so pleased at demonstrating the "*centrum ovale majus*" that he is not seriously disturbed at the presence of an unexpected rent in the callosum and an irregular orifice at either side. Continuing his operations, he finds the interior of the brain a mass of amorphous pulp; suspects that the names in the books have much the same significance as those of the heavenly constellations; modestly admits that he may not be sufficiently advanced to comprehend the brain, and resolves that, when this branch is undertaken again, his *armamentarium* shall consist not of a scalpel but a spoon.

§ 4. *Importance of Early Recognition of the Form and Connections of the Encephalic Cavities.*—In Vol. VIII., p. 196, § 35, the recommendation would be more accurate were the word *details* printed in italics. What the writer desires to inculcate is the desirability of appreciating the fact that the brain has resulted from the unequal thickening of the walls of a series of mesal cavities which were primarily subequal in size, and from the great development of a pair of lateral masses, the hemicerebrums, about the lateral extensions, paracœles, of the mesal series. This idea may be gained from an embryo brain (Vol. VIII., Figs. 4691–4693), from a cast of the adult cavity (Fig. 4703), and from the mesal aspect (Fig. 4711) and cerebral cavity (Fig. 4740), without attempting at first to master the exact contours, much less to learn the names of all the elevations and depressions.

§ 5. *Preliminary Work upon Animal Brains.*—In Vol. VIII., p. 195, § 3, the brain of the domestic cat was recommended. Its advantages are unquestionable in respect to accessibility, ease of removal and preservation, and simplicity of fissural arrangement. The employment of the equally accessible and larger brain of the sheep has been hindered by the difficulty of extracting it from the head with either nippers or saw as commonly employed. This was obviated in the spring of 1890 by P. A. Fish, who devised the following method: The cranium is removed from the rest of the head by sawing on a plane coinciding with the ventral margins of the orbits and of the foramen magnum. The corners of the mass are then sawn off, and the cranium nipped away, beginning with the base.*

In addition to the practical reasons referred to above and in Vol. VIII., the brains of the cat, dog, pig, and sheep present this great advantage over that of man, *viz.*, there is less preponderance of the cerebrum and cerebellum over the other regions and the segmental constitution of the organ is thus more easily recognized. This is stated and illustrated in Vol. VIII., pp. 114–116. In the present volume it is more clearly indicated in Fig. 5, where the dorso-ventral lines, A–E, transect the several segments without involving adjoining segments, although the last requires the section to be made from the ventral side, and all are more or less oblique.†

§ 6. *Utilization of Infant and Fœtal Brains.*—The treatment of this subject in Vol. VIII. (pp. 195, 196, §§ 4, 6, 28, 29, 30) is unsatisfactory, partly from lack of experience since acquired, and partly from excessive condensation. The procedures depend upon the object in view and upon the age and condition of the specimen.

§ 7. *Early Fœtal Brains, Two to Four Months.*—Unless one has acquired considerable skill in manipulating such delicate objects, these should be hardened in place by one of the following methods, or by a combination of them; a five per cent. solution of zinc chloride in alcohol is very effective with embryo brains:

A. Injection of the preservative through the umbilical vein.

B. Immersion; if alcohol, or the above solution, is used the specimen should be suspended in it.

C. Injection of the preservative with a hypodermic syringe both into the body in general and into the cavities of the brain.‡ The cannula should be pushed through the scalp at the margin of the prefontanel, obliquely latero-ventrad so as to traverse the thin parietes and enter the large frontal portion of the paracœle; Fig. 62, Vol. VIII., Figs. 4708, 4709. The success of the injection is shown by the expansion of the opposite half of the head due to the passage of the liquid through the portas into the corresponding paracœle.

The exposure of such brains must be done under or over alcohol; the cranium, and dura must be divided together at each cut. The operation is tedious, but the results are revelations, no matter how often performed; no specimens are more beautiful or instructive; see Figs. 4697, 4756.

§ 8. *Brains of the middle and later gestative periods and at term* are most useful for the comprehension of the early and simple condition of the fissures and of the

* Methods of Studying the Brain: the "Cartwright Lectures" for 1884. *New York Medical Journal*, xxxix., 1884, pp. 141–148, 177–183, 205–209, 233–237, 373–377, 457–461, 513–516, 653–656; xl., 113–116; 64 fig. Abstracts in *New York Medical Record*, xxv., 1884, pp. 141–143, 197–199, 225–227, 365–367, 449, 450, 545, 546.

† The article Anatomy in the last edition of the Encyclopædia Britannica (i., 876) seems to acquiesce in the present state of things as beyond remedy: "In taking the brain out of the cranial cavity this commissure [the medicommissure] is usually more or less torn through, and the cavity [diacœle] is consequently enlarged."

* So expeditious is this method that in 1892 a hardened brain was supplied to each of the one hundred and sixty members of the general class in Physiology for dissection, in addition to the large series of permanent preparations, transections and selected half-brains with good mesal aspects put in their hands for examination. The study of the sheep's brain occupied the class at three exercises of two hours each. The directions form part of the writer's "Physiology Practicums," and he hopes shortly to publish in detail the methods of removal and preservation.

† As to monkey brains see § 8.

‡ So far as the writer is aware, this was first done by Professor S. H. Gage, May 17, 1892, upon specimen 2947.

order of their appearance.* The best results are obtained by their prompt removal as described in §§ 25–29, and hardening in Fish's liquid or other zinc chloride mixture. The arterial injection of such brains rarely preserves them well, and the gyres are commonly so pressed together as to interfere with both the removal of the pia and the recognition of their relations.

§ 9. In Volume VIII., p. 196, § 13, it is suggested that the use to be made of a brain be determined upon in advance. The city neurologist has perhaps only to decide that a brain is needed; but others, like the writer, may find it advantageous to keep in a portfolio (see Vol. VIII., p. 198, § 56) slip memoranda of what he wishes to do with fresh brains, or heads, adult or young, as the case may be; when the opportunity occurs he has only to decide among several things that might be done, and little time is lost.

§ 10. *Preservative Liquids.*—In Volume VIII., p. 196, § 23, a preference was expressed for alcohol. But the brain inevitably flattens in it more or less, and there is difficulty in recognizing the cinerea from the alba.

§ 11. *Potassium Dichromate.*—This is the chief ingredient of the well-known "Müller's liquid," which consists of two parts of it and one of sodium sulphate in one hundred parts of water. Beyond increasing the buoyancy of the liquid, the sodium sulphate seems to have no special value for either microscopic or macroscopic purposes and is often omitted.

Mr. B. B. Stroud has determined for this article that, at the temperature of 20° C. (68° F.), a saturated solution of potassium dichromate contains about ten per cent. of the salt; at boiling the per cent. is forty-four. His method of using it for sheep brains (§§ 5 and 15, notes) was to effect the solution rapidly in boiling water; when cool, enough water was added to float the brain just below the surface.

As soon as the brain is firm to the touch it may be soaked for a day in water and then in alcohol, at first about forty per cent., then stronger, until the alcohol ceases to be colored, after which it may be kept in alcohol of not less than eighty per cent.†

The alcohol that is so colored may be used for the same purpose with other brains, or in the storage of specimens not requiring it to be either colorless or strong.

The Incompatibility of Alcohol with Compounds of Chromic Acid.—A chemist to whom the matter was submitted states that when alcohol and potassium dichromate are mixed in any proportion the salt will be at least partially reduced, and there will also be formed, from the alcohol, various compounds, as acetic acid, acetic aldehyde, etc. These processes will take place in either light or dark, but more rapidly in the light.

§ 12. *Fish's Liquid.*—The following combination was devised in 1892 by Instructor P. A. Fish, of the Anatomical Department of Cornell University, and is found to answer the three requirements of preservation of shape, hardening of substance, and differentiation of tissue:‡ Alcohol (ninety-five per cent.), 200 c.c.; water, 800 c.c.; glycerine, 75 c.c.; zinc chloride, 50 grms. The alcohol and water should be mixed first, so as to get a strength of twenty-two per cent. as determined by the alcoömeter; the variation in commercial alcohol is such as may render it necessary to add more to the mixture, but the total of the twenty-two per cent. mixture should be only about 1,000 c.c. When shaken up thoroughly the specific gravity of the mixture should be about 1.04; if less, a little more glycerine and zinc chloride may be added.

When the brain is introduced it should rest just at the surface, and the vessel should be deep enough to prevent its touching the bottom. If any part projects it may be submerged by covering it with a thin layer of absorbent cotton, the edges of which dip into the liquid. Masses having one flat side, *e.g.*, hemicerebrums, should have that side up, the reverse of the desirable position when—as in alcohol—the specimen sinks to the bottom. If possible the liquid should be injected into the cavities, and into the vessels, and these injections should be repeated daily for a week.

After one to three days the brain will probably sink to the bottom; the pia should then be removed, preferably without taking it from the liquid; it may be steadied with beds of cotton.

Half of the liquid is now to be replaced by ninety-five per cent. alcohol; this is best done by drawing off a part with a syringe and introducing an equal quantity of the alcohol. In the lighter liquid the brain will sink to the bottom, and for two days should rest on the flat side if there is one; if all the surfaces are convex, they should be padded with cotton, and the specimen turned frequently. After two days more half the lighter liquid may be replaced by alcohol, and in two or three days more all of it. The removed liquid may be utilized in various ways; the percentage of zinc chloride is hardly great enough to be corrosive, and the alcoholic strength may be increased by the addition of ninety-five per cent.

§ 13. *Dry Preparations of the Brain.*—Laskowsky's method was mentioned in Vol. VIII., p. 196, § 27, note; the following is translated from the abstract in the *Neurologisches Centralblatt*, vi., 341–342:

A. Rinse the fresh specimen in water to remove blood.

B. Place in a mixture of water, 100 parts; alcohol (ninety-five per cent.), 20 parts; boracic acid, 5 parts; let it remain in a cool place [for at least three days; time not given].

C. Remove the pia.

D. In a saturated solution of zinc chloride in alcohol let the brain remain five or six days; the bottom of the vessel should be covered with cotton.

E. For fifteen to twenty days soak in a mixture of glycerine, 100 parts; alcohol, 20 parts; carbolic acid, 5 parts; boracic acid, 5 parts.

F. Let it dry in the air, protected from dust.

The specimen is claimed to retain its natural volume, distinction of color, and elasticity.*

§ 14. *Preserving-Jars.*—Besides those mentioned in Vol. VIII., p. 199, the following deserve mention from the combination of three desirable qualities—width of mouth, clearness of glass, and cheapness:

A. Tall, round, screw-capped jars, with nickel-plated caps, cork-lined, three sizes, viz.: 4 oz., 8 oz., and 16 oz.; Whitall, Tatum & Co., New York (Fig. 65).

B. Butter-jar, 10 x 20 ctm., with tin screw-cap, lined, capacity about 1 litre; Excelsior Package Co., 49 Warren Street, New York.

C. Landenberger's Specimen Jars.—These have a rubber ring and a glass top retained by a wire. The smaller size is 3 x 3 in., capacity 6 oz. (180 c.c.); the larger, 3 x 4 (high), capacity 10 oz. (300 c.c.) (Fig. 66).

§ 15. *Entocœlian Injection.*—To fill with a hardening and preservative liquid cavities surrounded by flexible walls would seem to be a natural device both for the better preservation of the mass and for the maintenance of the forms and relations of the cavities.†

* The writer desires to reiterate here the conviction expressed in Vol. VIII., p. 149, § 195, and on two previous occasions there named, as to the inutility of the brains of ordinary monkeys and even of apes for the elucidation of human fissural problems; indeed, our present comprehension and nomenclature of cerebral elevations and depressions would be far better than they are had neither Gratiolet nor any other anatomist ever examined a monkey brain.

† The specimens may be more completely decolorized by absolute alcohol (W. C. Krauss), by hydrogen peroxide (Unna, *Arch. für Mikros. Anat.*, xxx., 48, 1887), or by a one per cent. solution of chloral hydrate (Lee, "Microtomist's Vade Mecum").

‡ The microscopical distinction between alba and cinerea is permanent, but immersion in alcohol bleaches the cinerea to nearly the color of the alba in about a fortnight.

* Experiments are now in progress in the anatomical laboratory of Cornell University upon other methods of making dry preparations of the brain. Methods have been described by Stieda (*Neurolog. Centralblatt*, 1892, No. 5), by Moeli (*Centralb. allg. Path. u. path. Anat.*, iii., p. 1, 888), and by Struthers (*Jour. Anat. and Physiol.*, xxii., Appendix, p. ix).

† The method was first employed by the writer, as assistant to the late Professor Louis Agassiz, at Nahant, Mass., in July, 1867, for permanent preparations of great vascular sinuses in rays. Since that time it has been applied in the anatomical laboratory of Cornell University to the preparation and study of hollow organs of all kinds, stomach, cæcum, heart, uterus, kidney, and brain. In 1880 he first learned that the injection of alcohol into hearts was advised in 1860 by Hyrtl, and in 1879 by Mojsisovics; the former ascribes the idea to William Hunter; the writer is not aware that injection of a preservative into the brain cavities was practised or suggested by anyone prior to December 14, 1881, when he employed it upon a child's brain.

The account of entocœlian injection in Vol. VIII., p. 201, § 80, is not only too brief, but requires emendation in the light of later experience.

A. Without conceding the existence of other natural orifices from the paracœles (lateral ventricles) (p. 107, § 54), both human and animal brains present outlets for the

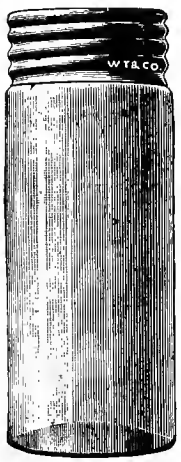

FIG. 65.—Screw-capped jar; see § 14, A.

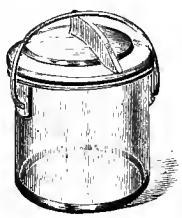

FIG. 66.—Specimen jar; see § 14, C. For sale by H. Landenberger, 25 N. 13th Street, Philadelphia.

escape of the injected liquid so as to obviate the danger of rupturing the thinner parietes under any pressure that might be required for filling the cavities. With animals the myelocœle (central canal of the spinal cord) is pervious through life. With a cat, for example, where 4 ctm. of the myel remained attached to the brain, alcohol injected into the diacœle (third ventricle) with a syringe escaped from the myelocœle in a stream 8 to 10 ctm. long, although the orifice of exit was 42 mm. from the tip of the metacœle and 66 from the place of injection. With human brains (excepting early stages when the myelocœle would probably be sufficiently pervious) there is an ample outlet at the metapore (foramen of Magendie), described under "Meninges;" the same may be the case with apes and some monkeys. Hence the cannula, instead of fitting loosely, may be tied into the infundibulum, or made large enough to fit it closely. In the latter case the cannula may need a rubber collar to prevent its entrance so far as to lacerate the medicommissure or parietes. This precaution may be rendered superfluous by using a cannula which is bent upon itself at a right angle, in the form of a capital letter L, turned one quarter way around thus, ⌐; the shorter arm enters the orifice, the longer rests upon the base of the brain and has attached to it the tube connected with the syringe or injection reservoir. This tube should be short and slender; in the intervals of injecting it may be compressed, or plugged with a glass or cork.*

Entocœlian injection, whether repeated or continuous, may be accomplished from any artificial orifice. The most favorable place is the aqueduct (mesocœle) after transection of the brain (§ 25, E); the cannula may be selected so as to fit it closely; with the cerebellar portion of the brain the metapore would serve as the outlet; with the cerebral it might be necessary to tie the infundibulum to prevent too ready escape therefrom; with a small stream at a slight elevation above the brain it is probable that any excess would be provided for by oozing along the rima. †

A small glass syringe may be employed for injecting preservative liquids into the brain-cavities, either directly or by attaching a rubber tube and cannula.

§ 16. *Arterial Injection of the Preservative.*—This is referred to in Vol. VIII., p. 196, §§ 20 and 68, and is exemplified in Figs. 4684 and 4711. As compared with immersion it has the great advantages of rapidity and thoroughness. Any preservative may be employed, and alcohol may be used at full strength. A low temperature is needless, and even, perhaps, undesirable, as admitted in Vol. VIII., explanation of Fig. 4884.

Barring a slight shrinkage, the natural conditions and relations are maintained.*

It must be admitted, however, that sometimes the gyres are somewhat crowded against each other, so that the pial folds are less readily and safely extracted, and the fissural relations less easily determined.

This is not the occasion for a complete history of injection processes, or for the presentation of claims to originality. The transmission of preservative liquids to the tissues by a constant pressure apparatus connected with the vessels by which blood reached the parts during life is really so simple as well as effectual that it is hard to account for its comparatively infrequent suggestion and adoption. Without previous acquaintance with what had been done by others,† on October 7, 1883, with the co-operation of Professor S. H. Gage, the writer began upon the body of a young chimpanzee (No. 265) an alinjection of the entire body which was prolonged for ten days and was completely successful. In November, 1885, a manatee (No. 844), 150 ctm. long, was prepared in like manner: all the cats (75 to 150 per year) used by the general class in Physiology are alinjected and packed away till wanted; still-born children are commonly so preserved, and the writer recommends that, with alcohol obtained free of tax, all anatomical material in medical dissecting-rooms be thus rendered innocuous, free from unpleasant odor, and fit for prolonged and thorough examination.

§ 17. *Location of the Arteries.*—In Vol. VIII., p. 200, § 68, the relations of the arteries were very briefly referred to; the practical importance of the matter warrants a fuller consideration.

Nearly opposite the hyoid bone, or the cephalic margin of the larynx, each common carotid divides into an ectocarotid ("external") and an entocarotid ("internal"). In the adult they differ little in size, but may be distinguished in that (1) the ectocarotid branches at once and lies farther ventrad, while the entocarotid continues unbranched to the cranium and is accompanied by the vagus nerve.

If the neck was severed close to the head the two arteries may be dealt with independently. If at the level of the chin (as in the head shown in Fig. 4684) the common carotid may be followed up between the muscles, using the tracer rather than the scalpel as much as possible. But if the neck is entire, and especially if it is to be kept so, the ectocarotid may be exposed as for surgical ligation by an incision along the ventral ("anterior") margin of the sterno-mastoid from the lobule of the ear. In any case the ligature must be applied close to the bifurcation of the common carotid or the superior thyroid artery (Fig. 2430) may not be included. As to the vertebral artery, unless there are special reasons for not injuring the vertebræ, the transverse process may be nipped away in order to expose the vessel. The cannula is to be inserted in one, and the other tied after the arteries have been cleared. Since the two arteries unite to form the basilar it makes no difference which has the

* At the writer's suggestion L-shaped cannulas were used last summer in the preparation of sheep brains for the class in Physiology; the preparator, B. B. Stroud, succeeded in making these cannulas very small, and with the point slightly enlarged so as to be more securely tied in the infundibulum.

† For the exposition of the forms and membranous parietes of the encephalic cavities, nothing seems to promise better than the method briefly described under Figs. 4736 and 4751, a combination of arterial injection with injection into the medicornus opened by cutting off the lateral regions of the cranium and brain.

* In this connection, the writer cannot refrain from expressing his regret at the non-application of this and other exact methods of preservation and determination to the brain of Guiteau; see *N. Y. Med. Jour.*, February 23, 1884, p. 206, and *Amer. Jour. of the Med. Sciences*, January, 1883, p. 219.

† Arterial alinjection of the brain is named or implied by Ecker ("Cerebral Convolutions," p. 45), by Mondino (*Trans. Roy. Microsc. Assoc.*, 1885, p. 904), by Foster and Langley ("Pract. Physiology," p. 215), by Key and Retzius ("Studien," i., p. 104), and by the editors of the tenth edition of "Quain," vol. iii., Fig. 88. It was done in 1863 for Marshall upon a Bushman (*Philos. Trans.*, cliv., p. 501); the dates of its performance for Flower and Owen are mislaid.

cannula, excepting that there is some convenience in placing it and the carotid cannula on the same side.

§ 18. *Securing the Cannulas.*—Preferably one cannula is to be inserted in the carotid, whichever is the longer, and another in the vertebral of the same side. Each is to be very securely tied; if there is no shoulder at the cannula point, then tie also around the rubber tubing at its base. All the knots should be the so-called "surgeon's," one end of the thread being passed through twice instead of once; "Anat. Technology," Fig. 41.

§ 19. *Continuous injection* necessitates, in addition to the means of supporting the brain mentioned in § 34, (first) an escape-tube (Fig. 4884) whereby the overflow may pass into the escape-jar, (second) some means of supporting the cannulas and tubes.

The first requirement may be provided for by inserting a metal or glass tube in a hole near the top of a wooden pail, or, with a metal pail, having a tube set at that place; in either case a rubber tube conducts the overflow to the escape-jar. The second end may be attained in either of several ways: The metal pail shown in the figure has soldered to the sides several tubes serving as sockets for flexible wire "cranes;" these wires (of lead, copper, or unannealed brass) may be fixed by wooden wedges if they do not fit securely; with a wooden pail they may be pushed into holes bored vertically into the rim. In either case the wires should be large and the free end beaten out rather thin, so as to be bent easily in the fingers about the tubes connected with the cannulas. Unless the operator has metallic screw-pinch cocks for regulating the flow, so small as not to drag undesirably upon the wire, he may secure the same end by fixing to another wire a wooden spring clothes-pin, by means of which the rubber tube may be compressed.

§ 20. *Turning the Head.*—There are reasons for believing that the position of a head under injection should be changed daily, in order that no one region of the cerebral surface shall be more than twenty-four hours in close contact with the cranial wall.

§ 21. *Repeated Alinjection.*—It is probable that the injection of, say one litre of ninety-five per cent. alcohol, morning, noon, and night, for a week, would harden a brain very well, but accurate experiments on this point have not been made as yet under the writer's observation. If it be tried especial care should be taken to exclude air-bubbles (§ 22), to keep the brain wholly submerged or its base covered with a layer of absorbent cotton dipping into the alcohol. Such injections may be made conveniently with an ordinary rubber-bulb syringe. Repeated injection will conduce to the preservation of the cœlian parietes and of the plexal attachments, but is less effectual than continuous for maintaining the size and form of the cavities.

§ 22. *Exclusion of Air-bubbles During Arterial Injection.*—This is accomplished by letting the alcohol run until no bubbles appear either in the cannula or in a glass tube which is introduced near the can; the can itself should always be at a higher level than the adjoining tube, especially when it is lowered for the introduction of fresh alcohol, since bubbles are then most apt to be formed; on this account the tube should be of ample length.

§ 23. *Filtration.*—Whatever liquid is to be injected into the encephalic vessels must be carefully filtered through filtering-paper, or through absorbent cotton crowded into the pipe of a funnel. This necessity applies to unused alcohol as well as to that which has already passed through tissues.

§ 24. *Starch Injection Mixture.*—Of the mixture first proposed by Pansch, the following modification has been devised by Professor S. H. Gage and the writer:

Dry starch powder	100 c.c.
Chloral hydrate	10 grms.
Water	50 c.c.
Alcohol (ninety-five per cent.)	50 c.c.
Glycerine	25 c.c.
Coloring matter.	

After thoroughly mixing the mass it should be filtered through one or two thicknesses of wet cheese-cloth. To prevent the starch from settling, the cloth should be tilted from side to side or the mass may be stirred during the filtration. If the mass is not freshly prepared for every injection, the stock mass should be filtered occasionally to remove hair or any other object that might clog the cannula.

Among the colors that are available, probably vermilion, red lead, ultramarine, Berlin blue, chrome orange, yellow, or green, are preferable.

§ 25. *Removing the Brain from late Fœtuses, Still-borns, or Young Children.*—This is most conveniently done if the cranium and maxillary region are first cut away from the neck and maudible by cutting with coarse curved scissors from the corners of the mouth to the nape of the neck. The mass thus obtained is compact and may stand upright in liquid.

A. Instruments and materials required. Coarse forceps; coarse, curved scissors for bone; another sharp pair for soft parts; tracer (Fig. 4880); nippers (Fig. 4881); large scalpel; narrow-bladed scalpel, preferably a probe-pointed bistoury;* four vessels, holding about two litres each; two of water; one of preservative; one of saturated brine; if the weight of the brain is to be ascertained (§ 36) the body should be weighed before the head is removed, and there should be provided a fifth vessel of normal salt solution (15 to 2,000).

B. The scalp should be removed completely, together with the ears, and temporal muscles as far as the zygomas.

C. Cranium and dura. In young subjects these adhere closely; hence, contrary to what is recommended with adults, they should be removed together in pieces. With the tracer-point lift the united pericranium (ectal periosteum) and dura near the left margin of the prefontanel, and with the scissors or scalpel slit the tough membrane so as to expose a little of the brain. Grasp the cut edge with the forceps and with the scissors cut out a piece including pericranium, dura, and intervening area of parietal bone. Continue in this way, using the nippers when necessary, until the entire left hemicerebrum is exposed. More and more care will be required to avoid injuring the delicate brain, either by the instruments or the cut edges of bone.

Leaving the falx undisturbed, expose the right hemicerebrum in the same way, but with even more precaution and holding the head so that the left is more or less completely supported in the brine.

D. Falx. Cut the veins that pass from the dorsal margins of the cerebrum to the longitudinal sinus; they are more easily dealt with if the head be slightly tilted toward one side. From Vol. VIII., Figs. 4684 or 4711, recognize that at about the junction of the cephalic and middle third the falx extends only half-way to the callosum. Lift it with the forceps just enough to steady it and cut with the scissors. Draw the cephalic third cephalad and cut off. The caudal two-thirds may be steadied and cut as near as possible to the line of its junction with the tentorium, but must not be pulled upon on account of its connection through the falcial sinus with the velar veins.

E. Transecting the mesencephal. Tilt the head cephalad. Cut the veins that pass to the dura from the sides of the brain and near the caudal end. With the scissors cut the vessels and connective tissue and membranes just caudad of the splenium (Fig. 4711) so as to expose the gemina, the dorsal lobes of the mesencephal corresponding to the crura ventrad (Figs. 4689, 4712, 4783). This is the narrow region connecting the wider cerebellar mass with the still wider cerebral portion, and hence called sometimes the isthmus. With the probe-pointed bistoury or sharp, narrow scalpel cut this just caudad of the conarium; the knife should point almost directly at the tip of the nose if the pons is to be wholly avoided.

* This is practically a longer and stronger syringotome (Fig. 4880), the cutting edge being about 5 ctm. (2 in.) long, ending in a probe point. The curvé is less than that of the syring itome. It replaces the syringotome in the dissection of the entire human brain, and it is particularly applicable to transecting the brain through the mesencephal, to tracing the medicornu and to slitting the pia in following the Sylvian or other deep fissures.

F. Cutting the nerves, etc. The cerebral mass is now held to the base of the skull by the mesal hypophysis (Fig. 4712) and by the paired optic nerves and olfactory crura and bulbs. The slender stalk (infundibulum) of the hypophysis is to be cut first; then the firm fibrous optic nerves. The olfactory crura and bulbs are easily torn, but if care be taken to avoid pulling upon them the latter may be dislodged from their cavities with the blunt point of the bistoury or the tips of the scissors.

G. Medisecting the cerebrum. The cerebrum now floats free, and ordinarily should be medisected at once. Remove the rest of the head to the normal salt solution. Steady the cerebrum by packing absorbent cotton about the base. Divaricate the opposed dorsal parts of the hemicerebrums till the white callosum is visible. Place the edge of the scalpel at the genu and with one sweep, steady and perpendicular, divide the callosum, fornix, precommissure, medicommissure, and conarium; the halves will then fall asunder so that the chiasma and crura may be medisected.*

H. The cerebellum, *etc.*—With the scissors cut the tentorium at its margins. Turn the head so as to expose the cranial nerves and cut them; lastly, with the curved scissors divide the myel as far down as possible. Transfer to the salt solution.

I. Weighing. From the pan of brine, each portion is to be transferred in turn to the salt-solution, and weighed according to the method described in § 36.

§ 26. *Removing the Hemicerebrums Separately.*—The following modification of the method just described has some advantages. After the exposure of the left hemicerebrum cut the veins as before. Let the head tilt to the left so as to expose the callosum. Divide it, as directed above, down to the base of the skull; then the left half of the mesencephal; then the infundibulum and optic nerve; and finally dislodge the olfactory bulb.

These last parts are then to be attended to first on the right side; the falx is easily removed, and the hemicerebrum comes out as soon as the veins are cut. The chief objection to this method is the danger of cutting the mesal aspect of one of the frontal lobes.

§ 27. When there are reasons for not mutilating the head, the removal of a child's brain is much less convenient. The body and legs should be wrapped up so as to be held and turned easily. Unless the child can be held by an assistant, it will be found convenient to let it rest in a sort of trough, like a piece of large roof-gutter; or to roll it up in a sheet of lead, which, upon pressure, will flatten so as to maintain any desired position. The tray or trough must be supported at a level with the rim of the vessel of brine, so that the head may hang over into it when desired. Needle and thread must be provided for sewing up the scalp.

§ 28. *Ventral Exposure.*—For some purposes, *e.g.*, when the organ is to be kept entire, or when the nerve-roots are to be retained, the young brain may advantageously be exposed from the ventral side; this aspect should be first studied, as shown in Figs. 4689 and 4711; then the base of the cranium may be nipped away, or cut with the coarse scissors; it will be well to expose one side completely first, so that any errors detected may be avoided on the other. With care the hypophysis (Figs. 4712 and 4728) may be retained.

This method is less applicable to adult brains, on account of the thickness of the skull; this, however, may be softened by nitric acid; Vol. VIII., § 6, note.

§ 29. On February 1, 1884, the writer removed the cranium of a small monkey (*Midas*, No. 342) by means of a dental engine, working a small saw and a burr. It may be predicted that in time the work now done laboriously with saw and nippers will be accomplished more neatly and expeditiously by some apparatus like the electro-osteotome of Dr. M. J. Roberts, whom the writer is proud to claim as a former student and assistant; see *Virginia Med. Monthly*, March, 1887.

When it is desired to inject the arteries of a subject after the removal of the brain, if the arteries (carotid and vertebral) cannot be tied or caught with *serres-fines*, the regions in which they open may be filled with plaster-of-Paris.

§ 30. *Removing the Adult Brain.*—Portions of the operation are described in Vol. VIII., p. 199.* The writer is confident that whoever once adopts the plan of making a second sagittal section of the calva, one to two centimetres from the meson, will never again attempt to remove the entire calva in the customary fashion.

A. Saw. There is no special advantage of the expensive surgical or anatomical saw over the ordinary carpenter's instrument; it should be thin-bladed, fine-toothed, kept sharp and well-set, and used for no other purpose.

B. Supporting the brain in brine. Although decidedly firmer than in infancy the adult brain should nevertheless be supported in brine during the later stages of its removal; this is particularly essential if the organ is to be removed entire.

The brine should be in an ample vessel, and, if wetting the floor is to be avoided, should stand in a pan or tray. The head is to hang over the end of the operating-table; the vessel of brine is therefore most conveniently placed upon a revolving stool (like a piano-stool) or in a firm chair with some low boxes or thick pieces of board whereby it may be raised or lowered according to the position of the head.

C. The longitudinal sinus should be slit to let out the blood, unless the calval dura is to be removed entire; usually, notwithstanding all precautions, the saw has cut the dura at some point. There—or at any other point—commence with the scissors or probe-pointed bistoury, and cut the dura along the line of the cranial edge first on one side. The head and entire body must now be turned so that the hemicerebrum is supported in the brine. When the dura of the other side is cut the falx may be cut near the cephalic end. In lifting it observe the precautions mentioned in connection with the fœtal brain (§ 25, D). The transection at the mesencephal gives no special difficulty beyond the weight of the cerebrum and the tendency of the head to assume undesirable positions; an assistant is wellnigh indispensable. The extraction of the cerebellum, etc., is practically the same as with the young brain (§ 25, H), and is described in Vol. VIII., p. 199, § 67.

§ 31. *By Removal of the Occipital Region of the Cranium.*—At the meeting of the American Neurological Association, June 22, 1883, as reported in its "Transactions," p. 84, as reprinted from the *Journal of Nervous and Mental Disease*, July, 1883, Dr. Spitzka described as follows a method which, he informs the writer, he has known to be employed by some German anatomists. The writer has not tested this method personally, but is disposed to regard it as better adapted to pathological than to anatomical purposes, and as such entitled to be considered in connection with the usual method, and with that described in Vol. V. of this work, pp. 789–791.

"The scalp is divided in the median line, beginning a little in front of the coronal suture, and extending down the neck. If it is desired to remove the spinal cord the incision is extended to the lumbo-sacral region. Two lateral flaps are formed in the head region, the soft parts being peeled from the dorsal aspect of the cervical vertebræ and the posterior half of the skull. A circular incision is made [with the saw] in the skull, behind the ears, and completely encircling it down to the foramen magnum, care being taken not to injure the connection between the articular processes of the atlas and the occipital condyles: the posterior half of the skull is removed exactly as the calvarium ordinarily is, by taps of a chisel; sometimes a rongeur forceps suffices to complete the division near the foramen magnum. The adhesion about the lateral [and longitudinal] sinus and torcular Hero-

* Contrary to the suggestion in Vol. VIII., p. 196, § 19, it is probable that the best result may be obtained by dividing the callosum first and the chiasma last; if the operation is performed in a long vessel of saturated brine, so that parts do not tear by their own weight, even the tender medicommissure may be cut before it yields.

* See Dr. W. W. Gannett's article in Vol. V., pp. 789–790.

phili can be readily overcome by a home-made apparatus like the knife [spatula, or round-pointed knife, curved flatwise] shown by Professor Wilder. The advantages of this method are: 1, The spinal cord and brain can be demonstrated *in continuo;* 2, the critical operation of lifting the hemispheres and gouging out or injuring the cerebellum in dividing the tentorium is obviated; 3, the nerves and arachnoidal laminæ at the base may be divided without allowing the brain to drag by its own weight. These nerves are divided from behind, forward. As soon as the chiasm is divided, the skull is inclined a little, and the brain allowed to fall into the hands of the operator by its own weight, it being completely separated, except where the olfactory filaments pass through the ethmoid; but these yield readily, and I have gotten the olfactory bulb intact as often by this as the other method. The removal accomplished, the occipital segment is riveted back, and a stick of wood inserted in the spinal canal and extending to the cranial interior restores the strength to the head support, impaired by the breaking up of part of the vertebral attachments."

§ 32. The method of Féré (as briefly described in a paper "Procedé de coupe du crâne," *Soc. Anat. de Paris Bulletin*, ii., 206–207, March, 1877) is by a circular incision very low down from the eyebrows ventrad of the auditory meatus to a point between the foramen magnum and the dorsal arch of the atlas. This, if successful, would uncover the brain very fully and permit its replacement in the calva after extraction; but it seems inevitable that the petrous bones should give trouble as well as be themselves destroyed.

§ 33. *Removal in the Dura.*—Space will not permit detailed directions for removing the brain in the dura; suffice to say that with care and patience and anatomical knowledge it may be accomplished so that only a small part of the dura is absent from the central region of the base. For the safe handling of the brain and for alinjection purposes even the dorsal half of the dura is worth saving.

§ 34. *Supporting the Brain for Injection.*—If the dura has been retained, at three places upon each side, frontal, temporal, and cerebellar (or occipital if the metepencephal has been removed) pin to the dura pieces of broad, stout tape (or strips of cloth 2 to 3 ctm. wide) 10 to 15 ctm. long; in place of pins there may be used garment clasps with serrated edges.

§ 35. For temporary purposes, *e.g.*, examination of the base, preparation for injection, and the single injection of a mass, etc., the brain, supported as directed in Vol. VIII., p. 195, §§ 10 and 11, may be steadied and raised or lowered as required, within any vessel of appropriate size; if of wood, the strips of cloth may be secured by tacks (artists' "thumb tacks" are most convenient); if of glass or metal then an elastic band (*e.g.*, a rubber ring from a jar, or an elastic tape) may be stretched about the rim and the strips passed under it.

§ 36. *Weighing the Fresh Brain.*—One method is described in Vol. VIII., p. 198, § 50. There the brain is added to a pan of liquid already balanced upon the scales. After recording the weight required to balance the added brain, then—having first wet the hands with a liquid identical in composition with that in which the brain is immersed—remove the brain and record the loss of weight. Theoretically it should be the same as had to be added before; practically there is usually some difference, and the average of the two should be taken as representing the true weight.

In employing the first method, some trouble will be avoided if, after the pan of liquid has been counterpoised upon the scales by an approximately equal weight, say 500 or 1,000 or 1,500 grammes, the exact balancing be accomplished by removing or adding liquid with a syringe.

§ 37. *Determining the Volume of a Brain.*—This is done as with any other mass, in either of two ways.

A. Into a vessel of accurately known capacity pour a given volume of liquid; dip the hands in the same, and transfer to it the brain; then, from a graduated vessel add enough more of the liquid to fill the first vessel. The difference between the total capacity of the vessel and the sum of the two volumes of liquid introduced represents the volume of the brain.

B. Set a vessel in a deep pan, dish, or pail. With any liquid (salt-solution, water, or alcohol and water) that is lighter than the brain, fill the vessel just to the brim. Let the brain into it gradually; the overflow will represent its volume.

Obviously a combination of the two methods is most satisfactory.

§ 38. *Storage of Hemicerebrums.*—The human hemicerebrum is a somewhat bulky mass, and may occupy a six by eight inch Whitall & Tatum jar (Vol. VIII., Fig. 4883); sometimes both halves of a cerebrum may be accommodated, although the undivided cerebrum or entire brain commonly requires a nine by eight inch jar.

The most favorable method of storing several hemicerebrums is in jars nine inches in diameter and of any desired height; the specimens are set in tiers of three, their dorsal convexities against the sides of the jar; successive tiers are so placed that a hemicerebrum rests upon the interval between two below. There will be a central vacancy which, if the jar is to be transported, may be filled with absorbent cotton; the alcohol (ninety-five per cent.) should be introduced last.

§ 39. *Removal of the Pia.*—The early removal of the pia* is recommended in Vol. VIII., p. 196, § 33. The writer has seen some otherwise valuable cerebrums materially injured by faulty methods, and offers here a few suggestions.

A. Begin with the central fissure, if it can be recognized, and at about the middle of its length. Apply the coarse forceps so that their approaching points move in the direction of the length of the fissure; pinch up a fold of pia; with the scissors snip at either side of the fold so as to raise it a little; then carry the forceps, held in the same way, more deeply into the fissure, not more than one centimetre deep, and attempt to draw out the intra-fissural fold of pia. If successful, continue to pull *lengthwise of the fissure*, cutting the pia at either side whenever necessary.

Most of the other fissures may be dealt with in the same way; but some, notably the occipital and calcarine, are very deep, and arteries traverse them which must usually be cut more than once.

The Sylvian fissure is not only deep, but spreads laterad over the insula, and there are several arteries. Rather than run the risk of tearing the adjoining gyres it is better to remove only so much pia as easily separates, leaving the rest and the arteries until one of the operculums can be cut off and afterward replaced.

While removing the pia or studying the lateral fissures of young or fœtal brains, breaking is avoided and divarication of the gyres facilitated if the hemicerebrum is placed on its meson on a piece of thick Manila paper (such as is used for the portfolios), which is sufficiently firm to support the organ and yet yields so as to permit the exposure of the fissural depths. When the mesal surface is studied the specimen should rest in a thick bed of cotton.

§ 40. *Prevention of Drying.*—The strong alcohol in which brains are preserved (eighty per cent. and upward) evaporates rapidly while the brain is exposed, as in examination or dissection; it may be dipped in the alcohol occasionally, or—which is preferable with delicate specimens—the alcohol may be allowed to drip gently upon it from a pledget of absorbent cotton. When a specimen only partly submerged in alcohol has to be left for a short time, drying may be prevented by covering it with a thin layer of cotton, one end of which dips into the liquid.

§ 41. *Labelling Specimens.*—Much of the real value of a specimen depends upon its identification as being a certain part of a certain brain, taken from an individual of a certain age, sex, and nationality, and preserved in a certain way. Even if the possessor has so few specimens that he feels sure of remembering the entire history of

* It is understood that this includes the arachnoid, which on most parts of the cerebrum adheres closely to the pia; Vol. VIII., Fig. 4687.

each, his death would abolish the source of information. Hence *every specimen should be labelled in some way.*

In Vol. VIII., p. 198, §§ 55, 56, the method was briefly indicated. Since that volume appeared the writer has observed surprising instances of carelessness in this regard, even upon the part of some who should set an example of scientific accuracy.

Were the specimen never to be removed from the jar in which it alone is kept, the object could be accomplished by inserting the label in the jar or attaching it thereto; but this is rarely an adequate precaution, neither is it often possible to state all the desirable data upon a label attached to the specimen itself. The most satisfactory plan tried by the writer is *the adoption of a serial number for each brain.* This number corresponds to a list or catalogue (Vol. VIII., p. 198, § 56), and is affixed to each brain and to every separated part thereof; that is, the first brain obtained or prepared is numbered 1, and all its parts, when separated, bear the same number, with the addition of letters *a, b, c, etc.*, when there is (which is very seldom) any chance of non-recognition of the nature of a fragment. These numbers may be written with lead pencil (not common ink), and last for some time if not handled; but if written with India ink (ordinary drawing ink, with an equal volume of water), on good paper or parchment, they are permanent. The label may be affixed by one or two small pins.*

For purposes of dissection, photographing, or drawing it may sometimes be necessary to remove the label, but ordinarily it should be affixed to some other region, so that there may be no possibility of misplacement.

§ 42. *Distinctive Labels.*—The ready recognition of brains belonging to groups may be provided for as follows:

A. The sexes are distinguished by using quadrangular labels for males and circular ones for females.

B. Presumed normal white brains have white labels; Africans (of all shades), gray; murderers and other criminals, red; insane and idiots, blue.

§ 43. *Dissection of the Brain.*—As commonly practised this contrasts strongly with the examination of the rest of the body. With the latter, dissection is universal, and sections are seldom made or even studied;† but with the former, sections, macroscopic or microscopic, are the rule, and dissections, careful, prolonged, and thorough, are nearly unknown in medical schools. Like the preponderance of osteology over neurology, the difference is due to the "nature of things;" but like many other natural conditions it may need modification.

The advantages of sections for surgical, pathological, and regional study are obvious; they are easily made, even with the fresh adult human brain, especially by means of the apparatus devised by Professor Dalton.‡ If the human brain were like that of the frog or opossum, with the several segments of approximately equal size, and nearly upon the same plane, the common method would be more appropriate for macroscopic study. But, in view of the extreme cranial flexure and the overlapping of certain segments by others, the objections to sections are as follows:

1. They present plane surfaces which do not naturally exist in the brain.

2. They are almost invariably oblique with respect to the axis.

3. They always include more than one encephalic segment, and are therefore, so far as the beginner is concerned, apt to be more confusing than instructive.

4. They present the parts in contiguity rather than continuity.§

The foregoing objections apply to all sections. A macroscopic section, especially of a brain which has had the cavities alinjected, presents the advantage of exhibiting in perspective enough of the natural contours of parts to facilitate their recognition and comparison.

Admitting, then, that sections have their uses, what is urged is, not that section-making be practised less, but dissection more.

§ 44. *Preliminary Dissection of Alcoholic Brains.*—In the article in Volume VIII., § 34, this is recommended in a single line. The writer is yearly more convinced of its importance on three grounds:

A. The brain is a complex organ and at the best perplexing; the simpler features of form, location, and relation to cavities are morphological, while color, like histological composition, has a physiological significance.

B. The fresh brain is less easy to dissect neatly, and requires constant support against its own weight, whereas the alcoholic may be held in any position and carved like cheese.

C. The beginner should advance cautiously, and therefore slowly, and the medical student is especially liable to interruption. The fresh brain remains fresh but a very short time, while the alcoholic is in itself imperishable. Leisure means not only more careful dissection, but also the taking of notes and the making of drawings; hence all the arguments which the writer has advanced ("Anatomical Technology," pp. 55, 56), in favor of preliminary anatomical work upon a small animal, which may be kept in alcohol for an indefinite time at slight expense, apply to all alcoholic brains in general, and to those of moderate size in particular.

D. After repeated dissection of alcoholic preparations, the anatomist is better qualified to manipulate the fresh brain and to appreciate its beauty. The last word is used advisedly, for, however unattractive may be "subjects" and pathological "cases," the most exacting artistic sense can hardly fail of satisfaction with the soft white and gray and pink of the newly extracted brain. Resting securely in its calva, for him who has been disciplined by prolonged experience with the "pickled" organ, there are few more attractive, stimulating, or nourishing articles of intellectual pabulum than a fresh brain "upon the half shell."

§ 45. *Dissection.*—Whether fresh or hardened, the writer believes the first step should be to slice off the dorsal parts of the cerebrum to near the level of the callosum and the next the exposure of the paracœles as described in connection with Fig. 61; compare Vol. V., p. 790.

The occipital lobes may then be cut off opposite the splenium and one or both medicornus followed to the tip of the temporal lobe.

The next object should be to remove the overlapping parts of the cerebrum from the subjacent diencephal (and so much as may remain of the other segments) so as to obtain a view of the ventral aspect of the splenium and fornix. These may be transected a little caudad of the portas.

There will then appear the velum, with the conarium. If the velum be lifted carefully there will be recognized the attachments along the dorso-mesal curvature of the thalami which are commonly ignored but insisted upon in Vol. VIII., Fig. 4751.

A transection through the portas will give a view of their boundaries, of the cephalic aspect of the medicommissure, and of the caudal surface of the fornix and the precommissure; most of the other features are more easily examined upon the mesal aspect of the medisected brain.

Somewhat full directions for dissection are given by Edinger, in the first part of Lect. III. Complete directions are desirable, accompanied by figures indicating the appearances presented at each stage, such as the writer has framed for the brains of the cat ("Anatomical Technology") and sheep ("Physiology Practicums").

* The ordinary pins are apt to corrode, more or less, and discolor the brain, or tear it when removed. It is to be hoped that pins of aluminium may ere long be available.

† Notwithstanding the example and opportunity offered by works like Braune's "Atlas of Topographical Anatomy" and Dwight's "Frozen Sections of a Child" and "Anatomy of the Head."

‡ Topographical Anatomy of the Brain. Philadelphia. 1885, vol. i., pp. 4–10; abstracts in *N. Y. Med. Record*, February 15, 1879; July 31, 1880.

§ Solly's vigorous reprobation refers particularly to horizontal slicing: "It is unfortunate indeed that candidates for the medical diploma are still very generally required to describe the appearances presented by the brain dissected, or rather destroyed, by the old method of slicing—a method most unphilosophical in its conception, and totally inadequate to impart any real information in regard to the structure of the brain."

§ 46. *Methods of Representing the Brain.**—The following considerations and suggestions† apply more or less directly to all natural history illustrations, but with especial force to the human brain, on account of its softness when fresh, the difficulty of preserving it, the great size of the entire organ, the minuteness of certain portions, the large number of recognizable parts within a small area, the continuity of all, the contiguity of some which are otherwise associated but remotely, the intermixture of two differently colored substances, the complicated relations of the meninges to each other, to the vessels, and to the cavities, and the preponderance of curved and oblique contours over straight lines and planes.

§ 47. *Importance of Orientation.*—With all organs, but especially with the brain, it is essential that the location of the region represented be easily recognized; otherwise details may be unappreciated or even misapprehended. So far as possible, therefore, less familiar parts should be accompanied by such as are unmistakable. It might seem that useless expense was incurred by the publishers of Bourgery and Jacob's magnificent plates in the introduction of faces artistically drawn and colored; but even the expert neurologist is guided in the comprehension of the relative position of brain parts by reference to the apparently superfluous facial outlines.

§ 48. *Enlargement of Complex Regions.*—It often happens that the same section or dissection includes regions that are comparatively simple, and others that are very complex; shown upon a single scale, either the complex parts are unintelligible, or the total is undesirably and needlessly large. Hence, just as the histologist aims first to obtain a general view of all the parts in their gross relations, and then focuses a higher power upon a selected region, so the representer of encephalic structures should give first a view of the whole, if only an outline, and then an enlargement of complex parts to any extent required for their complete elucidation; he can hardly make this enlargement excessive. Compare, *e.g.*, Quain's figures, 258 and 290, and Figs. 4740 and 4742 in Vol. VIII. of this work.

§ 49. Terminal and limiting parts, membranes, and apparently atelic (functionless) parts and conditions should be distinctly shown, or the insufficiency of their representation admitted. "The little things of the brain" might well form the subject of an entire article. From the stand-points of physiology and medical practice such parts as the terma, valvula, crista, conarium, hypophysis, and habena, and such conditions as the reflection of the endyma upon the plexuses, and the dorsal limitation of the porta, are of comparatively slight importance; but their morphological significance is, at least in some cases, inversely to their functional activity, and they cannot be ignored without endangering the success of any attempt to understand or explain the structure of the brain.

Anatomical figures should be something more than pictures conveying a general and vague idea. Where is there an adequate representation of the relation of the diatela to the habenæ, and of the cephalic end of the latter? From the published figures could any student be expected to comprehend the locations and boundaries of the "foramina of Monro" or of "Magendie?" The tenia is easily enough shown as a white band throughout most of its course, but where are its extremities accurately delineated? Anyone can see the caudate prolongation of the striatum, but representations of its termination at the tip of the medicornu are as rare as are figures of the extremity of the filum terminale. Even so considerable a part as the flocculus is seldom figured in such a way as to display either its form or its attachment.

The avoidance of the morphological incongruities and deficiencies which are to be detected in nearly every portrayal of encephalic anatomy demands the admission of three propositions, which are mere truisms in themselves, but radical affirmations when contrasted with their almost universal non-recognition in anatomical works:

1. Every part, organ, membrane,* or surface is either limited or continuous with some other part. If limited, its limits must be defined; if not, its extension must be indicated.

2. Every cavity is either open or closed. If closed, the continuity of its parietes must be demonstrated; if open, its communications must be shown.

3. Every elongated part has a middle and two extremities; not only the former but the latter must be represented.

§ 50. Figures—original ones especially—should be multiplied and descriptions reduced. In descriptive anatomy, whether human or comparative, the text should be subordinate to the illustrations. Some treatises (Charles Bell, Meckel, Milne-Edwards, etc.) seem to have been prepared upon the idea that the description is essential and the figures merely supplementary; on the contrary, words should be employed only when pictures will not suffice—that is, for explanation, commentary, generalization, hypothesis, and manipulative directions.

The arguments for the multiplication of figures may be summarized as follows:

1. A figure is usually a guarantee that something like the object represented has been seen, at least by the artist, and that a certain amount of time has been devoted to its contemplation.

2. The information conveyed by a figure is more real, and likely to be more lasting than that which is expressed in words. In respect to reality and impressiveness, the sources of knowledge may be ranked as follows, in an ascending scale: (1) Description; (2) picture; (3) model; (4) object seen; (5) object handled; (6) object personally prepared. The picture is thus intermediate in value between the thing itself and a description thereof.

3. A figure, if clear and properly placed, is more readily understood than a description, and a saving of time is thus effected. It may be easier for the author to write than to draw, or even than to supervise a drawing, but his personal inconvenience or loss of time should not outweigh the gain to his readers. This applies particularly to dictionaries, cyclopædias, and journals, which are commonly read or consulted in haste. Editors and publishers would find eventual profit in offering to authors the fullest encouragement to employ illustrations so far as possible, and curtail their descriptions in proportion. That it is rather the exception than the rule for such encouragement to be offered is probably due to several causes: *a*, Publishing houses have usually a staff of printers who must be employed, whereas the various processes involved in the making of pictures are commonly done outside at extra expense; *b*, authors too often content themselves with carelessly made copies of "stock figures" instead of insisting upon original representations of objects prepared by themselves. Hence, on the one hand, the exceptionally liberal publisher is liable to get a poor return for any allowance made for drawings, and, on the other, the exceptionally painstaking author is apt to be told that, at best, the engraving will be done if he will furnish the drawings; and, if he cannot draw himself, their cost is likely to deter him from their introduction.† In short, all the existing conditions work to the disadvantage of the reader, who gets but a "pennyworth of [pictorial] bread to a monstrous deal of [verbal] sack."

Before this state of things can be amended the au-

* Every student of any branch of Natural History should compel himself to learn to draw, however slight may be his inherited artistic capacity; not merely the laboratory students in Cornell University, but the members of the large general classes in Physiology and Zoölogy are required to make drawings of entire animals, and of the parts exposed in their dissections.

† The treatment of this subject is based upon the writer's "Cartwright Lecture," III., as reported, with illustrations, in the *N. Y. Medical Journal*, June 14 and August 2, 1884.

* So essential is the exemplification of cœlian circumscription and endymal continuity, that the endyma should be represented by a distinct and rather heavy line, continuous excepting at the metapore; see Vol. VIII., Fig. 4711.

† The liberal provision of the publishers of the REFERENCE HANDBOOK for original illustrations of the writer's articles in Vol. VIII. has been acknowledged therein on p. 107; they have since manifested what might almost be called an unbusiness-like generosity in furnishing the writer with electrotypes of many of the cuts for the use of his students.

thors of books and papers must see clearly the importance of illustration; to paraphrase a witty saying as to the making of an index, the drawings should be made or personally superintended by the author, even if some one else has to write the text.

4. Figures usually occupy less space than descriptions conveying an equal amount of information. This means condensation, convenience, and economy in the present, and a due consideration for our successors in the not far distant future. Exact data are not accessible, but no thoughtful and public-spirited person (unless he be a publisher or printer) can contemplate without concern the logical results of the present rate of book-making activity.

§ 51. Borrowed figures should be fully credited, and all modifications, whether of size or features, explicitly stated. To copy is to compliment, but unacknowledged copying is theft, and unspecified change is misrepresentation.

The ill-effects of omitting to state the source of a figure are two: 1, The originator loses credit to which he is justly entitled; 2, the reader may be seriously misled by the apparent duplication of some really unique feature or the confirmation of an error. For example, in the representations of the meson of the cat's brain by Leuret (Leuret et Gratiolet, Pl. V., Fig. 2), the pseudocœle ("fifth ventricle") is made even more extensive than in man, reaching almost to the splenium. The figure is reproduced, without credit or correction, in Mivart's "The Cat" (Fig. 129). Whoever remarks the coincidence in respect to the pseudocœle, but fails to note that one figure is simply a copy of the other, may naturally infer that the feature in question is normal, or at least not anomalous.

On the other hand, if informed that three of Mivart's figures (125, 126, 129) were copied from Leuret, the student might conclude that the representation of the base of the brain (Fig. 128) was derived from the same source; this would be most injurious to the reputation of Leuret, for the figure in question displays several features (the size and direction of the hypophysis, the disconnected fissure on the temporal lobe, the relations of the pons to the trigeminus and abducens nerves) which it is safe to say never were observed in a feline brain.

Nor is it enough to give the sources of figures in a list, or in the preface, as in Huxley's "Vertebrated Animals;" so great is the labor of preparing an original figure that the acknowledgement of it should be equally as explicit as that of a verbal quotation.

Finally, in the case of modified figures, it needs but a moment's reflection to see that nothing short of an accurate statement of the nature and extent of the alteration can insure full justice to the originator.

§ 52. Drawings should be made as notes. In many cases an outline* drawing, even if hastily made, would convey to the maker, or any one else, at a future time more prompt and complete information than could be embodied in writing covering the same space. But the general employment of sketches, in addition to words, or in place of them, can hardly be looked for until children are taught to draw the intelligible objects about them before they are drilled in the making of the—to them—unmeaning pot-hooks of the alphabet.

§ 53. Figures should be more frequently employed in preliminary or incomplete publication. Probably one of the reasons for the comparative infrequency of pictorial representations of normal, abnormal, and pathological structures, especially in journals, is the difficulty, often the impossibility, of preparing a detailed figure in time for publication. But this need not prevent the early appearance of a figure, if only in outline, illustrating one or more points of greatest importance.

§ 54. Figures should be based upon photographs. Photography enables the anatomist to (*a*) record the appearances of perishable specimens, or of such as are in course of dissection; (*b*) insure the proper perspective; (*c*) save time and labor upon the part of the draughtsman, and thus either reduce the cost of the drawings or render a larger number attainable.

It is seldom that a single anatomical preparation is so perfect as to display all that is needed, and yet present no superfluous parts; often, too, certain points are to be brought out with "diagrammatic clearness," others being subordinated or omitted altogether. Hence, as a rule, the photograph forms rather the basis for the completed figure, and two or more similar preparations may be required for the elucidation of all the desired features.*

§ 55. Figures should be placed so as to be most readily understood and instructively compared. In comparing pictures of two or more houses, ships, or stoves, the architect, shipbuilder, or dealer places them in such positions with regard to one another and his own eyes as may minimize the effort at mental transposition. If asked the principle on which he acts, he will probably say that no principle is needed, that he simply follows nature, experience, and common sense.

With few exceptions it seems to be reserved for those whose business is the contemplation of natural objects, who are credited with more than the average degree of intelligence, and who have at command the recorded experience of centuries, to disregard a matter whose simplicity is equalled only by its importance. In most works there is an utter absence of system. Seldom, indeed, are symmetrical figures placed otherwise than with the meson coinciding with that of the observer, but even this would be less likely to confuse than the apposition of transections of a subcylindrical mass like the myel with the dorsum above in one case and below in another.†

The prevalent carelessness in this regard may be ascribed to three sources: *a*, The still too common idea that illustrations are of secondary importance; *b*, the fact that most figures have been copied and thus placed without regularity, as in the original; *c*, some time and trouble are required to reverse them.

§ 56. *General Rules for the Placing of Figures.*—These rules are based upon a consideration of the whole subject; there is probably no one of them to which exceptions may not exist; but such exceptions should always have a well-defined reason and not occur through inadvertence.

1. Figures should be coadjusted so as to facilitate comparison with each other and with typical structures in normal positions.

2. The dorsal side should be above.

3. Direct views are to be preferred to oblique, though the latter are at times indispensable; *e.g.*, Vol. VIII., Figs. 4740, 4776.

4. Symmetrical figures, or parts thereof, should be so placed that the meson is vertical, *e.g.*, Figs. 4688, 4689, 4698, 4770, 4772.

5. When there is no choice between the right and left sides, the latter should be represented; *e.g.*, Figs. 4767, 4713.

6. Of medisected organs, unless there is special reason for choice, the mesal aspect of the right half is to be shown; *e.g.*, Figs. 4684, 4711.‡

* There is a general and almost unconquerable predilection for shaded drawings. However advantageous shading may be in ordinary art as an element of finished pictures, and when merely a general effect is desired, in anatomical figures correct outlines are essential, and shading should be deferred until the last; otherwise it is too apt to "cover a multitude" of inaccuracies.

* A chief obstacle to the employment of photographs as a basis for figures of brains and embryos has been the difficulty of supporting such delicate objects within range of the camera in its usual horizontal, or nearly horizontal, position. This obstacle is wholly removed by the photographic table devised by Professor Gage and used in the Anatomical Laboratory of Cornell University since 1873. With this the camera may be readily adjusted to any angle, and brought into a vertical position so as to cover an object lying upon cotton, or in alcohol, or even alive in water. The apparatus is described and figured in *Science*, April 11, 1884.

† The common disregard of uniformity in this respect was made the subject of a communication by a medical professor to the Association of American Anatomists at its meeting in December, 1892.

‡ If the fuller discussion of this subject in the *New York Medical Journal*, August 2, 1884, be consulted, the following corrections should be made:

Explanation of Fig. 57, last line, transpose *antimesal* and *symmesal*.
Fig. 59, for *antimesal* read *symmesal*.
Fig. 64, for *symmesal* read *antimesal*.

§ 57. *Designation of Parts upon Figures.*—The full technical names of parts should be given if possible.* From the purely artistic point of view, of course, any extraneous line upon a picture is a disfigurement. But if it be once admitted that the primary object of an anatomical drawing is to convey accurate information, then, unless the shaded figure can be duplicated in an outline (as in Tiedemann, Vicq d'Azyr and Dalton), there should be no sacrifice of the essential to the accessory.

It may be a question whether the names should be upon the parts (as in Gray) or at the sides of the figure, and connected with the parts by lines (Gegenbaur). Upon the whole the latter method seems preferable, especially if the technical names are used.

§ 58. Abbreviations should represent technical terms; they should be uniform throughout the work, and be placed at the sides of the figure.

Four methods of designating parts by abbreviations have been employed: 1, By numbers and unsignificant and ununiform letters, which may or may not be explained in the text (Owen); 2, by unsignificant characters, uniform only in part, and explained at a distance from the figure (Reichert); 3, by uniform and significant, but partly vernacular, abbreviations (Parker); 4, by uniform technical abbreviations ("Anatomical Technology").

The advantages of uniformity in the use of abbreviations are obvious, but it is by no means easy to avoid the charge of ambiguity. Where uniformity is not attempted, care should at least be taken to avoid the use of the same abbreviation for the names of parts which are liable to be taken for one another. For example, in Schwalbe's two representations of the lateral aspect of the crura and adjacent parts (Figs. 280, 281) not only are opposite sides shown for no good reason, with some differences of detail which are puzzling rather than instructive, not only is the pons designated in one by *p* and in the other by *po*, and the tractus opticus by *to* in one and *tr.o* in the other, but the letters *tp* stand for the *tænia pontis* in Fig. 280, and in Fig. 281 for the *tractus pedunculari transversus* [cimbia]. Since these parts are similar in general appearance and direction, and only one appears in each figure, it is doubtful whether any but the most expert anatomist, thoroughly familar with this somewhat obscure region, could escape at least a temporary misapprehension.

§ 59. Abbreviations should be explained in alphabetical order. The "practical" business man would exclaim, "Of course, how else should they be?" An "unscientific" child would adopt the alphabetical order with letters as he would the order of notation with numbers. But the super-scientific writer, especially if he be a German, scruples not to save a few moments of his own time at the expense of others, by giving the verbal equivalents of ten (Huxley, Fig. 19), fifteen (Balfour, ii., Fig. 271), twenty (Quain, Fig. 263), twenty-five (Schwalbe, Fig. 279), or even forty (Meynert [Stricker], Fig. 253) abbreviations, either in no recognizable order at all, or as they occur upon the figure.† The time wasted by each consulter of the figure (not to mention the effect of just indignation) would nearly equal what it would have cost the author to place the abbreviations in alphabetical sequence. *Burt G. Wilder.*

BRAIN, TUMORS OF THE. The article on tumors of the brain published in Vol. I. of the REFERENCE HANDBOOK was completed on the very eve of an important epoch. It was in 1884, and this same year an English surgeon, Mr. Godlee, performed the daring feat of opening the cranial cavity of a man affected with a tumor of the brain, and removing the neoplasm. The patient died at the end of a month; nevertheless he survived the immediate effects of the operation, and was also relieved of the headache, vomiting, and epileptic convulsions which had been the most distressing symptoms of his disease (see Case 1 of table).

Between this date, November 25, 1884, and the present writing, January, 1893, the operation of trephining for brain tumor has been performed eighty-five times. These cases have been arranged in chronological order in the table commencing on next page:*

The intellectual, philosophic, and even romantic interest attaching to the operations for brain tumors much exceeds their actual practical importance. The attempt has been made to estimate this from analysis, not only of the operations which have been performed, but also of the fatal cases of brain tumors on record, not operated, but submitted to post-mortem examination. The latter has shown that a very large proportion would have been inoperable, either because a local diagnosis could not have been made, or because the locality, though diagnosed, was inaccessible; or because the tumors were multiple or malignant; or, finally, because they were too large for extirpation. The last objection can often be met by the observation that an early operation might have proved successful, though by delay the tumor had grown beyond the bounds of surgical possibilities. This observation, however, holds good for tumors in any part of the body.

Tubercular tumors—the most common variety by far in childhood—are frequently multiple, either at the time of operation or by recurrence shortly after; and are then, of course, unfavorable for operation. For extremely malignant tumors (carcinoma) the prognosis is naturally as hopeless when the growth is situated in the brain as when it exists in other organs. On the other hand, sarcomata, when primary, have not unfrequently been removed with success.†

A table quoted by Keen, in the article on "Brain Surgery," in this HANDBOOK, shows the relative proportion of different varieties of brain tumors in a total of five hundred and eighty cases collected by Hale White and Bernhardt. Nearly a quarter of all (twenty-three per cent.) were tubercular, only four per cent. were carcinomatous. In twenty-two per cent of the cases cited the nature of the tumor is not stated.

Hale White estimates that only nine of his one hundred cases could be considered as operable. No tumor, even the most benign, could be considered operable which is situated at the base of the brain, or in the cerebral axis (Starr), which is widely infiltrated, or which, as already noted, is multiple. Out of three hundred brain tumors in children collected by Starr, one-third were in the cerebral axis. Tumors of the cerebellum are fairly accessible, but operations upon them have proved very much more dangerous than operations upon the cerebrum. The space for operation is much narrower; precise localizing symptoms are much less distinct, and frequently fail altogether. On the other hand, the general symptoms are especially severe, owing to the excessive intracranial pressure; and this same condition endangers the operation by causing the brain to bulge through the opening. The close proximity of the affected part to the most vital organs of the cerebro-spinal axis renders shock imminent. The tumor is very frequently tubercular, and finally optic neuritis has nearly always reached an advanced stage before the operation is undertaken, so that when, by exception, the patient has survived the operation, he has remained blind.‡

* This need not preclude using, in place of Latin terms, the paronyms appropriate to the language in which the paper is written: *e.g.*, for *hippocampus*, *hippocamp* (Eng.), *Hippokamp* (Ger.), *hippocampe* (Fr.), or *hippocampo* (Ital.). See Vol. VIII., pp. 530-531.

† Almost equally objectionable is the omission of the original pagination in reprints from periodicals.

* Seventy-two cases were tabulated by Knapp more briefly in his monograph on intracranial tumors in 1890. The table given in the text necessarily includes Knapp's cases, but has been compiled from the original sources, and contains more details than are given by Knapp. Horsley mentioned two more cases, at the International Medical Congress, of which he gives no details. Keen has two more cases, as yet unpublished.

† In the case reported by Weir and Amidon the cerebral symptoms occurred after the patient had already been operated upon for sarcoma of the neck (Annals of Surgery, June, 1887).

‡ The symptom of choked disk, when present, has long been considered more nearly pathognomonic than any other of cerebral tumor. Segnin has, however, recently declared that many cases of enormous tumors do not present choked disk, and, on the other hand, this ocular lesion occurs in persons who have no intracranial disease. "Indeed, in my experience as regards tumors of the hemispheres, the rule is that the optic nerves are normal" (Bost. M. & S. Journal, February 5, 1891).

No. of case.	Operator, date, reference.	Sex and age.	Trauma or not.	Time between trauma and first symptoms or duration.	General symptoms.	Localizing symptoms.	Diagnosis.	Operation.	Situation and nature of tumor.	First result.	Final result.
1.	Bennett and Godlee (*Lancet*, Dec. 20, 1884).	Man, 25 years.	Blow on head.	One year.	Violent headache, diffused, for some months; severe monthly convulsions eighteen months after blow, ceased eighteen months before operation; double optic neuritis (vision normal); vomiting.	Paroxysmal twitching left side face and tongue, first symptom; aura on left side precedes general convulsion, this for two and one-half years; progressive paresis left arm, then twitchings left leg, then slight paresis left side face; paresis arm most marked at shoulder.	Tumor upper third fissure Rolando.	November 25, 1884. At first no tumor found: incision inch long into anterior central convolution.	Glioma, size of walnut, middle upper third right ascending convolution.	Temporary recovery; diminished headache, vomiting, convulsions; paresis increased.	Development hernia cerebri; then septic meningitis; death in one month.
2.	Macewen (*Lancet*, May 16, 1885).	Male, 35 years.	.....	.....	.....	Left hemiparesis; right facial paralysis.	.....	Trephined over right ascending frontal; mass removed.	Tubercular membranous mass.	.....	Recovery.
3.	Sciamanna (*Bull. d. R. Accad. Med. di Roma*, xi., 1885; Quoted by Knapp, "Intra-cranial Growths").	Male, 46 years.	Injury to head in right frontal parietal region.	....	Headache, vomiting, fainting, convulsions; slow pulse, somnolence.	Left hemiplegia; later, right oculo-motor and facial paralysis.	....	Trephined over seat of injury; nothing found.	Glioma right centrum ovale, from right inferior cornu to corpora quadrigemina.	.....	Death in two days.
4.	Hirschfelder and Morse (*Pacific Med. and Surg. Journal*, April, 1886).	Man, 71 years.	None.	.....	Dull, heavy pain, especially over occipital protuberance, vertigo; increased tendon reflexes; optic neuritis both eyes, most on left, failure of vision in last three months; occasional convulsions, vomiting, hiccup; totters on standing with closed eyes.	Jerkings left face, arm; then paresis left arm; drooping left side forehead, corner mouth; left leg stiff and lame; slight anæsthesia left trigeminus.	Tumor middle portion right post. centralis gyrus; pressure on parietal lobe (inferred from anæsthesia); posterior convol. also diagnosed, because face, arm, and leg all involved.	February 15, 1886. Tumor excised, 2½ c.c.	Soft infiltrating glioma middle portion right post. centralis gyrus.	....	Death on eighteenth day of septic encephalitis.
5.	Fraser (*Lancet*, February 27, 1884).	Man, 44 years.	Injury to head.	.....	Headache, vertigo, vomiting, stupidity.	Right hemiplegia, with contracture; indistinct speech, amnesic aphasia, agraphia.	Tumor of left ascending frontal convolution.	Trephined; nothing found.	Glioma left temporal lobe, involving ascending convolutions; second (?) tumor in middle right ascending parietal.	.....	Death.
6.	Durante (*Lancet*, Oct. 1, 1887).	Woman, 35 years.	None.	.....	Impaired memory; severe vomiting: movements uncertain: melancholia, taciturnity.	Anosmia one year: left eye displaced downward.	Tumor anterior lobe; paralysis olfactory nerve.	May, 1884. Dura here perforated by tumor; drainage-tube through opening made into ethmoid; enucleated.	Fibro-sarcoma occupied anterior fossa cranium; weighed 70 grms.	Stitches removed seventh day; drainage-tube fifteenth day.	Patient recovered promptly; still well four years after operation.
7.	Græme Hammond (*Medical News*, April 23, 1887).	Woman, 29 years.	.....	Illness, two and one-half years.	Début in sudden loss consciousness. At time of operation, double choked disk; exaggerated reflexes; four or five epileptic attacks; agonizing headache, anterior, on left side.	Convulsions limited to left side; paralysis left face; gradual paresis, then paralysis left arm; gradual paresis left leg.	Tumor cortical or subcortical at motor centres.	Operation; tumor not found.	Three cysts in a line in motor region of anterior central convolution, right side.	.....	Death in twenty-one hours.
8.	Weir ("Annals of Surgery," St. Louis, 1887, with Amidon).	Woman, 26 years.	Four previous operations for sarcoma, neck.	Two months duration symptoms.	Precipitate micturition and defecation; frontal headache: slight optic neuritis, left side.	Cramps left leg, paresis left knee; cramps and numbness left hand; narrowing left palpebral fissure; paralysis left upper arm; left patellar reflex exaggerated.	Tumor upper extremity Rolandic fissure, one inch from median line.	Trephining; no tumor found.	Sarcomatous tumor from lower surface left lobe cerebellum compressing medulla; originated in pia, extended into spinal canal 10 ctm.; not continuous with cerebellum.	Disappearance of headache and spasms; temporary recovery. Hernia cerebri which increased to size of hen's egg.	Death in ten weeks.

9.	Horsley (*Am. Journal Med. Sciences*, April, 1887).	Male, 20 years.	None.	.....	None described, except frequent headache.	Cramps left thumb and forefinger; clonic opposition twice daily for three months; then epileptic fits, always beginning with same clonic spasms; conjugate deviation head and eyes to left; left lower limb drawn up; paralysis left leg after a fit; reflexes exaggerated in left arm.	Tumor at thumb centre; *i.e.*, junction lower and middle thirds ascending parietal convolution.	Tumor removed with excision of surrounding tissue, June 21, 1886.	Tubercular nodule at junction lower and middle thirds ascending parietal convolution.	Second day, paresis left buccal branch facial; paralysis left arm; fifth day, left hemianæsthesia without analgesia; complete loss muscular sense; persistent exaggeration deep reflexes.	Complete recovery from epilepsy and paralysis.
10.	Horsley (*Brit. M. d. Jour.*, April 23, 1887).	Male, 38 years.	None.	... .	Epileptic convulsions; semi-comatose for ten days before operation.	Convulsions began in left shoulder, followed by left hemiplegia.	Tumor involving upper part of middle third of Rolandic region.	Tumor removed.	Infiltrating glioma, 4½ oz., from shoulder centre as diagnosed.	Return full consciousness; mental state, normal for three and one-half months; diminution paralysis; patient walking in two and one-half months; no fits.	Recurrence tumor in three months. Death in six months.
11.	Ibid.	Male, 37 years.	None.	.....	Constant headache.	Gradually increasing right hemiplegia; fits beginning in right forefinger; slight defect of speech; no fits for three months before operation.	Tumor in left motor cortex, involving hand centre, pressing on Broca's convolution.	Removed December 7, 1886.	Tumor, 4½ oz.; situated as diagnosed.	.....	No more headaches or convulsions; hemiplegia not cured, but progressed no further.
12.	Ibid.	Male, 18 years.	None.	.....	Headache, vomiting; optic neuritis; increasing weakness all limbs; epileptoid attacks; one year in bed.	Left arm and leg especially weak; in fit conjugate deviation head and eyes to right.	Tumor in right lobe of cerebellum.	Removed December 17, 1886.	Tubercular tumor; 7 drachms, as diagnosed.	Died in nineteen hours from shock; chronic general tuberculosis of viscera.	
13	Bennett May (*Lancet*, April 16, 1887).	Male, 7 years.	.....	.....	Frontal headache; vomiting; amblyopia; optic neuritis; nystagmus; abolition knee-jerks.	Gait reeling backward and to left.	Cerebellar tumor.	Removal tumor.	Tubercle size of pigeon's egg.	Shock.	Death.
14.	Suckling (*Lancet*, October 1, 1887).	Girl, 12 years.	.....	....	Headache, vomiting; dimness vision two years; diplopia for two weeks; vertigo; double optic neuritis; nystagmus; diminished knee-jerks.	For nine months right hemiparesis; paresis both external recti; dilated left pupil; intentional tremor right arm; staggering, tendency to fall forward; mouth to left; left conjunctival reflex lost; paralysis left eyelid; diminished faradaic contractility for all left side face.	Tumor left lobe cerebellum, growing down, compressing left facial and both sixth pair nerves.	Curved incision, convexity downward to base of left mastoid process; two trephine openings on line from occipital protuberance to tip of mastoid; cerebellum bulged; tumor inaccessible.	At post-mortem tumor found occupying all left lobe and much of middle lobe.	Shock.	Death in forty-eight hours.
15.	Birdsall and Weir (*Phil. Med. News*, 1887).	Male, 42 years.	None.	.....	Since 1885 vomiting; moderate headache; drowsiness; begioning neuro-retinitis; diplopia, transitory.	Unsteadiness gait; numbness right leg, hand, and shoulder; left lateral hemianopsia.	Tumor on mesial aspect right occipital lobe, involving primarily the cuneus, and perhaps paracentral lobule; locomotion impaired from pressure on tentorium.	March 9, 1887. Trephining one inch above occipital protuberance, one inch from median line; tumor too large for removal; incised, softened contents removed.	Sarcoma occupied tip of right occipital lobe.	Death from hemorrhage in a few hours.	
16.	Markoe (*Phil. Med. News*, November 5, 1887).	Man, 25 years.	Injury to head.	.....	Convulsions; dull headache.	Depression over left parietal.	....	Operation over depression; cyst removed containing brain substance.	Cyst hemorrhagic.	.....	Recovery.
17.	Macewen (*Lancet*, August 11, 1888).	Girl, 7 years.	No record.	.....	Convulsions.	Pain and spasms in right great toe. Paresis right leg.	.....	Removal tumor.	Tubercle size of hazel-nut from top of left ascending parietal; tubercles in meninges.	....	Recovery.
18.	Ibid.	Male, 22 years.	Injury to head.	... .	....	Paresis right arm; spasm tongue, face platysma.	....	Removal.	Cyst size of filbert removed from base of left ascending frontal.	....	Recovery.

No. of case.	Operator, date, reference.	Sex and age.	Trauma or not.	Time between trauma and first symptoms or duration.	General symptoms	Localizing symptoms.	Diagnosis.	Operation.	Situation and nature of tumor.	First result.	Final result.
19.	Macewen (*Lancet*, August 11, 1888).	Female, 25 years.	Syphilis.	.	....	Left hemiplegia.	..	Trephined over right parietal region; removed degenerated gumma.	Yellow mass over upper part right ascending convolutions.	.....	Recovery.
20.	Lucas Championnière (*Journal de Med. et de Chir.*, lix., 1888).	Male, 29 years.	.....	.....	.....	Right hemiplegia; aphasia.	.....	Trephined over left ascending frontal convolution; removed tumor.	Large hyperostosis.	Recovery: still partly paralyzed.	
21.	Rannie (*Brit. Med. Journal*, May 19, 1888).	Black woman, 35 years.	Syphilis, tertiary.	.....	Intense headache, eighteen months; buzzing in ears, visual hallucinations; gloomy dreams; alternated exaltation and depression; convulsions, June 1, 1887.	Pain and tenderness right frontal and parietal region; in fit left angle mouth retracted; conjugate deviation to left side; left upper extremity adducted: forearm flexed, wrist and fingers flexed; left leg extended stiffly, clonic convulsions left arm and face, then left hemiparesis face and limbs.	.....	Operation June 9, 1888, over right ascending frontal convolution: growth removed with piece of dura and brain-tissue.	Degenerating gumma.	Paresis remained, but steadily diminished; headache and fits ceased.	Recovery.
22.	Von Bergmann ("Surgical Diseases of Brain." Wood's Monographs).	Man, 25 years.	.....	.....	Epileptic attacks; headache; début with sudden apoplexy.	Right hemiplegia and contraction motor aphasia; loss of muscle sense.	Tumor in Rolandic region.	Chiselled piece of skull 7x7¼ ctm.; cyst evacuated, communicating with lateral ventricle.	.....	.....	Death in four weeks from meningitis.
23.	Seguin and Weir (*Am. Jour. Med. Sciences*, 1888).	Male, 39 years.	None.	.. ..	Memory impaired for two years; no optic neuritis; mental action slow but accurate; headache only recently.	Five years before operation spasm drawing right cheek and neck; epileptic attack three years later, preceded by twitching right forearm, hand; eight months before operation paresis right arm; speech thick and slow; paresis lower facial; slight anæsthesia right cheek; numbness over right arm.	Tumor, probably subcortical, in left hemisphere, involving centre for face and partly for arm.	Trephined, removed tumor.	Sarcoma size of large almond within white substance, one inch below posterior edge second frontal and anterior edge precentral gyri; *i.e.*, in fasciculus for face.	Temporary complete hemiplegia; nearly complete aphasia; eight weeks after operation epileptic attack began with twitching right side face; aphasia diminished then increased again.	Six months after operation in perfect health: slight hemiparesis right side; walk normal, knee-jerks normal both sides; sensibility normal: aphasia almost gone.
24.	Keen ("Trans. Am. Surg. Ass'n," vol. vi., 1888).	Male, 26 years.	Injury to head when three years old.	Twenty years.	General neuralgic pains, 1884: violent epilepsy twice weekly, 1885; severe pain in head; pulse 60°, irregular; anorexia; insomnia; two years before operation temporary blindness, first in right eye, then left; moderate headache; optic neuritis.	Painful scar on left side head; paralysis right arm, then right leg, then right face; right pupil dilated, insensitive; vision right eye imperfect; marked aphasia; in fit, right hand closes tightly, first finger, then thumb; right deviates upward and outward; paresis right internus right eye, and of left inferior and superior recti; paresis inferior fibres orbicularis on both sides; vision right eye much reduced: left, homonymous hemianopsia; clonic convulsions, chiefly in right limbs; slight paresis right hand.	Tumor pressing on anterior lobe, left hemisphere, involving third frontal convolution; fibroma. Operation December 15, 1887. Incision through tender scar; enucleated tumor from fossa behind squamous bone.	Fibroma presented at opening; extended from base third frontal convolution backward 2½ inches to fissure Rolando, upward into external part, first frontal internally to corpus striatum; weighed 3 oz.; measured 7¼ in. in circumference.	First week, increased aphasia; large clot found in wound; then disintegrated; then aphasia diminished. Second week, temperature, 104° F.; hernia; diarrhœa; abundant discharge cerebro-spinal fluid; temperature normal by third week.	.....	Recovery eighty-fourth day; mind clearer; paralysis gone; one epileptic attack in five weeks.

25.	Wille (*Allgem. Wiener M.d. Zeitung*. December 18, 1888).	Woman, 43 years.	. . . . .	. . . . .	Dementia; difficult deglutition; incontinence urine and fæces; disturbance speech; later, convulsions.	Swelling over left parietal bone. After incision, paresis right leg, right facial, right mon.	Tumor parietal lobe.	First operation, incised swelling; no pus; later necrosis bone trephined; subdural pus evacuated; no tumor found.	Tumor, size pigeon egg, in front part left paracentral lobule, extending into upper part ascending parietal convolution; second smaller tumor in middle of ascending parietal convolution, both gliomata.	Death.	
26.	Fitzgerald ("Sajous's Annuaire," Vol. II., 1888, p. 36).	Girl, 16 years.	....	.....	Convulsions.	Amaurosis right eye; partial paralysis (?).	....	Left temple trephined; contents of cyst evacuated.	Echinococcus.	.....	Recovery.
27.	Heath and Ross (*Lancet*, April 7, 1888).	Male, 20 years.	.. ..	....	Headache; optic neuritis.	Left hemispasm; left hemiparesis; tenderness of lower right ascending frontal.	....	Trephined over tender spot; large adherent growth found; could not be removed.	....	Relief of headache.	Recovery.
28.	Macewen (*Br. Med. Journal*, August 11, 1888).	Female.	... .	.. ..	Headache; dulness.	Orbital growth; nodule on skull half way between ascending frontal and anterior aspect; spasm right face and arm; myosis left pupil.	.....	Trephined over nodule; tumor durn one-half inch thick removed.	....	Recovery.	Died eight years later of nephritis.
29.	Pean (*Gazette des Hôpitaux*, Febrnary 21, 1889).	Man, 28 years.	.....	... .	Epileptic attacks six years, extremely frequent; temperature, 104° F.; night before operation thirty-seven attacks status epilepticus.	Painful spasm right great toe; stiffness right lower limb; tonic, then clonic convulsions same limb; extension these to arm and face; not always loss of consciousness.	Tumor motor centre right lower extremity.	Operation December 7, 1888. Trephined at upper part left ascending frontal and parietal convolutions; trephine just outside sagittal suture. Enucleated tumor without injury to brain.	Tumor at post. half of opening; grows from dura over left ascending convolutions; fibro-lipoma (Pean); endothelioma (Cornil).	Day after, only six fits.	Two months after operation no more attacks.
30.	Fischer (*Verhandl. d. deutsch Gesell. f. Chirurg.*, 18th Congress; also, "Annals Surgery," St. Louis, 1889).	Male, 37 years.	....	.....	Vertigo, convulsions.	Paresis, then paralysis right arm; diminished sensibility; paresis leg; slight aphasia.	.....	First operation nothing found: second, removed tumor piecemeal.	Sarcoma pressing on left central convolutions.	After first trephining, convulsion, headache ceased; paralysis less; aphasia increased after second operation; also recovery.	Death two months later from recurrence growth in dura.
31.	Pilcher and Dana ("Annals Surgery," St. Louis, 1889).	Man, 33 years.	Thrown from carriage, struck head, in 1882.	One year to first general symptoms	Irritable, childish; apathetic after one year: general convulsions, 1884, then petit mal; severe frontal headache; mental impairment; double optic neuritis; exaggerated reflexes.	In abortive attack, conjugate deviation head and eyes to left; tonic spasm right arm and leg.	....	Operation over seat of injury, angular gyrus; no tumor found.	Glioma in left occipital lobe, extends to tip of left frontal, reaches lateral ventricle, island of Reil softened. Cicatrix had misled.	Death from respiratory failure.	
32.	Wood and Agnew (*Univ. Med. Magazine*, April, 1889).	Man	... .	....	Vertigo, severe headache; loss mental power; optic neuritis; loss equilibrium.	Left hemianopsia.	....	Trephined over right cuneus; found and evacuated hemorrhagic cyst.	Tumor right temporo-sphenoidal lobe.	.....	Death from hemorrhage.
33.	Parker (*Brit. Med. Journal*, Nov. 30, 1889).	Man, 38 years.	.. ..	.....	Long-standing headache; mental dulness.	Total paralysis left arm: paresis left leg; puffy swelling of scalp over right parietal eminence.	.....	Trephining over swelling. Tumor removed with adherent dura. Suppuration on nineteenth day; hernia cerebri reduced by mechanical pressure.	Rounded gummous tumor size walnut under right parietal eminence.	Total hemiplegia one day after first operation. Ten days afterward, second for suppuration. Total loss headache.	Recovery on eighteenth day.
34.	Thomas ("Trans. Amer. Inst. Homeop.," 1889, p. 461).	Woman.	.....	.....	Headache; thick speech; no optic neuritis.	Spasm left hand; loss of consciousness; paresis left leg and face; paralysis and rigidity left arm.	... .	Removed tumor weighing 3 oz.	Middle Rolandic region, pressing on but not involving convolutions.	.....	Death in three days.
35.	Limont and Page (*Brit. Med. Journal*, Oct. 26. 1889).	Woman, 32 years.	Confinement.	Fourteen days.	Sudden unconsciousness; numerous convulsions.	Spasms right arm: speech affected.	.....	Portion large glioma removed (from lower part ascending frontal?)	.....	Temporary recovery.	Growth recurred.

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36.	Maunsell (*New Zealand Medical Journal*, 1889).	Man, 18 years.	.....	.....	Headache; vertigo; vomiting; reeling gait; blindness; anosmia; convulsions; dilatation pupils; incontinence urine and faeces; head and neck much swollen; eyes prominent; head retracted.	Staggering to right; convulsions begin with retraction head; involve right arm and leg.	....	Trephined over cerebellum; evacuated subtentorial cyst.	Cyst of cerebellum four inches long, two inches broad.	.....	Recovery, but blindness persists.
37.	Verco (Intercolonial Medical Congress, Australasia, 1889).	Boy, 11 years.	Fall from tree.	Eight months.	Pains in head; screaming at night from pain; tired sighing; three convulsions three weeks ago; occasional vomiting; incontinence urine and faeces; tenderness head; dimness vision; pupils dilated; sluggish; double optic neuritis; head very large, 24 inches in circumference.	Left palpebral fissure smaller; paresis left lower facial; hyperæsthesia right front chest; paresis left hand; slight bulging right temporal and anterior parietal region.	Hydatid cyst from size of head, unilateral bulging, and paresis.	Trephined over bulging region, 4½ inches above right meatus, 4½ inches behind angular process, 3½ inches from sagittal suture.	Cyst over area 4x2; adherent to temporo-sphenoidal lobe; central convolutions displaced upward.	Death from meningitis; temperature 104° Fahr.	
38.	Mercanton and Combe (*Revue Méd. de la Suisse*, Aug. 20, 1889).	Girl, 12 years.	Blow by teacher's ruler over nose and forehead.	Fifteen months.	Headache first symptom; diminished vision; in two years atrophy optic disks.	Jacksonian epilepsy right arm; no aura, no loss of consciousness; temporary paralysis arm after attack; later right face, then right leg involved, then aphasia after attacks; intentional tremor; rotation head to right, no deviation eyes, tender point near bregma to right of sagittal suture.	Tumor in middle left ascending frontal convolution, reaching superior third above, inferior third below, also to island Reil (from aphasia of transmissibilty).	No record.	.....	No record.	
39.	Kocher (*Brit. Med. Journal*, September, 1889, Correspondence from Berne).	.....	.....	....	Choked disk; amblyopia; headache; staggering.	....	Tumor of cerebellum.	Operation to relieve pressure; one opening posterior right side below tentorium, one anterior on left side; extreme tension dura; hernia cerebellum, removed with sharp spoon.	....	In four days congestion disks disappeared; no improvement of sight.	
40.	Keen (REFERENCE HANDBOOK MED. SCIENCES, Art. "Brain Surgery," 1889).	Boy, 4 years.	.. . .	....	Enlargement head; double optic neuritis; amblyopia.	None.	Tumor cerebellum pressing on straight sinus, causing internal hydrocephalus.	Tapping ventricles; trephined 1½ inch behind external auditory meatus (side not recorded), 1½ inch above Reid's base line; hollow needle and horsehair drain introduced; drainage fifty-two days; repeated probing brain; irrigation ventricles.	Tumor cerebellum, with density same as brain.	Diminution choked disks from day to day, but atrophy beginning.	Death fifty-two days after first operation.

41.	Keetley (*Lancet*, 1889, vol. ii., p. 593).	Child, 7 years.	Fall.	Fourteen days.	Giddiness; staggering; vomiting; knee-jerks exaggerated; attack of collapse, followed by subnormal temperature.	Slight internal strabismus left eye.	....	Exploratory operation through left squamous bone; nothing found.	Pons enlarged to three times natural size by infiltrating glioma; no inflammation or abscess; pons uniformly yellowish.	Insensibility; rigidity limbs, especially left arm; ptosis right upper eyelid; vomiting one-half pint black fluid; temperature 105.6° F.	Death in two days.
42.	Maudsley and Fitzgerald ("Trans. Intercol. Med. Congress, 1889").	Male, 28 years.	.....	.....	Headache; vomiting; vertigo, staggering; dim vision, blindness later; optic atrophy.	Awkwardness, left side; anosmia, left side; dilatation right pupil; slight paresis right facial; absence left knee-jerk; deafness left ear.	Tumor left lobe cerebellum compressing left facial and auditory nerves.	Trephined over left lobe cerebellum; solid nodule found, not removed; loss of much brain substance.	Solid nodule fixed to temporal bone.	Recovery, with persistent blindness and deafness.	
43.	Barton ("Ann. Surg.," St. Louis, 1889).	Woman, 30 years.	Syphilis; necrosis os frontis; abscess opened.	Symptoms brain pressure developed after operation on abscess.	Lethargy; confusion; anxiety.	Incomplete right hemiplegia; failure to find words for thoughts.	....	Trephined through necrosed bone; removed softening syphilitic gumma.	....	Immediate improvement in paralysis and speech.	Recurrence of drowsiness in three weeks; death in month, encephalitis.
44.	Lampiasi (*Wien. Med.*, May 19, 1889; from Knapp, loc. cit.).	Child, 2 years.	.....	.....	Convulsions; optic neuritis; exophthalmos.	....	.. ..	Trephining over cerebellum.	Tubercle size of egg in cerebellum.	Death in four days.	
45.	Horsley (*Brit. Med. Journal*, December 6, 1890). [Paper read at International Med. Congress, Berlin.] Ibid. (Three cases mentioned without details for record.)	No record.	None.	.....	Epileptic convulsions; attacks dyspnœa.	In fits, body rotated violently to left around central axis.	Tumor in middle lobe cerebellum.	Removed first one-half occipital bone; later, the other half.	.....	Abolition of dyspnœa, headache, and rotatory convulsion.	Life prolonged in comfort for two years.
46.	Knapp and Bradford (*Boston Med. and Surg. Journal*, April, 1890).	Male, 32 years.	....	.....	Vomiting three months in 1886; paresis both hands 1887, then convulsions; in 1888, headache; double optic neuritis.	Left hemiplegia and contraction left arm; exaggerated reflexes on left; operation advised, March, 1887; tactile left hemianæsthesia; loss muscular sense and paralysis left arm; paresis left leg; sensory aura in left wrist; clonic spasm left hand.	Tumor ascending frontal convolution below level first frontal sulcus, extending back and upward.	1889. Removed tumor; operation lasted fifty minutes.	Tubercle, 35¼ grms., middle right ascending frontal convolution.	Death from shock in three-quarters of an hour.	
47.	Springthorpe (*Austral. Med. Journal*, November 15, 1890).	Boy, 13 years.	Fall off five foot fence on right forehead.	Never well after fall; operation three years later	Severe headaches; gradual loss of sight; attacks vomiting; convulsions; vertigo; epistaxis; tottering gait; atrophy both optic disks; diminished knee-jerks.	Conjugate deviation head and eyes to right in fits; anæsthesia of formication in both hands; hearing right ear dull; falling toward right side and backward.	Cerebellar tumor.	Trephined over right lobe cerebellum: clear, serous fluid escaped; no tumor found.	At post-mortem, found glioma middle lobe cerebellum, with decomposing cavity in centre; numerous hemorrhages; all channels to lateral ventricles dilated; ventricles full of blood-stained fluid; cranial bones thinned; main pressure on right side.	Death.	
48.	Oppenheim (*Deutsch Med. Wochenschrift*, 1890).	Woman, 36 years.	.....	.....	Convulsions daily; headache; loss mental power; no choked disk; salivation; vomiting; six months pregnant.	Pain in right half of forehead; mouth drawn to right; paralysis left eyelid; total paralysis left arm; contracture; slight paresis left leg; sensibility blunted face and arm.	Cortical tumor lower part right ascending convolution.	Trephined; no pulsation; incised dura; anterior convolutions deep bluish red and swollen; opened into cyst; abundant serous fluid evacuated; no response to electricity over convolutions.	Glioma, with cystic degeneration.	Sensory and motor paralysis diminished next day.	Fairly complete recovery.

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49.	Graham (*Austral. Medical Gazette*, June, 1890).	Boy, 15 years.	Fall over rock, ten feet.	Unconscious two days; first symptoms five years later.	Severe frontal headache; giddiness; nausea; attack vomiting, four days; blindness; post. neuritic atrophy; attacks drowsiness, etc.; coma begins just before operation.	Amaurosis left eye; leans to right side in walking; paresis right leg; protrusion eyes.	.....	Trephined over upper portion fissure Rolando. Entered cyst, evacuated, removed by traction.	Hydatid cyst; pia intact; motor area depressed; cyst had grown from arachnoid; capacity cyst, 19 oz.	Seventh day began to take interest; vicissitudes till fourteenth day; thence steady improvement.	Recovery, but with blindness.
50.	Church (*N. American Practitioner*, 1890, p. 433).	Man, 38 years.	.....	.....	Apoplectic seizure; afterward convulsions; constant frontal headache.	Fits begin with pain and spasm in right index finger, then other fingers, wrist, elbow, shoulder invaded by pain and clonic spasm; then loss consciousness and general convulsions; pain and contraction persist in right hand.	.....	Trephined over arm centre on left side. Area brain equal to silver dollar of central and frontal gyres decorticated to depth one-quarter inch.	Spider-shaped new growth, with long filaments on surface of convolution.	Next day aphasia, right motory and sensory hemiplegia: then twitchings in limbs preceded restoration functions; rise of temperature; a month later small abscess at wound.	Recovery, but convulsions recurred in two months.
51.	Sokes (*Brit. Med. Journal*, 1890).	Man, 42 years.	....	.....	Coma at time of operation; absence choked disk; fixed headache and vomiting.	Tonic spasms left side, beginning in leg, invading trunk, arm, face; then paralysis in same order.	Tumor at leg and arm centres.	Trephined over these centres; found nothing: operation relieved pressure.	Small spindle-celled sarcoma in parietal lobe, behind leg centre; same consistency as brain, remote from arm centre, yet arm engaged.	Recovery consciousness, and diminution paralysis.	Death in three weeks.
52.	Beach (*Boston Med. and Surg. Journal*, April, 1890).	Man, 51 years.	.....	.....	Severe frontal and occipital headache; mental dulness; double optic neuritis.	Short attacks of aphasia, without agraphia or loss of consciousness; tremor right hand; permanent hesitancy speech; twitching right hand and right eyelid; then paresis extensors right hand.	Tumor anterior lobe, pressing on lower part central convolutions.	Trephined; nothing found.	Tumor found on supposed level, but behind motor area: posterior edge limited by post. ascending branch of Sylvian fissure; anterior by small sulcus: motor and frontal convolutions healthy; optic tracts compressed.	... ...	Death second day.
53.	Wyman (*Med. News*, February 8, 1890).	Young man.	....	... ...	Frontal headache a year; fever several weeks' duration; diminished vision; double choked disk; vomiting; epileptic attacks; great muscular weakness.	Divergent squint after convulsion; slight movement retation; anosmia.	Tumor in region of sella turcica.	Trephined frontal bone above supra-orbital ridge on right side; probe passed along orbital plate; nothing found.	Tumor 2½ inches long, contained in a cavity in left hemisphere cerebellum; all ventricles distended with fluid.	Death.	
54.	Clarke (*Lancet*, March 1, 1890).	Man, 47 years.	Syphilis	Thirty years before symptoms.	Severe headache left side; several weeks; convulsions; unconscious three hours, then repeatedly; exaggeration reflexes both sides.	Initial paralysis, then paresis right leg; ataxia of torsion in right leg, then leg forcibly flexed; hemispasm; paresis right arm; recurrent twitchings and numbness right limbs; face drawn to right in fits; speech affected afterward, then slight motor aphasia	....	Trephined over upper part fissure Rolando, close to mesial line of skull; dura opaque, no pulsation; dense subdural growth, one-half inch thick; partial removal on account of proximity to sinus.	Very chronic syphilitic neoplasm growing from dura and falx cerebri.	Twitchings in foot for two days, did not spread; abscess formed in wound.	Death from septicæmia on nineteenth day.
55.	Walker (*Brit. Med. Journal*, Aug. 23, 1890).	Boy, 14 years.	Fall against tree in coasting.	Eighteen months before admission: first symptoms in three weeks after accident.	Dizziness, then paresis hands; staggering; mental power failed with speech; vomiting.	Hesitation in speech, then aphasia; hemorrhage right ear and mouth; offensive discharge right ear; series spasms left side; complete left hemiplegia (not left-handed); contracture: exaggeration left tendon reflex; hemianopsia not tested.	Tumor with descending sclerosis.	Exploratory operation over left ascending frontal; negative result.	Cystic mass at left of sella turcica springing from apex petrous bone.	Death in few hours.	

56.	Dumin (*Neurol. Centralblatt*, August 15, 1890; quoted by Knapp, loc. cit.).	No record.	.....	.....	.....	Hemiplegia; aphasia; Jacksonian epilepsy.	....	Trephined; removed tumor.	Tumor of anterior central convolution.	Recovery.	Sudden death four months after operation.
57.	Bremer and Carson (*Am. Jour. Med. Sciences*, September, 1890).	Male, 23 years.	.....	.....	Morning vomiting; peculiar gait; beginning choked disk; absence mental initiative.	Spasm left arm and neck; temporary aphasia; left hemiparesis with contraction in left foot; contractions platysma always begin spasm.	Cerebral tumor; slow growth in or beneath Rolandic region near centres for wrist and platysma.	Trephined over right fissure Rolando; tumor removed.	Cavernous angioma.	.....	Recovery.
58.	Kerr (*Occident. Med. Times*, 1890; from Knapp).	Male, 35 years.	Injury to head.	.....	... .	Right hemiparesis and spasm; scar over upper part fissure Rolando.	.....	Trephined over scar; nothing found.	Glioma left corpus striatum and optic thalamus.	.....	Death.
59.	Eskridge (from Knapp).	Female, 32 years.	.....	.....	Loss of strength, memory, mental power; headache.	Right hemiparesis, then hemiplegia.	....	Trephined, Feb. 25, 1890; tumor too large for removal.	Glioma, 3¾ x 4 in., in left frontal lobe, reaching beyond fissure Rolando.	.....	Death in eight days.
60.	Doyen (Congrès Français de Chirurgie, 1891).	Boy, 16 years.	.....	Symptoms seven years before operation.	Torpor of intelligence, gradually deepening to imbecility; vertigo, absences; epileptic attacks of increasing severity.	Left hemiparesis; diminution visual field on right side, then blindness and optic neuritis on this side; bulging right squamous bone.	Tumor of meninges or brain behind bulging bone compressing central convolutions.	Operation November 5, 1889, over bulging bone; very large cyst found; opened; drained.	Congenital serous cyst in locality diagnosed.	Drain withdrawn second day because causing bleeding; replaced sixth day, 360 c.c. albuminous liquid evacuated; then every three or four days till 50 c.c. left; permanent drain in six weeks; cure in two months.	Entire recovery; "marvellous expansion of intelligence;" disappearance of paralysis.
61.	Blocq and Reymer (Congrès Français de Chirurgie, 1891).	Boy, 10½ years.	.....	First symptoms five years before operation.	Crises, beginning at five years in prickling of facial mucous surfaces and increased secretion from conjunctiva, nose, and mouth; at eight years, falls: at nine, convulsive attacks, growing more intense; intelligence intact.	Attacks five to six times a day; mouth dragged to right, associated with prickling sensation at mouth and tongue: deviation tongue on right side, and bitten on right side; eyes fixed; head turned to right, then loss consciousness; right arm raised in flexion and adduction, then leg, then general convulsion after attack; right hemianæsthesia; temporary paralysis right arm.	Partial sensitivo-motrice epilepsy; neoplasm at inferior and middle third central convolutions.	Operation, August 19, 1890. Localization according to Poirier; cyst found extending toward frontal convolutions; wall excised; drainage. Second operation, removed cyst, volume of large walnut, December 13th.	.....	Attacks returned in sixteen days; after second operation patient well for six days, then attack followed by aphasia for two hours.	Recovery; no further attacks three and one-half months after operation.
62.	McCall Anderson (*Brit. Med. Journal*, 1891).	Boy, 16 years.	....	Four and one-half years before admission.	Sudden epileptic attack; second fit eighteen months ago, then others; at first arrested by bromides, then eighty-nine attacks in ten weeks; double optic neuritis; increased excretion earthy phosphates.	Exaggerated reflexes wrist and knee on left side; slight left facial paralysis; numbness and pain left thumb and index; acute pain above right ear, tenderness two inches behind; paresis left arm and leg.	Tumor at Horsley's thumb centre, junction middle lower third right parietal convolution.	Trephined just behind line for Rolandic fissure, three inches from upper extremity; at first found nothing; second trephine higher up; then brain substance bulged at first opening; tumor size of plum rolled out.	....	No epileptic attack for eight weeks; still some spastic contraction muscles fingers, wrist, elbow, but power to move arm.	Perfect recovery.
63.	Seguin (*Boston Med. and Surg. Journal*, February, 1891; from Knapp).	.....	.....	.....	No record.	....	Tumor under motor centre for left leg.	Trephined; nothing found.	Glioma, one-half inch in diameter, found at autopsy at point diagnosed in medullary substance below cortex; same consistency as brain.	....	Death.
64.	Bullard and Bradford (*Boston Med. and Surg. Journal*, April 30, 1891).	Female, 6½ years.	....	.....	Vomiting; vertigo; staggering; weakness all four limbs; incoördination; blindness; optic neuritis; headache.	.....	.....	Trephined over tornia; opening made into sinus.	Cheesy tubercle in cerebellum.	.....	Death from hemorrhage.

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65.	Knapp and Bradford (Case xxix. of "Essay," 1891).	Male, 28 years.	.....	.....	Headache; vomiting; optic neuritis; blindness; paræsthesia mouth and hands; deafness; anosmia.	Tenderness in right temporal region; absence left knee-jerk; slight paresis left hand.	....	Trephined over tender spot; nothing found; operation only to relieve intracranial pressure.	Tumor involving left lateral lobe of cerebellum.	Relief from headache; cerebral hernia; left hemiplegia and left anæsthesia.	Death from encephalitis about ten weeks later.
66.	Mills and Keen (*Amer. Journal Med. Sciences*, 1891).	Female, 27 years.	First symptoms ten years before admission.	.....	No optic neuritis; no general symptoms.	Left hemiparæsthesia for few moments; attacks at intervals weeks or months; in four years complicated by spasm left limbs, then passing to right; most marked in arm; prickling sensation left arm; cry; extension left arm, this leg; head twists to right.	.....	Trephined 1.75 inch to right of median line, in line of fissure Rolando; cranial index = 0.75; tumor removed.	Small growth, originating in pia, had bored through dura and formed nest in skull. one-sixteenth inch in front of trephine; Faradisation just behind fissure elevated shoulder; above opening Faradisation gave same, also flexion leg and thigh; growth looked like hypertrophied Pacchionian body, but proved sarcoma.	Movement left shoulder paralyzed; all paralysis disappeared on thirty-third day, though limbs weak.	Same attacks continued, but less severe.
67.	Koehler and Oppenheimer (*Berlin klin. Wochen.*, 1891).	Woman, 36 years.	Attack apoplexy one year before admission.	.....	Epileptic attacks; loss of memory; irritability; headache; vertigo; no optic neuritis.	Incomplete left paresis; then paralysis left arm; paresis left leg; knee-jerk exaggerated on left side; attack begins with drawing mouth to left; drawing in left arm, thumb, and index; then clonic convulsion arm; paralysis left half face.	Lesion right motor zone.	Operation while patient six months pregnant: trephined over lower part right parietal convolutions; dura did not pulsate; no reaction to electricity; swollen convolution over cyst; evacuated, anterior part removed.	Cyst size of hen's egg; cystic degenerated sarcoma.	Headache ceased; paralysis left facial; paresis left leg disappeared; arm recovered; normal delivery. At autopsy several months later softened tumor found size of apple in cortex and medullary substance of lower part central convolutions; interstitial encephalitis.	Typical epileptic attack four months after. Death.
68.	Keen (*Amer. Journal Medical Sciences*, Sept., 1891).	Man, 56 years.	Injury to head.	Eighteen years; first symptoms two years before admission.	Headache; nausea; vertigo; diminished vision; vomiting attacks; double optic neuritis.	Aphasia; right lateral hemianopsia; lesion left side brain; right hemiparesis; apraxia.	Tumor parieto-occipital lobe in angular gyrus, with pressure on left cuneus.	Trephined 1.3 ctm. behind parieto-occipital fissure, 3.2 ctm. to left of median line; dura bulged; no pulsation; no response to Faradic current; elastic hard body 6.3 ctm. below surface; some pieces removed.	Tumor size of filbert, 5 ctm. from end of occipital lobe, 2.5 ctm. from median line; angular gyrus removed at operation; infiltrating glioma.	.....	Death in fourteen hours.
69.	Castro ("Ann. Surgery," St. Louis, 1891).	Boy, 14 years.	Five months.	.....	Headache; vomiting.	Atrophy right leg and arm; reflexes exaggerated on left; pain on left side head.	.....	Trephined over fissure Rolando; removed tumor.	Blackish tumor size of walnut.	Bulging wound on seventh day; on twelfth day cicatrix opened; cyst, 7 ctm. ejected.	Death, from diphtheria of wound.
70.	Poirier (*Rev. de Chir.*, 1892).	Man, 32 years.	.....	Epileptic attacks twelve years, every fortnight.	....	Jacksonian epilepsy.	.....	Removal tumor through hole made by mallet and chisel.	Tumor; central gyri vascular.	.....	Recovery; freedom from attacks.
71.	Booth and Curtis (Neurological Society, New York, December 6, 1892).	....	.....	.....	General epileptic convulsions; marked psychic changes; choked disk, bilateral.	Anosmia on left side; bone eroded at angular process left frontal bone.	.....	Trephined over eroded bone; tumor removed.	Tumor, tuberculous.	.....	Recovery.

72.	Llobet (*Revue de Chirurgie*, December, 1892).	Boy, 13 years.	.....	Two yrs.; headache.	Headache violent: abolition intelligence and memory; crying and anger; exaggerated patellar reflexes; pulse slow; respiration slow and irregular.	Jacksonian epilepsy two months after headache; total hemiplegia right side; contracture in flexion forearm and fingers; right leg in flexion; foot in equinus varus; diminution vision right eye; mydriasis.	Tumor in psychomotor centre left hemisphere.	Resection temporal bone: flap 8x10 ctm.; no pulsation brain; fluctuation; evacuated 260 grms. fluid; extracted cyst.	Hydatid cyst.	Disappearance headache, epilepsy, hemiplegia, contracture, aphasia; reflexes became normal, also pulse and respiration.	Recovery, but memory not returned in three months.
73.	Nelson Dobson (*Lancet*, May 14, 1892).	Girl, 18 years.	.....	Ten weeks.	Cerebral vomiting; pain in forehead; blindness six weeks; intense double optic neuritis.	Twitching attacks in left arm, beginning in thumb and first finger; sensory aura in same parts.	.....	Trephined over Rolandio fissure; nothing found.	Multiple cerebral tubercles in right hemisphere; disseminated tuberculosis.	Hernia cerebri.	Death in a month.
74.	Hitzig (*Berlin. klin. Wochenschrift*, July 18, 1892).	Man, 29 years.	Blow on head.	.....	Headache; incipient dementia. choked disk; narrowed visual fields; paresis both legs; exaggerated both patella reflexes; mental symptoms preceded motor.	Paresis left hand in repeated attacks; diminished vision of right eye; paresis left facial; head inclined to left; paresis left arm; swelling soft tissues; over right temporal region of head, tenderness.	Tumor posterior part frontal lobe, adjacent to middle and lower part ascending frontal convolution on right side.	Trepanned at point indicated; high grade hyperostosis; skull one centimetre thick; tumor found; opening enlarged to 16 ctm. long and 9 ctm. broad; successful removal.	Tumor, 280 grms., equal to weight of half a hemisphere; sarcoma.	Facial paresis and deviation tongue persist; paralysis arm increased.	Recovery.
75.	Ibid.	Man, 46 years.	Blow on right side head.	Eighteen months before admission; first symptoms in ten days after blow.	Consciousness intact; no general symptoms; paresis both lower extremities; increase patellar reflexes.	Paresis index finger, then thumb and middle finger; later, convulsion left side, then paralysis hand, arm; paresis left facial, left vocal cord; tongue pushed to left; ankle-clonus left side.	.....	Trephining discovered cyst size of goose egg, proved to be an encapsulated cysto-sarcoma; removed in second operation.	.....	....	Recovery.
76.	Von Brammann (*Wien. Med. Wochens.*, 1892).	No record.	Fall on head.	Eighteen months previous to admission.	....	Paresis three fingers left hand, arm, and left half face; twitchings.	Tumor at fissure Rolando.	Trephined; bluish cystic tumor perceived through dura; 30 grms. clear serum withdrawn; drainage.	Round-celled sarcoma.	Recovery after first operation; recurrence in three weeks; second and third operation; at last tumor removed.	Recovery persists three months after operations.
77.	Ibid.	No record.	Blow on head in former years	.....	Persistent headache; diminished vision; diminished mental power.	Sudden weakness in left hand; gradual paralysis left arm and left face; neuritis left eye.	Tumor Rolandic area.	Trephined; tumor extirpated; temporary collapse.	Spindle-cell sarcoma; small cyst.	.....	Recovery.
78.	Nixon (*Med. Press and Circular*, 1892).	Man, 28 years.	History of syphilis.	....	Giddiness; vomiting; amnesia; defective vision; intense headache; double optic neuritis; dulness; paresis sphincters. (These symptoms all sudden.)	Left hemiplegia; suppurating sebaceous cyst; exposed bone over right parietal eminence.	.....	Operation over exposed bone; neoplasm incompletely removed.	Hard cartilaginous neoplasm adherent to superior longitudinal sinus.	Marked improvement; disappearance pain, paralysis, and sphincter paralysis.	Death fifth week, from secondary hemorrhage from wound.
79.	Clegg (*Liverpool Med. Chir. Journal*, 1892).	Man, 31 years.	... .	.....	Exophthalmos, double optic neuritis: severe amblyopia; convulsion after temporary aphasia.	Aphasia and right hemiplegia; temperature one degree higher on left side: eye suppurates; after first operation epileptic attacks, beginning in right side face, right arm; rarely right leg.	.....	Eyeball removed; inside, spindle-cell sarcoma surrounding optic nerve; second operation three months later; trephined over speech area; no tumor discovered; threatened collapse.	.....	Jacksonian epilepsy continued; temporary recovery after second operation.	Return of pain and attacks in four months.
80.	Twynam (*Australasian Medical Gazette*, May, 1892).	Man.	Fall on buttocks.	Six weeks.	Giddiness five minutes after fall; headache in six weeks.	Paresis left hand and leg; some loss sensation; pain in right temporo-frontal region.	....	Trephine over upper part right ascending parietal; no bulging, but after needle ʒij. straw-colored fluid; no tumor found.	Tumor occupying whole medullary centre right parietal lobe, 68 by 57 mm.; extends from Rolandic fissure to parieto-occipital, bulging into roof lateral ventricle.	Bronchitic râles; death on fourth day.	

Case No.	Operator, date, reference.	Sex and age.	Trauma or not.	Time between trauma and first symptoms or duration.	General symptoms.	Localizing symptoms.	Diagnosis.	Operation.	Situation and nature of trauma.	First result.	Final result.
81.	Starr and McBurney (New York Academy Medicine, January 5, 1893).	Man.	...	.....	Marked psychic symptoms; sluggish thought and speech; headache; double optic neuritis; no failure vision; motor symptoms developed later; exaggerated reflexes both sides.	Tenderness on percussion left side head; right side hemiparesis.	Tumor frontal lobe impinging on motor centres.	Trephined; removed very large glioma sarcoma. (Operation proposed eleven months before finally performed.)	.....	Shock; death in few hours.	
82.	Ibid.	Man.	...	.....	Optic neuritis; blindness; staggering; severe headache.	Exaggerated reflexes on right side; some right anæsthesia of face.	Tumor right lobe cerebellum.	Trephined with apex of flap on superior curved line; no tumor found.	Tumor in middle lobe cerebellum.	Relief from headache.	Death sudden in few days.
83.	Ibid.	Child, 12 years.	....	.....	Vomiting; headache; blindness; choked disk; staggering.	No local symptoms.	Tumor middle lobe cerebellum.	Trephined between curved lines; cystic tumor tapped; could not be removed.	Cysto-sarcoma middle lobe.	.....	Death in few days.
84.	Gray and Wyeth (*Brain*, 1892-93).	Man, 38 years.	.....	Symptoms one month before operation; hard growth in Scarpa's triangle.	Headache; insomnia; cremaster reflex sluggish on both sides; somnolence before operation.	Paralysis right leg; paresis right arm; *muscular sense greatly impaired*; other sensibility preserved; exaggeration right knee-jerks.	Tumor left centrum ovale (Subcortical, because no convulsion) beneath upper part ascending parietal convolution.	Operation November 14, 1890. Laid bare ascending frontal, ascending parietal convolution, one-half, bases 2d and 3d quarter of an inch beneath surface, at 1st and 2d parietal junction of upper and middle third; had been penetrated by exploring needle.	Round-celled sarcoma size of hickory nut in ascending parietal convolution, one-quarter of an inch beneath surface, at junction of upper and middle third; had been penetrated by exploring needle.	.....	Death third day after; temperature, 108° F. for an hour.
85.	Stieglitz & Garster (Neurolog. Soc., Jan., 1893).	.....	.....	.....	.....	Twitching, then paresis right arm; loss of muscular sense; alexia.	Tumor arm centre.	Opening over left Rolandic area; cyst evacuated.	.....	Recovery, but slight symptoms recurrence six months later.	

Out of the 300 cases of tumor in children, 96 were situated in the cerebellum. This single fact suffices to establish a relatively unfavorable prognosis for brain tumors in childhood.

In this same list were found 56 cases of tumor of the cortex and centrum ovale, localities favorable for operation; 16 of these, however, were not correctly diagnosed, therefore could not have been operated, even if the operation had been suggested.

Out of the 40 which remain, localizing diagnosis would have been impossible in 21, though the autopsy showed that in some of them an operation would have been possible. In 19 cases the tumors were in the central convolutions, or subjacent centrum ovale, and in 13 of these local spasm followed by paresis made the precise diagnosis sufficiently clear. In the remaining 6 the locality was established by the symptom hemianopsia. The author estimates, however, that in only 16 of these cases could an operation have been undertaken with much hope of success, and as 10 of these were tubercular, the number of cases where even this new and heroic remedy offered hope of complete recovery was reduced to 6 out of a total of 300.

The statistics for adults, as regards localization, differ somewhat from the above. A table of 649 cases, compiled from the cases of Ladame and Bernhardt, has already been given in the article on "Brain Tumor" in the main body of this HANDBOOK. It may be worth while to reproduce this table. The tumor was situated in the:

		Per cent.
Centrum ovale in	192 cases	= 29
Cerebellum in	162 "	= 27
Cortex in	74 "	= 11
Pons in	56 "	= 8
Basal ganglia in	26 "	= 5
Medulla in	30 "	= 4
Corpora quadrigemina in	13 "	= 2
Cerebral peduncle in	10 "	= 1
Extra cerebral in	71 "	= 11

This table can be compared with Starr's as follows:

Tumors situated in	Children.	All cases.
Cerebellum	96 cases = 32%	162 cases = 27%
Cortex and centrum ovale	56 " = 18%	266 " = 41%

Thus consideration of the prevailing situation of brain tumors alone, would seem to justify Bergmann's dictum,[1] that the field for successful operation is very narrow, the reverse of what can be now affirmed of trephining for brain abscess. On the other hand, examination of the 85 cases in which operations have been performed gives a more favorable view. At this date (January, 1893) there is a record of 39 successful operations against 46 unsuccessful cases, and one trephining to relieve intracranial pressure.[2] These have been performed in all parts of the world, even British Guiana having contributed a successful case in 1888 (Rannie, *British Medical Journal*, 1888). The following table summarizes these results. "Successful" implies that the tumor was found and removed, that the serious symptoms subsided and the patient lived more than two months, or even recovered completely. "Unsuccessful" refers, not only to the death of the patient from the immediate consequences of the operation, but also to the impossibility of completing this, either because the tumor was not found at the locality supposed, or proved too large or too deeply seated to be completely removed; finally to the speedy recurrence of the tumor so as to cause the death of the patient in a short time, notwithstanding the immediate success of the operation.

Successful		39
Unsuccessful:		
Tumor not found	20	
Tumor not removed	10	
Death from operation or speedy recurrence of neoplasm	16	46
		85

In 1888 Dr. Keen wrote (REFERENCE HANDBOOK, "Brain Surgery") that the percentage of mortality was thirty-five per cent. This calculation was based upon the 17 operations which had then been performed, with six recoveries, and included among them one case (Heath, *Lancet*, 1888, Case 27 of table), which we have placed among the unsuccessful cases, because, although the patient survived the operation and was relieved, the tumor was too large for removal. The percentage of successes (11 cases out of 17) was nearly sixty-five. To-day, the larger number of cases yields as successful about forty-six per cent., as failures, nearly fifty-four per cent. The less favorable result is not surprising, for the operation has been attempted under a much greater variety of circumstances, so that a greater number of unfavorable conditions have been encountered. For this reason the estimate of the operation has varied in the same way as did that for tracheotomy. This operation on its first suggestion excited unbounded enthusiasm, until experience showed how numerous conditions of failure were inherent in the disease for which the operation was performed, and which could not be overcome by any degree of perfection in its surgical technique.

The precision is surprising with which small tumors have sometimes been localized for removal. In Seguin and Weir's case (No. 24) the neoplasm was only the size of an almond, and lay an inch below the surface. In another case, however, reported by Seguin, a glioma one-half inch in diameter escaped detection. It was found at the autopsy at the locality diagnosed, under the motor centre for the left leg, but its consistency so resembled that of the brain tissue that it could not be differentiated (Case 63). The writer remarks that an operation may be undertaken too early on the brain—*i.e.*, before the tumor has grown sufficiently large to be appreciable, even although it may have occasioned pathognomonic symptoms.

In 19 other cases where the tumor was not found, the reason for the failure was quite different. In Keetley's case (41) the pons was found enlarged to three times its natural size by an infiltrating glioma. The only localizing symptom presented had been a slight internal strabismus of the left eye (paresis abducens). This fact should have suggested a pontine, and consequently inoperable tumor, as also the fact that the knee-jerks were exaggerated, while absence of paralysis, and existence of vomiting, giddiness, and staggering pointed to a tumor of the cerebellum.* With the latter, however, the knee-jerks are habitually diminished, and this special combination of negative and positive signs should suggest a lesion of the pons, in spite of the absence of many of its characteristic paralyses. The patient, a child of seven, who had had a fall fourteen days before the onset of the symptoms, had an attack of collapse followed by a subnormal temperature just before the operation, another circumstance pointing to the pons. An exploratory operation was made through the left squamous bone, but nothing found, and the child died two days later.

In Pilcher's case (31) there was a scar after an injury situated over the left angular gyrus, and the skull was trephined at this point. The patient had marked mental impairment, epileptic attacks, beginning in a conjugate deviation of head and eyes to the left, and tonic hemispasm on the right side. Shafer (*Brain*, April, 1888) claims that excitation of the brain near the angular gyrus produces conjugate deviations of the eyes to the opposite side. The centre for such deviation is placed by Horsley at the posterior extremity of the middle frontal gyrus; and the autopsy in this case would seem to confirm that localization. A glioma was found on the left side, in the occipital lobe, but extending forward as far as the frontal lobe. The island of Reil was softened. The mental impairment, taken together with the conjugate deviation of the eyes, pointed to the frontal lobes, where also the headache was situated. Nothing indicated the occipital lobe, and at the angular gyrus nothing was found. In Sciammana's case (3) also the patient was trephined, unsuccessfully, at the seat of an injury to the head in the right parietal region. The tumor was a glioma, lying in the right centrum ovale and extending from the right inferior cornu to the corpora quadrigemina. Crossed paralysis had existed, left hemiplegia, followed by right oculo-motor and facial paralysis. This is not explained by the autopsy.

Kerr's operation (58) is the third on the list misled by a scar. The indication was the more plausible because the scar was situated over the upper part of the left fissure of Rolando, in a patient suffering with hemispasm and hemiparesis. A glioma was found in the left corpus striatum and optic thalamus. This is the only case on the list where a tumor in this situation had simulated a cortical tumor.

In Knapp's second case (65), the trephine was applied over a tender spot in the right temporal region, although there were well-marked symptoms of a cerebellar tumor. After death, ten weeks after the operation, the tumor was found in the left lateral lobe of the cerebellum. In this case the left knee-jerk was absent, and there was slight paresis of the left hand, symptoms which, together with the characteristic symptoms of tumor, might have sufficed to indicate the cerebellum.

In seven other cases an erroneous diagnosis was made of tumor of the cortical motor centres (Fraser, Hammond, Amidon, Stokes, Walker, Dobson, Twynam), and in one (Beach) of tumor of the frontal lobe pressing on the central convolutions (Cases 5, 7, 8, 51, 55, 73, 80).

In Fraser's case (5) the localizing symptoms were right hemiplegia and contracture, indistinct speech, amnesic aphasia, agraphia. The error depended on the duplicity of the lesion. There was a tumor in the middle of the right ascending parietal convolution, and another in the left temporal lobe involving the ascending convolutions. The amnesic character of the aphasia really pointed to the left temporal lobe rather than to the neighborhood of Broca's convolution. It is difficult to understand the failure in Hammond's case (7), as the autopsy revealed three cysts in a line in the anterior central convolution precisely where the lesion had been diagnosed. In Amidon and Weir's case (8) the tumor was found in the cerebellum at the autopsy, although the patient had had left hemispasm and paralysis of the left arm. Two circumstances, however, pointed to the cerebellum—with the left-sided paralysis co-existed a paresis of the right arm, thus a bilateral motor defect, and there was also optic neuritis on the left side. Stokes's case (51) shows, as the author remarks, that the motor centre for the leg extends farther back than is usually assumed, or else that transmitted pressure from a distance may cause the same symptoms as a lesion at the centre. A spindle-celled sarcoma was found in the parietal lobe, just behind the leg centre, and being of the same consistency as the brain, could not be distinguished.

In Walker's case (55) the symptoms were very confusing. Staggering seemed to indicate a cerebellar tumor, as also the vertigo and vomiting. But a marked mental defect pointed to the frontal lobes, and motor aphasia to a lesion on the left side. On the other hand, left hemispasm and hemiplegia were to be referred to the right side of the brain, and hemorrhage and an offensive discharge from the right ear seemed to localize the disease more precisely near the petrous bone. Paresis of both hands pointed to the cerebellum; exaggeration of the left tendon reflex, on the contrary, confirmed the indications offered by the left hemiplegia. An exploratory operation was performed over the left ascending frontal with negative result. At the autopsy a cystic mass was found at the left of the sella turcica, springing from the apex of the petrous bone. The record leaves unexplained why this should have been associated with discharge from the right ear.

Dobson's case (73) exhibited an apparently exquisitely precise symptom, namely, twitching attacks in left arm, beginning in thumb and first finger, with sensory aura in

* The knee-jerks are usually diminished in tumors of the cerebellum, whereas they are exaggerated in tumors of the pons. This may be a useful detail in distinguishing between these two lesions, whose symptoms often resemble each other.

same parts. Horsley has located the thumb centre just behind the middle of the ascending parietal convolution, and a signal symptom in Jacksoniam epilepsy, initiated at this point, has several times guided to an exact diagnosis. But in this case the centre was evidently irritated by pressure from a distance. There were multiple cerebral tubercles in the right hemisphere. This is the second case of multiple tumor on the list.

In Twynam's case (80) the tumor seems to have escaped detection, partly because it lay too far below the surface in the medullary substance, partly because, as in Stokes's case, the tumor, though pressing on the central convolutions, lay behind them, in the parietal lobe. Besides the hemiparesis there was some loss of sensation, and this symptom, as well as the loss of muscular sense, seems to point to the parietal lobe rather than the central convolutions. Another fact in the same sense was the incomplete nature of the paralysis. The tumor found on autopsy was very large, 68 by 57 millimetres, extending from the Rolandic fissure to the parieto-occipital, and bulged into the roof of the lateral ventricle.

In Beach's case (52), finally, a tumor was diagnosed in the left frontal lobe, pressing on the lower part of the central convolutions. The first local symptom had been a motor aphasia, followed by tremor, then twitching of right hand and eyelid, then paresis of right hand. The tumor was found at the supposed level, but, as in Cases 51 and 80 (Stokes and Twynam), it lay in the parietal lobe behind the motor convolutions and between the posterior ascending branch of the Sylvian fissure and a small sulcus anteriorly which separated it from the ascending parietal convolution. There were no sensory symptoms to aid the diagnosis.

In Wille's case (25) a tumor of the left parietal lobe was diagnosed, but the diagnosis was guided by the existence of a swelling over the left parietal bone. Only after this had been incised did right hemiparesis appear, including the facial nerve. In a second operation subdural pus was evacuated but no tumor was found. At the autopsy was discovered a tumor the size of a pigeon's egg in the posterior part of the left paracentral lobule, extending into the upper part of the ascending parietal convolution. Also, and this makes the third case of multiplicity, a second tumor was found in the middle of the ascending parietal convolution. In two other cases on this list the tumor lay in the cerebellum. In Wyman's case (53) it had been diagnosed in the sella turcica, because, in addition to the general symptoms, the patient had a divergent squint (paralysis motor oculi), anosmia, and slight movement of rotation at the beginning of the convulsive attacks. There was great muscular weakness, but neither hemiplegia nor staggering. A tumor three-quarters of an inch long was found in a cavity hollowed out in the left hemisphere of the cerebellum. All the ventricles were distended with fluid. The great frequency of cerebellar tumors might, it would seem, have decided the surgeon to operate, if at all, in their locality. But instead of this he trephined the frontal bone above the supra-orbital ridge and passed a probe over the orbital plate to the sella turcica with necessarily negative result.

In Springthorpe's case (47) a cerebellar tumor was correctly diagnosed, and several symptoms pointed to pressure on the right lobe of the cerebellum. In the fits there was conjugate deviation of the head and eyes to the right side; the right ear was moderately deaf, and the patient fell backward and to the right side. An opening was made over the right lobe of the cerebellum, clear serous fluid escaped, but no tumor was found. At the

TABLE II.—*Twenty Cases of Operation where Tumor was not Found.*

No.	Name.	Diagnosis.	Real locality.	Result.	Remarks.
68	Seguin.	Tumor under motor centre for left leg.	Locality diagnosed.	Death.	Tumor very small, half inch in diameter, and of same consistency as brain.
41	Keetley.	No record.	Infiltrating glioma of pons.	Death in two days.	Symptoms pointed to cerebellar tumor, but exaggerated knee-jerks, attack of collapse, and subnormal temperature.
3	Sciammana.	Trephined over a scar or tender point.	Right centrum ovale.	Death in two days.	Symptoms not explained by autopsy.
31	Pilcher.	Trephined over a scar or tender point.	Occipital lobe.	Death.	Conjugate deviation eyes, pointed either to angular gyrus or upper part frontal lobe; latter affected by pressure.
58	Kerr.	Trephined over a scar or tender point.	Basal ganglia.	Death.	Hemispasm and hemiparesis fully simulated a cortical tumor.
65	Knapp and Bradford.	Trephined over a scar or tender point.	Cerebellum.	Death.	Symptoms indicated a cerebellar tumor, because general symptoms marked, left knee-jerk absent, and paresis left hand.
84	Gray and Wyeth.	Tumor in Rolandic convolutions.	Tumor of centrum ovale one-fourth inch below surface of ascending parietal convolution.	Death in three days; much exploration of brain by needles.	Failure due to identical consistency of neoplasm and brain-tissue.
5	Fraser.	Tumor in Rolandic convolutions.	Double lesion: first, ascending parietal: second, temporal lobe.	Death.	Amnesic aphasia really indicated temporal lobe or island of Reil.
7	Hammond.	Tumor in Rolandic convolutions.	Triple lesion, but all in motor convolution.	Death in twenty-one hours.	Failure to find three cysts is not explained.
8	Amidon and Weir.	Tumor in Rolandic convolutions.	Cerebellum.	Death in ten weeks.	There was bilateral motor defect and left optic neuritis, which might have suggested cerebellar lesion.
51	Stokes.	Tumor in Rolandic convolutions.	Parietal lobe, just behind leg centre.	Death in three weeks.	Symptoms very confusing, but included discharge from ear.
55	Walker.	Tumor in Rolandic convolutions.	Apex petrous bone.	Death in few hours.	
73	Dobson.	Tumor in Rolandic convolutions.	Multiple tubercles in hemisphere.	Death in one month.	Apparently characteristic cortical epilepsy.
80	Twynam.	Frontal lobe, pressing on motor convolutions.	Parietal lobe.	Death fourth day.	Some loss of sensation might have suggested superior parietal lobule.
52	Beach.	Frontal lobe, pressing on motor convolutions.	Parietal lobe.	Death second day.	In this case no sensory symptoms, and motor aphasia had preceded hemispasm.
25	Wille.	Parietal lobe (scalp swelling here).	First, in paracentral lobule; second, in ascending parietal.	Death.	
53	Wyman.	Sella turcica.	Left hemisphere of cerebellum.	Death.	Many cerebellar symptoms, but also paralysis abducens and anosmia.
47	Springthorpe.	Cerebellum, right hemisphere.	Middle lobe cerebellum.	Death.	Pressure on right side localized the symptoms.
82	Starr and McBurney.	Right lobe cerebellum.	Middle lobe cerebellum.	Sudden death in few days.	
40	Keen (REFERENCE HANDBOOK MEDICAL SCIENCES, 1889).	Tumor cerebellum.	Cerebellum.	Death in fifty-two days.	Tumor diagnosed but not sought; ventricles tapped for internal hydrocephalus.

autopsy a glioma with a central cavity was found to occupy the middle lobe of the cerebellum. All the ventricles were full of blood-stained fluid. The main pressure was upon the right side.

The last case has just been reported by Gray and operated by Wyeth (84). The exact locality of the tumor was correctly diagnosed, but it lay one-quarter inch below the surface (as had been expected from the absence of convulsions), and the consistency so closely resembled that of the medullary brain-tissue in which it was embedded that an exploring needle passed through it without detecting its presence, and it was discovered at the autopsy with difficulty, and by careful slicing of the brain.

Nearly all the cases where the tumor was not found at the site of operation proved fatal, the operation seeming to accelerate the natural march of the disease. One case, however (Amidon and Weir), survived ten weeks, another (Dobson) a month. Four cases illustrate the now accepted rule, that a scar, and still less a tender point on percussion, must not be selected as a site of operation, unless focal symptoms point to the same locality.

In the five cases of cerebellar tumor a retrospect of the symptoms, after the autopsy, makes them seem more significant than they had appeared before the operation. Cases 47 and 53, as do many other cases which have not been operated, show the impossibility of distinguishing with certainty whether a tumor of the cerebellum be situated in its lateral or its middle lobe. Nothnagel's law of the frequent latency of tumors of the lateral lobes should always incline the diagnosis in favor of a central lesion, unless lateral symptoms are very well marked. The danger of hemorrhage, however, from trephining over the centre of the cerebellum, *i.e.*, of the sinus, is very great, and, on the other hand, a tumor of the middle lobe is sometimes accessible from the side.

TABLE III.—*Tumor not Removed, Temporary Recovery.*

45	Horsley.	Tumor middle lobe cerebellum; removal occipital bone in two operations.	Life prolonged in comfort for two years.
27	Heath.	Large adherent growth over ascending frontal convolution.	Relief and prolonged recovery.
35	Limont and Page.	.....	Temporary recovery; recurrence of growth.
39	Kocher.	Tumor cerebellum diagnosed.	Double trephining relieved intracranial pressure, arrested optic neuritis.
49	Maudsley and Fitzgerald.	Tumor a solid nodule fixed to temporal bone.	Recovery with persistent blindness and deafness.

TABLE IV.—*Tumor not Removed, Fatal Cases.*

15	Birdsall and Weir.	Sarcoma at tip of occipital lobe; softened contents removed.	Death from hemorrhage in a few hours.
54	Clarke.	Subdural growth over upper end fissure Rolando adherent to longitudinal sinus; partial removal.	Death from septicæmia on nineteenth day.
59	Eskridge.	Glioma left frontal lobe reaching beyond fissure Rolando; too large for removal.	Death in eight days.
78	Nixon.	Bone necrosed over tumor; operation at this point; neoplasm is completely removed; cartilaginous, adherent to longitudinal sinus.	Death fifth week from secondary hemorrhage from wound.
83	Starr and McBurney.	Cysto-sarcoma middle lobe cerebellum; tapped but could not be removed.	Death in a few days.

Operation on tumors too large for removal, when the cranial opening was really made over the seat of the lesion, have not always proved so dangerous as in the class of cases just described. Thus, Horsley (Case 45) removed first one half of the occipital bone, then the other, where an inoperable tumor of the middle lobe of the cerebellum existed. The patient had suffered for a long time from epileptiform fits, with violent rotary movements, from severe headache and distressing attacks of dyspnœa. All these symptoms disappeared after the operation, and the patient's life was prolonged in comfort for two years.

In Heath's case (27), also, a large adherent growth was found over the right ascending frontal convolution, which could not be removed. Localized tenderness had existed over the site of the tumor. The patient was relieved of his headache by the operation, and, at the time of reporting, had made a good recovery. In Case 35 (Limont and Page) a portion of a large glioma was removed, with temporary recovery, but the growth recurred.

In Case 39 (Kocher) tumor of the cerebellum was diagnosed from the four classical general symptoms, in the absence of focal symptoms. A double trephine opening was made to relieve intracranial pressure, one posteriorly on the right side below the tentorium, one anteriorly on the left side. In four days congestion of the optic disks had disappeared, but there was no improvement of vision.

In Maudsley's case (42) a tumor had been diagnosed in the left lobe of the cerebellum, the trephine was applied at this locality and a tumor found, but it was a solid nodule, irremovably attached to the temporal bone. The patient recovered from the operation. Five other cases proved rapidly fatal. The entire list of ten cases is summarized in Tables III. and IV.

Death occurred after removal of the tumor in sixteen other cases. The causes may be thus tabulated:

TABLE V.—*Tumor Removed with Fatal Result.*

1	Bennett and Godlee.	Glioma upper third Rolandic fissure.	Hernia cerebri; septic meningitis; death in thirty days.
4	Hirschfelder and Morse.	Infiltrating glioma post central gyrus.	Death eighteenth day; septic encephalitis.
12	Horsley.	Tubercle right lobe cerebellum, seven drachms.	Death in nineteen hours from shock; general tuberculosis.
13	Bennett May.	Tubercle size of pigeon's egg in cerebellum.	Death from shock.
14	Suckling.	Tumor left and middle lobes cerebellum.	Death from shock in forty-eight hours.
22	Von Bergmann.	Cyst in Rolandic region communicating with lateral ventricle.	Death in four weeks from meningitis.
32	Wood and Agnew.	Right temporo-sphenoidal lobe.	Death from hemorrhage.
34	Thomas.	Tumor, three ounces, middle central convolutions.	Death in three days.
37	Verco.	Hydatid cyst adherent to temporo sphenoidal lobe.	Death from meningitis with temperature 104° F.
43	Barton.	Rolandic gyri syphilitic gumma with necrosed bone.	Death in a month from encephalitis.
44	Lampiasi.	Tubercle size of egg in cerebellum.	Death in four days.
46	Knapp and Bradford.	Tubercle, 35¾ grms., middle ascending frontal convolution.	Death from shock in three-quarters hour.
64	Bullard and Bradford.	Cheesy tubercle in cerebellum.	Sinus opened; death from hemorrhage.
68	Keen.	Tumor size of filbert five centimetres from end of occipital lobe.	Death in fourteen hours.
69	Castro.	Tumor size of walnut over Rolandic fissure.	Death from epidemic diphtheria affecting wound.
81	McBurney and Starr.	Very large glio-sarcoma from frontal lobe.	Death from shock in few hours.

Five out of these 16 cases are tumors of the cerebellum. Five cases on Table II., one on Table III., and one on Table V., were also cerebellar; thus 12 out of the total number of 46 unsuccessful cases, or twenty-six per cent.

The death from diphtheria (Castro) and that due to accidental opening of the cerebellar sinus (Bullard and Bradford) are theoretically avoidable. The case of glio-sarcoma removed by McBurney had been correctly diagnosed eleven months before, and the operation then advised. At that time it might have been successful, so that in this case the fatal issue may fairly have been attributed to the delay. It may perhaps be assumed that

the five deaths caused by septic meningo-encephalitis could have been avoided by more perfect antiseptic precautions.

The fatal issue is not clearly explained in the cases reported by Gray, Thomas, and Keen. The last case is particularly interesting, because the tumor had been correctly localized in the cuneus on account of the symptom of hemianopsia. It is the only case in the entire collection where this symptom was thus rendered available.

In 39 cases the operation was successful. The situation of the tumor in these cases is shown in the next table.

TABLE VI.—*Successful Cases.*

Number.	Name.	Diagnosis and Operation.	Locality.	Result.
2	Macewen.	Tubercular membranous mass removed from right ascending frontal gyrus.	Rolandic region.	Recovery complete.
10	Horsley.	Upper part middle third Rolandic region.	Ibid.	Recurrence tumor in three months; death in six months.
9	Ibid.	Tumor thumb centre in ascending parietal gyrus.	Ibid.	Complete recovery; disappearance of epilepsy and paralysis.
11	Ibid.	Tumor hand centre pressing on Broca's convolution.	Ibid.	Recovery; persistence, but arrest of hemiplegia.
17	Macewen.	Tubercle size of hazel-nut top of ascending parietal.	Ibid.	Recovery.
18	Ibid.	Cyst size of filbert base of left ascending frontal gyrus.	Ibid.	Recovery.
19	Ibid.	Yellow mass over upper part right ascending convolutions.	Ibid.	Recovery.
20	Lucas Championnière.	Large hyperostosis over left ascending frontal convolution.	Ibid.	Recovery, with persistent hemiplegia.
21	Rannie.	Degenerating gumma from right ascending frontal. Piece of dura and brain removed.	Ibid.	Recovery, with cessation symptoms.
23	Seguin and Weir.	Sarcoma size of almond one inch below posterior edge second frontal and anterior edge precentral gyrus.	Ibid.	Perfect health six months after operation; signs of recurrence later.
29	Pean.	Growth from dura over left ascending convolution; fibro-lipoma.	Ibid.	No more epileptic attacks two months after operation.
30	Fisher.	Sarcoma pressing on left central convolution.	Ibid.	Recurrence of tumor two months after operation and death.
38	Mercanton. and Combe.	Tumor middle left ascending frontal reaching to island of Reil.	Ibid.	No record, but presumed recovery.
48	Oppenheim.	Glioma in cystic degeneration lower part ascending convolution.	Ibid.	Complete recovery.
49	Graham.	Hydatid cyst upper portion fissure Rolando.	Ibid.	Recovery, with blindness.
50	Church.	Spider-shaped sarcoma over left arm centre; decortication one-quarter inch.	Ibid.	Recovery; recurrence epilepsy in two months.
56	Dumin.	Anterior convolutions.	Ibid.	Recovery; sudden death in four months after operation.
57	Bremer and Carson.	Cavernous angioma at fissure Rolando.	Ibid.	Recovery.
62	McCall Anderson.	Tumor at thumb centre right parietal convolution.	Ibid.	Perfect recovery; no attack for eight weeks.
66	Milla and Keen.	Small sarcoma from pia pressing upon central convolutions.	Ibid.	Recovery; diminished severity attacks.
72	Llobet.	Motor convolutions. Resected temporal bone.	Ibid.	Recovery, only memory not returned in three months.
61	Reynier and Blocq.	Cyst over central convolutions extending to frontal gyri.	Ibid.	Cyst drained in first, removed in second operation; no attacks during three and one-half months.
60	Doyen.	Very large cyst behind bulging bone.	Ibid.	Cyst drained for six weeks, 360 c.c. fluid at one time.
70	Poirier.	Vascular tumor central gyri.	Ibid.	Recovery; freedom from epilepsy.
29	Pean.	Right leg centre.	Ibid.	Recovery; cessation epilepsy at two months.
75	Hitzig.	Cyst size of goose-egg.	Ibid.	Recovery.
76	Von Brammann.	Cystic tumor at fissure Rolando. Drained twice; removed at third operation.	Ibid.	Recovery.
77	Ibid.	Spindle-celled cysto-sarcoma in Rolandic area.	Ibid.	Recovery.
85	Stieglitz and Gerster.	Tumor arm centre.	Ibid.	Recovery, but symptoms recurrence six months later.
16	Markoe.	Hemorrhage cyst over parietal lobe; depression skull.	Parietal lobe.	Recovery.
33	Parker.	Gummous tumor size of walnut under right parietal eminence.	Ibid.	Recovery on eightieth day.
24	Keen.	Fibroma base third frontal convolution, reaching to fissure Rolando.	Frontal lobe.	Recovery eighty-fourth day; epileptic attack five weeks later.
6	Durante.	Fibro-sarcoma, 70 grammes, in anterior fossa.	Ibid.	Prompt recovery, persisting four years after operation.
74	Hitzig.	Tumor, 280 grammes, posterior part frontal lobe.	Ibid.	Recovery.
79	Clegg.	Exophthalmos; removal sarcoma with eyeball.	Ibid.	Return of pain and attacks in four months.
26	Fitzgerald.	Echinococcus behind left temple.	Ibid.	Recovery.
28	Macewen.	Nodule on skull between ascending convolution and frontal lobe.	Tumor of dura at frontal lobe.	Recovery for eight years.
71	Booth and Curtis.	Erosion of bone at angular process frontal.	Tubercle frontal lobe.	Recovery.
36	Maunsell.	Cyst four inches long, three inches broad.	Cerebellum.	Recovery; blindness persists.

These cases of recovery include one, and only one, case of tumor of the cerebellum, and that was a cyst. This is to be reckoned against 12 fatal cases of cerebellum tumor, already noted. As might be expected, in the immense majority of successful cases the tumor is situated in the motor convolutions (29 out of 39 cases). This region unites all the conditions of success, facility of diagnosis, facility of operation, relative freedom from danger of shock. Among the unsuccessful cases the tumor was situated in the central convolutions only 7 times, and in one of these the death was purely accidental, due to an epidemic diphtheria. In all the others death was due to septic meningitis, in one case, also syphilitic. In one a communication existed between the tumor and the ventricle; in another, there was an adhesion to the longitudinal sinus.

The symptoms of lesion of the central convolutions are so well marked that when the tumor exists in this locality it cannot easily be overlooked. It sometimes happens, however, that tumors in other localities simulate the symptoms proper to disease in the cortical motor centres. Thus: 1. The tumor may be situated in the subcortical region of the centrum ovale, as in Gray's case (84). The diagnosis in this case, notwithstanding the monoplegia, was correctly made as subcortical, on account of the absence of spasm or convulsion. 2. The

tumor may lie in the frontal, parietal, or temporal lobes, and by transmitted pressure excite the symptoms proper to the motor area. The diagnosis, when possible, is made out by observing that lesions of intelligence, or speech, or sensibility, or vision, especially hemianopsia, have preceded motor symptoms, and that the latter remain incomplete—paresis, not paralysis. 3. Tumor of the basal ganglia may simulate cortical tumor. This occurred in Case 58 (Kerr). It is rather surprising that the mistake has not been made more frequently. That it has not, is due to the enormously valuable studies in "Jacksonian epilepsy," that may be ranked as the second link in the chain of investigation which, beginning with the researches of Hitzig and Ferrier on brain localization, have so rapidly led to brain surgery. Only one tumor of the occipital lobe has been operated at its site, the diagnosis having been guided by the remarkable symptom hemianopsia (Birdsall and Weir, 15).

In Pilcher and Dana's case (31) the tumor occupied the left occipital lobe, but the operation was made at the site of a scar corresponding to the angular gyrus. The tumor, therefore, was not found. It is not stated whether the patient was examined for hemianopsia.

It is claimed, especially by Starr, that an onset of symptoms with psychical changes is very characteristic of tumors of the frontal lobe. Such mental depression, however, is apt to occur with intracranial tumors in any locality, and cannot be considered a distinct indication of frontal lobe localization until, by extension backward, motor symptoms began to complicate the mental; or until conjugate deviation of head and eyes has become a signal symptom in convulsive attacks; or until anosmia be discovered. In several of the frontal lobe tumors here recorded an external lesion coexisted and guided the operator to the exact locality.

It seems to have become accepted that a fairly large opening through the skull is preferable to the small trephine openings originally chosen. With such large flaps much greater facility is offered for detecting a tumor, whose remote pressure symptoms had confused the preoperative diagnosis (see Gray's case).

From the foregoing record of cases we may deduce several propositions, which, collectively, contain the sum of new knowledge acquired in the treatment of brain tumors during the past decade.

In the first place, it has been demonstrated that it is practicable to open the cavity of the cranium, to penetrate the dura mater, to lay bare the brain, and even to excise portions of its tissue. The successful removal of brain tumors has restored to favor as a legitimate surgical procedure the old operation of trephining, which had fallen into desuetude.* So far this surgical restoration has proved more useful in other cases of brain disease than in that which is the subject of this chapter (see chapter on "Brain Surgery"). But the fact will always remain interesting, that it was the greater exploit of excising a cerebral neoplasm, which has, in entirely modern times, encouraged surgeons to the lesser effort of trephining for cerebral abscess and traumatic hemorrhage; and revived the old rules of unhesitating trephining in traumatic cases with depressed fracture.

Again, when Hughlings-Jackson first began to study the precise order of development of the sensori-motor phenomena in the class of convulsive attacks which now bears his name, their habitual dependence upon organic brain lesion had not yet been established. This has now been shown, and the cases of brain tumor attended by attacks of Jacksonian epilepsy have assumed the most favorable prognosis, because the fact of the attacks usually indicates that the tumor is situated in the cortex of the central convolutions, and from the details of the attack the exact motor centre may be inferred. Pursuing still further the line of thought, neurological surgeons have argued that if a tumor in the motor area determines a definite series of explosive symptoms—sensori-motor irritation, followed by sensori-motor paralysis—the occurrence of such symptoms, apart from indications of intracranial tumor, implies that the same motor region is irritated, though in some other way than by a neoplasm. Many cases of epilepsy, hitherto considered a functional disease,* have therefore been trephined, and in many of these, organic lesions, as cicatrices, have been removed from the surface of the brain or meninges, with the result of allaying or arresting the convulsive attacks. Finally, even in the absence of all visible lesion, portions of cortical tissue have been excised containing the centres of motor representation corresponding to the limb segments whose spasm initiates the attack.

It is not within the province of this article to discuss this latest and most interesting development of surgical method, which began with removing the tangible organic causes of epilepsy. We may observe, however, that the signal symptom of the attack (the felicitous expression is Seguin's), which is held to localize the lesion, because indicating the point of earliest and most intense irritation, does not necessarily show that the irritation originates at this point. It is quite as possible that the nerve-tissue has received an irritation propagated from some distant region, but not manifest until it has spent itself upon a motor centre and thence determined a nervous discharge. Excision of the motor centre, therefore, would not remove a cause of the spasm, but only the first effect, of some possibly inaccessible cause.

From the frequent failure of the operation as a cure for epilepsy one may suspect that some such condition of things often exists. The difficulty in these non-organic cases is paralleled in cases of tumor, where, though the convulsions are immediately initiated by irritation of the cortical motor area, the causal lesion is situated in some other part of the brain and cannot be found.

Another parallel has a more hopeful aspect. It has been sometimes found in cases of inoperable tumor that the symptoms due to pressure—vomiting, headache, and convulsions—could all be relieved when the pressure was lessened by trephining or removal of large pieces of cranial bones.† It seems therefore possible that in cases of epilepsy without gross or focal lesion, and before irremediable degeneration had set in, similarly afforded relief of intracranial pressure might arrest the disease.

Traumatism, even when not more severe than that of a fall on the head, has always been recognized as an important factor in the etiology of brain tumors. Out of the 85 cases of operation on record, there is a history of a fall or a blow in 20.‡ Morbid symptoms rarely develop very soon after the accident: months, sometimes years, intervene. In the light of the experience now accumulated, it is indicated to operate very early after the appearance of symptoms indicative of intracranial neoplasm; and the indication is especially formal if there is a history of previous traumatism. It is possible, as Seguin's case shows, to operate so early that the tumor has not yet grown large enough to be found at the operation. This is, however, the only case on the list where the operation failed from this cause; only when the tumor is situated entirely on the surface of the cortex is it liable to excite convulsive twitchings while yet very small; but in such a situation the tumor should be easily found.§ The danger of delay in operating is well shown in the first case of Starr and McBurney (Case 81). Eleven months intervened between the establishment of the diagnosis (when the operation was first proposed) and the time when the patient's consent to the operation was secured. In that time the tumor grew to such a size that its removal was followed by death from shock in a few hours.

* Horsley, in a learned lecture, claims to have found evidence of operative trephining on the skulls of prehistoric men.

* According to the present view, non-localizable, *i.e.*, generalized epilepsy depends upon a diffused microscopic sclerosis (Feré, Les Epilepsies) or a degeneration and vacuolation of ganglion cells (Dana, Treatise on Nervous Diseases).

† Horsley (see Case 45) removed first one half, then the other half of the occipital bone, "and the patient lived in comfort two years."

‡ Cases 1, 3, 5, 16, 18, 24, 31, 37, 38, 41, 49, 55, 58, 68, 74, 75, 76, 80, 82. Case 38 is particularly interesting. It is that of a little girl in a Swiss school who was struck on the head with a ruler by her teacher.

§ In Case 50 (Church) the tumor was a spider-like, filiform growth, extended on the surface of the central and frontal gyri.

The development of optic neuritis is not always proportioned to the size of the tumor, but much more to its situation. Hence, as has long been known, optic neuritis appears early and advances rapidly with tumors of the cerebellum, where the intracranial pressure is at its maximum. An early operation is often indicated to relieve this pressure before the optic nerves should have atrophied, in which case the patient would remain blind, even though he survived the operation and were relieved of other urgent symptoms.*

An important decision formulated by Horsley is that syphilitic tumors should be operated on, and not left to the uncertain influence of internal treatment. Bergmann, on the other hand, maintains the sufficiency of this treatment, and the superfluous risk of the operation.

If it be assumed that all tumors of the cortex and centrum ovale are conceivably operable, the proportion of operations to cases would be forty-one per cent., since 266 out of 649 cases of tumor are situated in these two localities. If to these be added 162 cases of the cerebellum the proportion would rise to sixty-five per cent. (table quoted on p. 132).

The special difficulties surrounding tumor of the cerebellum have already been emphasized. The general diagnosis is relatively easy, that is, it is usually easy to diagnose a tumor of the posterior cranial fossa and subtentorial. It is often difficult to distinguish between the middle lobe of the cerebellum and a lateral lobe; and usually impossible to distinguish between tumor of the bone compressing the cerebellum and tumor of the organ itself. A precious aid in diagnosticating tumors of the occipital lobe from those of the cerebellum is the existence of hemianopsia in the former, as against optic neuritis in the latter. Case 41 (Keetley) shows how a tumor of the pons may be mistaken for a cerebellar tumor, when by exception the paralyses of cranial nerves, so characteristic of pontine tumors, are lacking. The prognosis in cerebellar tumors, however, is rendered bad, far less by the difficulties of diagnosis, than by the special dangers of the operation which have already been mentioned. In the centrum ovale and cortex, on the contrary, the dangers of the operation are at the minimum, provided the tumor can be found. The difficulty of finding it depends upon: 1st, whether it lie in a latent zone or in one whose symptomatology has been determined; 2d, upon its proximity to the surface; 3d, upon the differentiation of its consistency with that of the brain.

The accessible regions of the cerebrum whose lesions have so far been connected with sufficiently definite differential symptoms, are as follows:

Frontal lobes: †	Marked and primary impairment of intelligence.
Posterior and second frontal convolution.	Spasmodic conjugate deviation head and eyes to side opposite lesion at beginning of epileptic attack; agraphia (?).
Left third frontal convolution.	Motor aphasia; anosmia on side of lesion (sometimes); secondary incomplete irritative or paralytic motor symptoms as tumor extends backward; exophthalmos, unilateral (sometimes).
Central convolutions.	Spasm, followed by paresis or paralysis, both permanent or intermittent, and occurring in attacks of Jacksonian epilepsy or as signal symptoms in general convulsion, in one or more segments of face or limbs innervated from the known motor-centres.
Parietal lobe:	
Anterior convolutions or superior parietal lobule.	Incomplete symptoms of irritation or paresis of motor symptoms, usually developed after general symptoms of brain tumor; diminished sensibility; loss of muscular sense.
Posterior convolutions:	
Angular gyrus.	Apraxia (?).
Occipital lobe:	
Cuneus.	Homonymous hemianopsia. Staggering, ataxia, from pressure on cerebellum (sometimes).
Temporal lobe:	
First convolution.	Sensory aphasia; motor spasm and paresis as tumor grows upward.
Tip of lobe.	Combination of motor aphasia from pressure on Broca's convolution, with sensory aphasia.
Island of Reil.	Aphasia of transmissibility.

Tumors of the centrum ovale are always latent, unless they become very large, or are near enough to the surface to affect the cortex. By lesion of the motor tracts they cause paralysis unpreceded by spasm. Two cases are recorded (cases of Sciammana and Gray) where tumors of the centrum ovale escaped detection at operation.

In Sciammana's case (3) the locality was not diagnosed, and the trephine applied over a misleading scar. In Gray's case (86) the position was made out with great precision, but the failure was due to the third operative difficulty which has been mentioned, namely, the soft consistency of the tumor.

This difficulty can never be foreseen in advance, and seems to be as great with large as with small tumors. Possibly some future therapeutic resource will enable the surgeon to prepare his patient for operation by the ingestion of some food or drug which should change the consistency of the tumor.

For details of cranio-topography, operative procedure, and technique, and the special dangers incident to the operation for brain tumor, the reader is referred to the article on "Brain Surgery," by Dr. Keen, in Vol. VIII. of the REFERENCE HANDBOOK.

Mary Putnam-Jacobi.

[1] Surgical Treatment Diseases of Brain, translation from Berlin edition, in Wood's Medical and Surgical Monographs, 1890, New York.
[2] Horsley, British Medical Journal, 1890, reports without detail several such cases of similar trephining.

BRAIN, VESSELS OF THE. ARTERIES, *Medidural.*—The furrows of the medidural artery on the entocranial wall deepen with years, and in old age the artery sinks quite into them. It has two primary branches, a larger cephalic and a caudal, the former again soon (at the sphenoidal angle of the parietal bone) separating into two secondary rami. The anterior ramus runs up behind the coronal suture, though a little more obliquely, being, according to Marchant, pretty constantly from 0. to 13 mm. (averaging 5 to 6 mm.) away at the foot of the suture, about 1 ctm. at its middle, and 15 mm. at its dorsal part. The second ramus starts on the entotemporal surface 4 ctm. behind the pterion, on an average. At its middle, on the entoparietal surface, it averages 54 mm. behind the coronal suture. Farther dorsad, the distance is very variable, 30 mm., more or less.

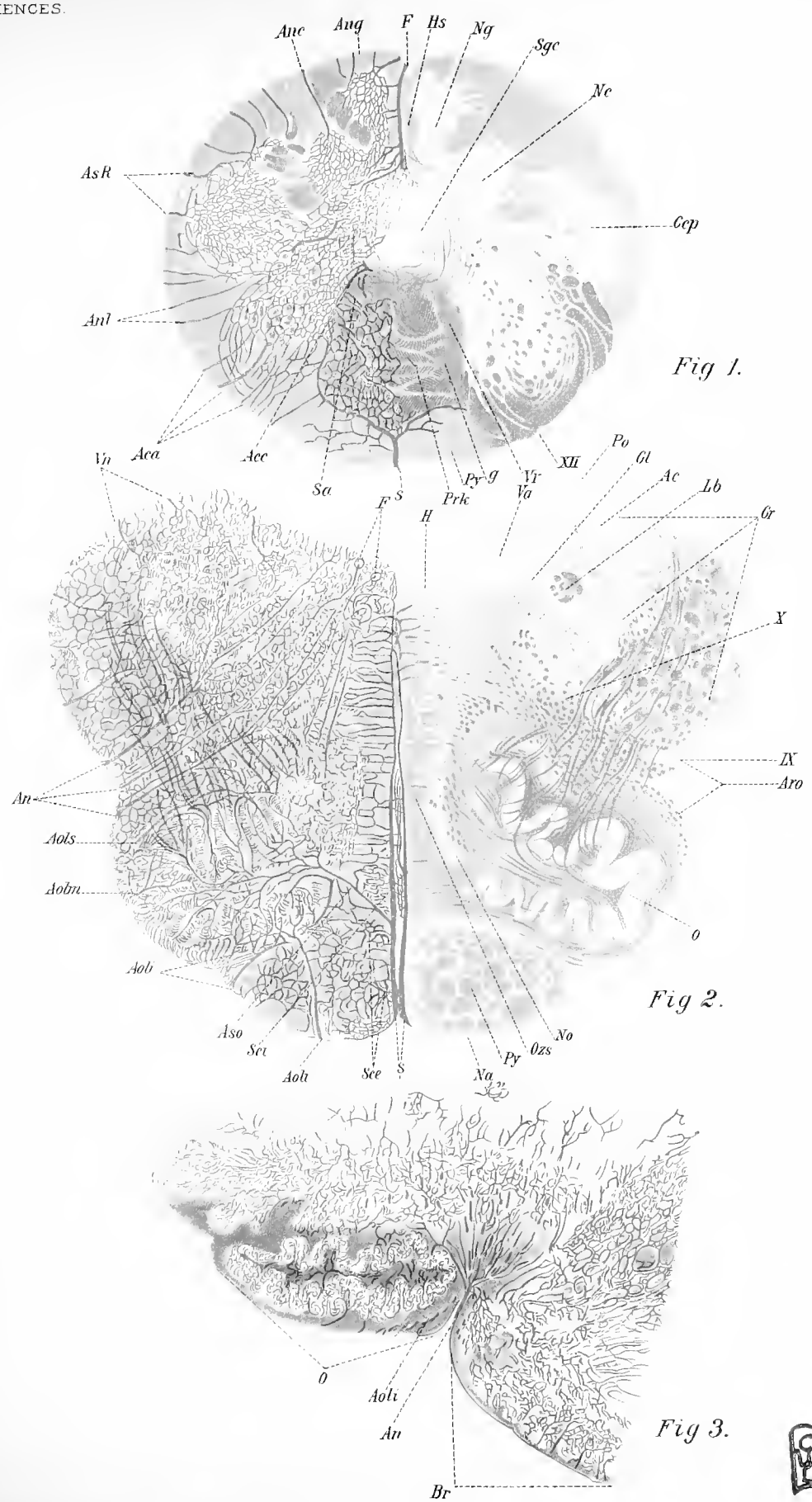
The primitive caudal branch leaves the temporal squama 58 mm. behind the pterion, then goes toward, and becomes parallel with, the lambdoidal suture.

The relations of these vessels to the subjacent cortex, important clinically, Duchaine sums up thus: 1. The cephalic branch runs up opposite the frontal lobe some ctm. before the central fissure, rather nearer the coronal suture. 2. The mid-ramus starts almost opposite the fissure, then runs up some ctm. behind it. 3. The caudal branch is always a ctm. or more distant from the fissure, and is still further separated above.

Variations in the Basal Arteries.—Dercum offers "A Collection of Anomalies of the Circle of Willis" (*Jour. of Nerv. and M. Dis.*, 1889, Jan.), and J. H. Lloyd (*Ibid.*, 1890, p. 225) gives such a case of a type described by Duret (right vertebral absent, both precerebrals from left carotid, etc.). St. John Bullen (*Jour. Mnt. Sci.*, 1890, Jan., p.

* See Case 49 (Graham). In the article on Brain Tumor in the REFERENCE HANDBOOK it has been noted that choked disk is sometimes due to neuritis from diffused cerebritis, sometimes also to direct pressure on the optic tract.

† The following case illustrates the possible latency of a tumor of the frontal lobe: Boy, aged eight. Extensive joint disease right elbow and left tarsus. Thirty hours before death convulsion for the first time. Began on left side, with spasmodic closure eyelid, twitching in face, neck, arm, leg. Wave of convulsion then passed rapidly to right limbs. Examination, then made for first time, discovered double optic neuritis and anosmia. Death. Tumor, 3½ inches long, 2½ inches thick, at base of right frontal lobe, extended from one-half inch of tip of frontal lobe to point corresponding to section through bases of first and second frontal convolutions, one inch anterior to fissure of Rolando. Came to surface at junction of third frontal with orbital gyrus. The tumor lay immediately behind and external to the root of the olfactory nerve.



Arterial Supply of Oblongata (from Adamkiewicz.)

33) bases the following statements on the examination of 1,565 brains (from the insane), but holds statistics too uncertain. Arterial variations occur much oftener in general paralytics than in those dying of other forms—this applying equally to all segments of the circle of Willis. However, such anomalies are more common in the postcommunicants than in all the others. Of these vessels: 1, Either may be absent; 2, may be replaced by a branch from the subcerebellar, internal carotid, postcerebral, or two small nutrient branches respectively from the last two vessels; 3, may supply unusual regions; or, 4, may be unconnected with the carotid system.

The precommunicant may be absent, or merely rudimentary, or double. Either of the postcerebrals may, 1, be absent; 2, be a branch of the carotid system; 3, be replaced by a large postcommunicant; or 4, by two thread-like vessels from the basilar.

Either precerebral may, 1, be replaced by two small trunks; or 2, be absent, its region being supplied by branches of the opposite artery. Only occasional variations are attributed to the vertebrals: 1, absence of one, the existing vessel being joined by a branch from the opposite carotid; 2, both may join the basilar on the same side; 3, or one may be represented by two or three branches before entering the formation of the basilar trunk.

Prechoroid Artery.—In general Kolisko's work corroborates that of Heubner. In a large number of examinations this vessel was never absent. It has a pretty constant diameter of ½ mm. In the fœtus it is relatively very large. In animals (dogs, cats, rabbits) it was regularly present, but arose from the Sylvian. The branch to the uncus was always present, but has free anastomoses in the pia. The branches in plexus and tela also anastomose freely with others near; but those to the brain-substance are terminal.

The prechoroid supplies the following parts: The posterior arm of the internal capsule, with the lamina medullaris externa of the thalamus to the level of the upper angle of the mid-lenticular segment—usually only the posterior two-thirds; the white substance back of the internal capsule as far as the roof of the medicornu; the inner lenticular segment; the uncus; the optic tract (in its posterior half); the lateral choroid plexus; the endyma of the posterior and lower parts of the paracœle; the greater part of the tail of the caudatum; exceptionally the external parts of the upper half of the thalamus.

But the posterior arm of the internal capsule is also in part supplied by the medicerebral and postcommunicant (the anterior third of this part by the latter vessel), the deeper parts by the prechoroid and postcommunicant, and the upper parts (above apex of mid-lenticular segment) by the Sylvian (lenticulo-optic ramus of Duret).

Circulatory disturbances in the supply-territory of the prechoroid cause opposite hemiplegia by softening in the posterior segment of the internal capsule, involving the pyramidal and cranial-motor tracts.

Hemianæsthesia, hemianopsia, and hemianosmia may likewise follow closure of the prechoroid, but are usually headed off by collateral supply.

Where the postcommunicant is large, its blocking may cause opposite facial and hypoglossal paralysis, since these tracts traverse the front part of the posterior arm of the capsule.

Arteries of Oblongata.—The recurrent spinals from the vertebrals are given as follows by Kadyi. Immediately after the vertebrals traverse the dura there arises from each a 1 mm. thick branch (dorso-myelic), which, after giving up twigs to the restiform body, descends along the dorsal border of the lateral columns of the cord. This is homologous with other branches entering by the dorsal nerve-roots. Sometimes this arises from the vertebral in common with the postcerebellar.

Near the union of the vertebral to the basilar there arises—usually one on each side, though unequal—the myelic branch for the ventro-myel. These two, however, either soon or oftener after entering the spinal canal, combine to form the azygoid ventri-myelic artery. They are thus continuous and homologous with the other myelic arterioles coming in along the ventral nerve-roots.

A full consideration of the minute details of the arterial distribution in the oblongata is given by Adamkiewicz. These vessels come wholly from the upper (intra-cranial) part of the vertebrals as they cross the ventral surface of the oblongata.

The main facts regarding the three classes of secondary or nutrient arterioles (external or surface vessels) he accepts from Duret: 1. The radicals, direct from the vertebrals, supply the outgoing nerve-roots (facial, acoustic, glosso-pharyngeal, vagus, accessorius, and hypoglossus). 2. The nuclears, at right angles from the one or two dorso-myelics in an extent of 3 to 4 ctm. These penetrate the median fissure, at the bottom of which they form a kind of sagittal leader, and end beneath the floor of the metepicœle (fourth ventricle). 3. Arteries for the other portions of the oblongata (olivary bodies, pyramids, corpora restiformia), in part at least from the myelics.

Moreover, on the oblongatal surface is a rich net-work of vessels. The ventro-myelics opposite the oblongata give off a multitude of twigs that take a very sinuous course and soon settle into the furrows. For the dorsal surface of the oblongata there is no external supply until below the calamus—upper end of myel. Its source is the dorso-myelics. These latter, at the first cervical roots, turn caudad between the accessory nerve-roots (nearer the dorsal), and when at the level of the fourth or fifth cervical roots, they end by also anastomosing with vessels of lower origin.

From the middle portion of the vertebrals, between the ventro- and dorso-myelics, arise the largest branches (subcerebellars), but these dodge the oblongata and are wholly for the cerebellum.

Topographically, he distinguishes three sets of finer or nutrient arterioles (internal or substantial vessels) after the manner of the myelic supply. 1'. Ventro-fissurals, relatively large, dividing in the ventral commissure into two branches, one to each side for the corresponding ventro-mesal cinerea. In the oblongata these supply principally the pyramidal tracts and decussation, lemniscus, interolivary tract, raphé, and the following nuclei—gray dorsal columna, n. pyramidalis, n. arciformis, oliva, and hypoglossus.

2'. Dorso-fissurals, of course only caudad of the calamus. These divide at the dorsal commissure into two border vessels, and are for the substance of the dorsal columns, nucleus gracilis, accessorius centre, and casually the hypoglossus.

3'. Coronal, radial, or lateral system. These are very numerous, penetrate the alba from all sides (excepting of course the metepicœle), and in part reach the subjacent cinerea to then help form its mass of capillaries. A subclass here—nuclear arteries—consists of 6 to 8 relatively large twigs entering the angulus restiformia olivaris and running parallel toward the middle of the floor of the metepicœle, to supply principally the centres for glosso-pharyngeus, vagus, hypoglossus, and acusticus. The following parts receive these radial or lateral affluents—the ventral columns, lateral nuclei, lateral cornu, caput of substantia gelatinosa, nuclei cuneati gracilis, arciformis et pyramidalis, and the oliva itself.

Width of Brain-arteries.—To make a relative estimate of the capacity of the arteries at the base, Bevan Lewis ("Examination of Brain," 1882, pp. 20–22) determined their average diameters in 45 cases (insane). That of the vertebral was, r. 3.147 mm., l. 3.42; of basilar, 3.82; of postcerebral, r. 2.658, l. 2.56; of carotid, r. 3.951, l. 4.02; of medicerebral, r. 3.133, l. 3.55; and of precerebral, r. 2.73, l. 2.66. The sectional areas are of course proportional to the squares of these diameters. As a rule, the united areas of branches equal very nearly the area of the parent trunk—excepting the preponderance of the vertebrals over the basilar (22.4 to 14.8).

Lowenfeld has found that the relation of the artery-width to the brain-weight is, even normally, somewhat variable, and that often, though not by any means in all cases, the width of the brain-vessels rises and falls with the width of the aorta; moreover, that not rarely abnormally small brain-arteries occur in otherwise well-developed arterial systems. He also made out a difference

in the two sides, the left carotid being usually wider than the right.

Pressure in the Brain-arteries.—A further matter, noted by St. John Bullen (*l. c.*) may partially indicate the relative pressures in the main brain-arteries. He remarked atheroma of the basal vessels in 410 of 1,565 autopsies, or 26 per cent. of the total. It was present to a considerable extent, either generally dispersed, or in special trunks only, in 175 cases, and to a less extent in 235. The relative frequency by location was: medicerebral, 38 per cent.; basilar, 30 per cent.; postcerebral, 21 per cent.; carotid, 10 per cent.

Mendel (1891) has found experimentally that the pressure in the cortical arteries is materially less than that in the carotids, while that in the striatal arteries is not materially less. This he attributes to the fact that the latter are terminal vessels, though it is doubtless quite as much due to their less circuitous supply. He further thus explains the frequency of hemorrhage in the striatal region.

Tedeschi's conclusions regarding the brain-arteries refer in part to moot points, but really contain nothing new and are deceptive in statement.

Veins. — The careful work of Hédon traverses this field along approved lines, and represents largely a verification of the work of others.

Oblongata Region. — The ventro-mesal chain of myelic veins is continued cephalad on the ventral surface of the oblongata to the furrow between this and the pons, there connecting with a fine venous network over the surface of the latter (Kadyi). This plexus in turn also connects with the veins of the cerebellum and of the base forward.

Besides irregular smaller ones, there are in particular two constant and considerable veins passing from this plexus, one on either side along the trigeminal nerve to the sinus petrosus (or cavernosus).

From the above-mentioned chain on the ventral surface of the oblongata, between the pyramids, there frequently arises a little trunk (up to ½ mm. or more thick) that joins one of the hypoglossal root-bundles and passes out with it through the precondyloid foramen—doubtless a part of Luschka's plexus venosus hypoglossi.

The dorso-myelic chain of veins is continued cephalad over the oblongata. From a constant mesal vein here a small veinule traverses the arachnoid, covering the cisterna magna. Sometimes this adjoins the accessory nerve, and Kadyi thinks it probably empties into the sinus plexus about the foramen magnum.

Among the cerebellar veins Hédon, referring to Merkel, mentions one that "comes from the flocculus and empties into the superpetrosal sinus. An important branch of this vein rises from the interior of the cerebellum in the region of the dentatum, receives also veins from the cerebellar medi-peduncle, and emerges with the peduncle under the flocculus. The main trunk can acquire a very considerable size when it receives a branch of the basilar vein" (Precerebellar vein, Fig. 67).

Other Veins.—A point once described by the writer has recently (1889) been more carefully gone over by Mittenzweig. In 200 cases he found 59 in which the pre-supracerebrals (to only 9 in which the post-supracerebrals) jumped over from the piarachnoid to the dura at 3 to 4 ctm. from the long sinus—thus favoring their rupture, as he thinks.

The post-perforating veins come, according to Hédon, from the cinerea of the walls of the diacœle, and even from the mesal surface of the thalamus. He also claims that in the striate nuclei the perforating veins anastomose with those going toward the cavities and Galen's system. He further recognizes the communications in the medicornu between the choroidal and the infra-cornual veins.

Developmental.—From various peculiarities in the vascular supply of the human brain, more especially the caudad displacement peripherally of the post-supracere-

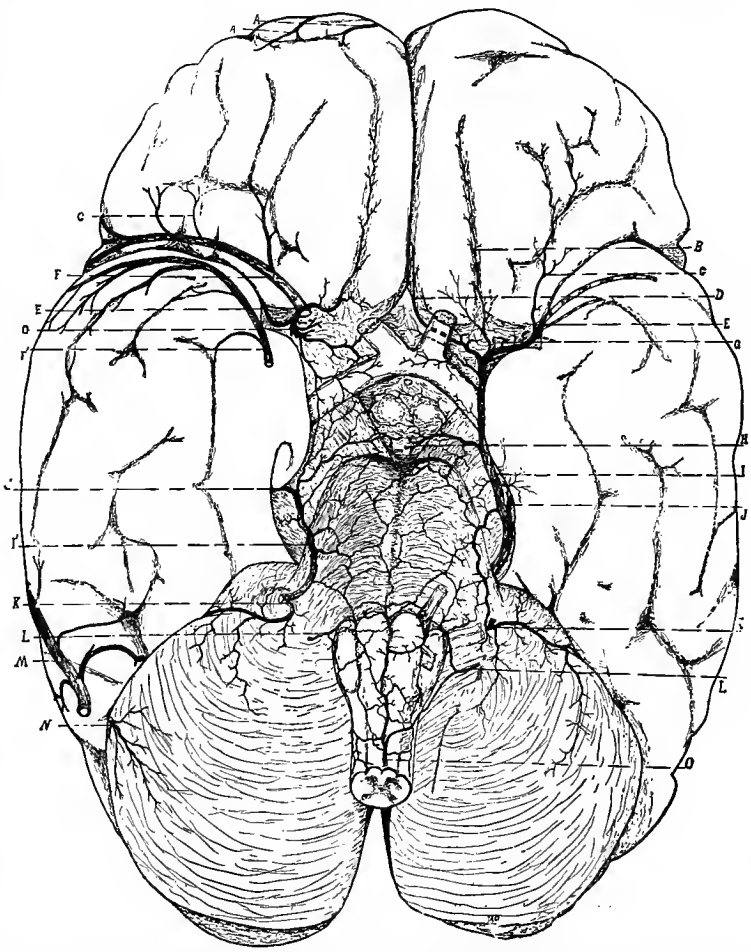


Fig. 67.—Veins of the Base (¾ nat. size). The two sides represent respectively the more common arrangements of these veins. Those of the myel and oblongata are largely after Kadyi. AA, supraccrebrals; B, ramus to olfactory bulb; CC, subfrontals; D, precerebral; EE, Sylvian or insular; F, medicerebral (to cavernous sinus); F′, post-medicerebral (per temporal sinus to superpetrosal); GG, preperforantes; H, postperforantes: I, subcerebral (to Galen's vein); I′, subcerebral (when emptying at base); JJ, subcornuals; KK, precerebellars; LL, hypoglossals (to precondyloid emissary); M, postcerebral (to lateral sinus); N, paracerebellar (to lateral sinus); O, ventrimyelic (anterior spinal).

bral veins, the writer has adduced evidence favorable in a general way to Hill's theory, and showing further that in any such rotation the brain and pia have glided caudad upon the dura and brain-case.

Here may be added a casual observation of a persistent fœtal form, made at the autopsy of a child of 22 months, dead of tubercular meningitis. The large left medicerebral vein took the temporal course in a deep groove (per temporal sinus, intradural), and passed out at the foramen jugulare spurium instead of passing to the supra-petrosal sinus, first, however, connecting with a much

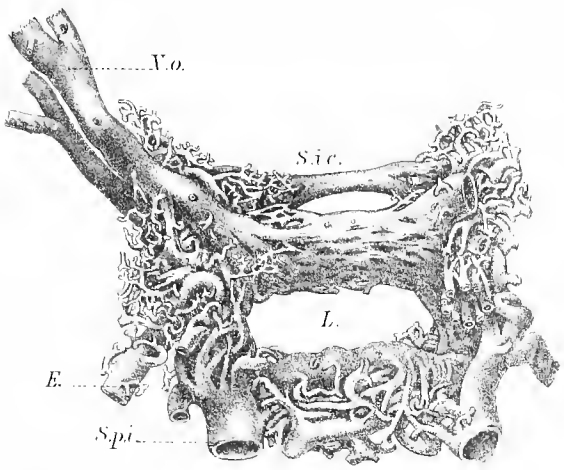


Fig 1.

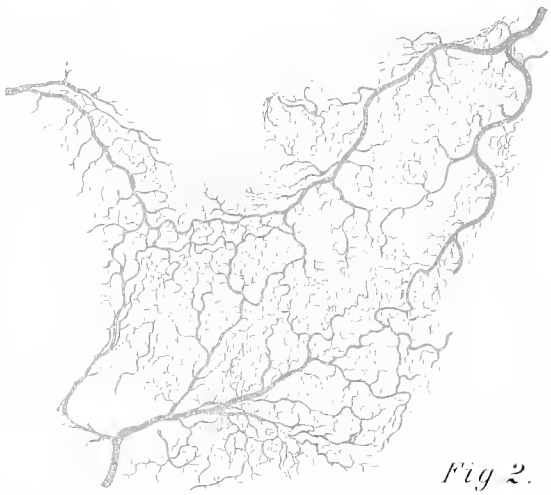


Fig 2.

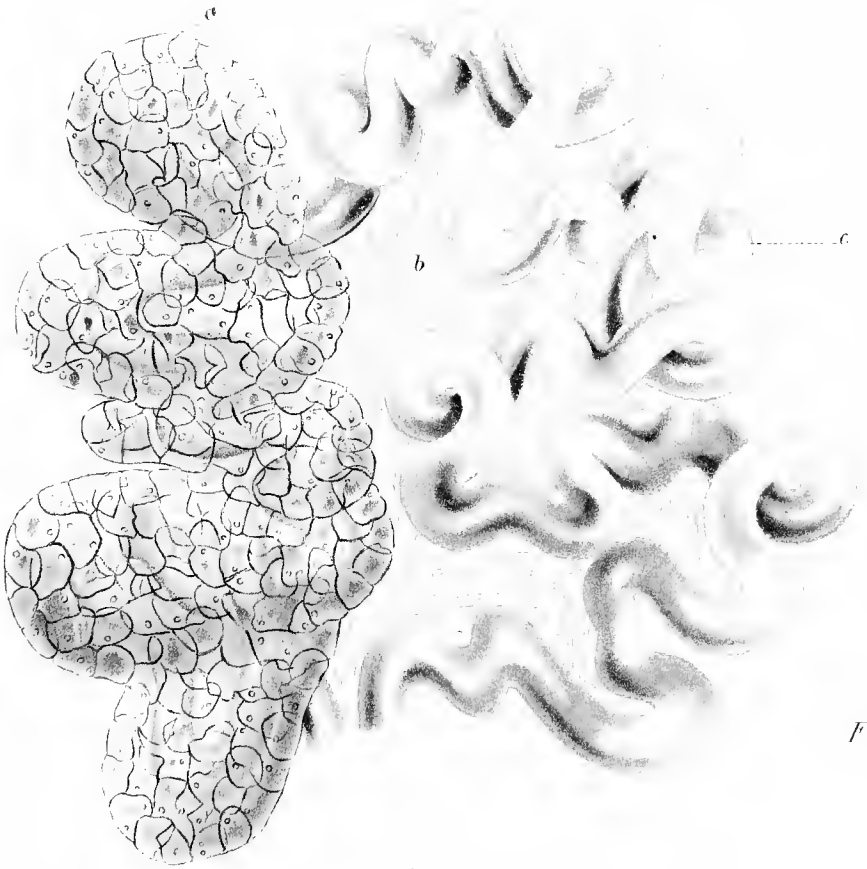


Fig 3.

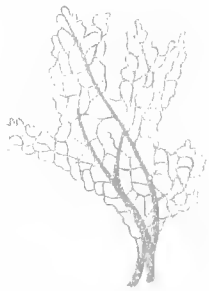


Fig 4.

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smaller prepetrosal sinus. No such appearance on the right.

SINUSES. *Occlusion.*—By experimental blocking of the dural sinuses in the dog, Ferrari (1888) has shown that a large part of the whole sinus system, *e.g.*, all the sinuses of the calvarium may be rendered impermeable without injury to the functions of the brain. However, occlusion of the collective blood-efferents from the skull is of course quickly fatal, being usually preceded by an epileptic attack. But all this and more had been already determined by clinical experience in man.

Lateral Sinus.—Körner (1889) has shown that intracranial disease from caries of the petrous is more frequent on the right, and from a study of 449 skulls he attributes this to the fact that the lateral sinus at its sigmoid flexure enters deeper into the mastoid and the petrous pyramid on the right than on the left, and thus on the right approaches nearer the primary focus of disease. In 22 cases on the right and 8 on the left, there were gaps in the bony partition. He also holds that in the brachycephali the sigmoid excavation goes lower and deeper than in the dolichocephali, and that hence in the former such encranial sequelæ follow more readily; but this has been disputed by Schülzke.

Birmingham, of Dublin (*Brit. Med. Journ.*, 1890, ii., 683) from an examination of 100 recent dry specimens, points out that the relations of the lateral sinus to the surface are extremely uncertain, owing both to variations in the sinus curves and to irregularities in the bones. It begins opposite the external occipital protuberance in fifty per cent.; lower (by never more than ½ inch) in thirty-three per cent.; and higher in seventeen per cent. It does not run forward horizontally, but is distinctly arched. The bend of the sinus where it turns down at the asterion may vary, within wide limits, from a gentle to a very sharp curve. It then runs down in front of the post-mastoid margin, about ½ inch behind the meatus, and turns into the jugular foramen about ¼ inch below the level of the meatus floor. Occasionally the sinus is only $\frac{1}{12}$ inch from the surface.

Venous Outlets.—Possibly a couple should be added from Hédon. Small rami accompany the olfactory bundles through the cribriform plate of the ethmoid, of course connecting above with the vein of the olfactory bulb. "A vein leaves the aqueduct of Fallopius by the stylo-mastoid foramen to anastomose with the external jugular or post-auricular (Sperino). It joins, according to Blandin, a small dural ramus traversing the hiatus of Fallopius."

LYMPHATICS.—The previous recorded results of Rossbach and Sehrwald, regarding lymphatics in the brain-substance, are evidently discredited by Frommann (*Centbl. f. med. Wissc.*, 1888, pp. 881–2). As regards the hypophysis, Pisenti and Viola (*Ibid.*, 1890, pp. 451–2) believe that certain structures observed by them represent lymph-spaces. A cortical lymph-connective system has been studied by Bevan Lewis.

Little evidence of lymphatics in the myel is found by Kadyi. The perivascular spaces of His occur, but are likely of artificial origin. From the results of one injection he figures a net-work of voluminous canals running longitudinally beside the central canal, and that possibly represent a lymphatic system.

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William Browning.

EXPLANATION OF PLATES.

PLATE XXXV.

ARTEBIAL SUPPLY OF OBLONGATA (FROM ADAMKIEWICZ), ENLARGED 6 DIAMETERS.

FIG. 1. At Decussation of Pyramids.

Hs, Dorsal Column.
Ng, Nucleus gracilis.
Nc, " cuneatus.
Sgc, Substantia gelatinosa centralis.
Ccp, Caput cornu posterioris (aut Tuberculum Rolando).
XII, Root of hypoglossus.
Vr, Remnant of ventral column.
Prk, Decussation eminence.
Py, Pyramid.
g, Boundary between Py and Vr.
S, Arteria sulci.
Sa, A. sulci (at deeper layers).
Acc, Aa. centrales cornuum anteriorum.
Aca, Aa. cornu anterioris.
Anl, A. nuclei lateralis.
As R, A. tuberculi Rolando.
Anc, A. nuclei cuneati.
Ang, Aa. nuclei gracilis.
F, A. fissuræ.

FIG. 2. Opposite Middle of Metepicœle.

H, Hypoglossus nucleus.
Va, Post. Vagus nucleus.
Po, Ponticulus (velum medullare posticum).
Gl, Glossopharyngeus nucleus.
Ac, Acusticus nucleus.
Lb, Longitudinal bundle. (Krause's respiratory fasciculus.)
Cr, Corpus restiforme.
X, Ant. Vagus nucleus.
IX, Root of Glossopharyngeus.
Arc, Angulus restiformio-olivaris.
O, Oliva.
No, Nucleus pyramidalis.
Ozs, Interolivary tract.
R, Raphé.
Py, Pyramid.
Na, Nucleus arciformis.
S, Arteria sulci.
Sce, Affluents to external nest-like capillary coils, from sulcus artery.
Sci, Affluents to inner same.
Aoli, Sub-lateral olivary artery.
Aso, Olivary ramus from sulcus artery.
Aoli, Sub-olivary arteries.
Aolm, Medilateral olivary artery.
Aols, Super-olivary artery.
An, Arteries of the nuclei (Glossopharyngeus, vagus, hypoglossus).
Vn, Nuclear vessels (glossopharyngeus, acusticus).
F, Arteria fissuræ.

FIG. 3. Longitudinal Section Through Olivary Body.

O, Oliva.
Br, Pons.
Aoli, Aa. olivæ laterales inferiores.
An, Aa. nuclearıæ.

PLATE XXXVI.

FIG. 1. Sinus Cavernosi et Intercavernosi—Sinus Circularis of Ridley.

Inferior aspect of a corrosion-preparation from a child, with afferents and efferents (somewhat enlarged, and also arbitrary as to execution of smaller vessels). From Langer's "Der Sinus cavernosus der harten Hirnhaut," *Sitzbr. d. k. Akad.*, 1885, Vienna (Fig. 5).

Vo, Vena ophthalmica superior et inferior.
Sic, Sinus intercavernosi.
E, Emissary veins passing through the oval foramen to the pterygoid plexus.
Spi, Sinus petrosus inferior.
L, Space for the dorsum ephippii.

FIG. 2. Fine anastomotic net-work between three arterial twigs in the pia of the parietal region. (Lucas, 1879.)

FIG. 3. Very perfectly injected vessels of a choroidal villus. Two hilus-vessels, a vein, and an artery. Loops, vascular nets, etc. Enlargement, 50 diameters. (From Luschka's "Die Adergeflechte des menschlichen Gebirns." 1855, Taf. ii., Fig. 2.)

FIG. 4. Lobule of a choroidal villus; one portion bare of epithelium. Sinuous vascular loop. Enlargement, 500 diameters. (Also from Luschka.)

a. = Portion covered by epithelium.
b. = Fibrillary connective tissue.
c. = Structureless connecting substance extending well beyond the capillaries.

BRIDES-LES-BAINS. A watering-place in Savoy, near Moûtiers, France.

LOCATION.—Brides-les-Bains is situated in a beautiful valley, with picturesque surroundings, about 1,800 feet above the level of the sea. The climate is mild and invigorating. Facilities for interesting excursions are plentiful, although the place is somewhat difficult to reach.

ACCESS.—From Paris, by the Paris, Lyons & Mediterranean Railroad, *viâ* Chambéry, to Albertville; thence by stage in about three hours to Brides.

ANALYSIS.—One litre of the water contains:

	Gramme.
Chloride of magnesium	0.3071
Chloride of sodium	1.3601
Chloride of potassium	0.0670
Chloride of lithium	traces
Sulphate of soda	1.6113
Sulphate of magnesia	0.1941
Sulphate of lime	1.8200
Bicarbonate of lime	0.4380
Carbonate of iron	0.0112
Carbonic acid gas	0.0837

The temperature of the springs varies from 85° F. to 95° F.

INDICATIONS.—These waters are employed in a great variety of affections, such as obesity, liver complaints, abdominal plethora, gastralgia, constipation, vesical catarrh, affections of the prostate gland, hæmorrhoids, cerebral congestion, neuralgia, migraine, sterility, heart affections, diabetes, gravel, and diseases of women. It is said that the waters, if taken in the morning before breakfast, in doses of from one to three glasses per day, are tonic and aperient in their effect; in stronger doses, of from four to eight glasses per day, they become laxative and purgative. They have the advantage that they can be taken daily for a long period as a slight purgative without causing the irritation produced by other more active waters. Season, middle of May to end of September.

ACCOMMODATION.—The *Grand Hotel des Thermes* is modern and good. The *Établissement des Bains* is equipped with the usual appliances for bathing, sprays, etc. There is a small *Casino*, and mild amusements are provided. The place is quiet, and devoid of fashionable life. *Edmund C. Wendt.*

BRIGHT'S DISEASES OF THE KIDNEY, DELAFIELD'S CLASSIFICATION OF. Since pathologists have learned to distinguish the various diseases of the kidneys, formerly grouped under the one designation of Bright's disease, there has been an effort made to do away with this name as one that is indefinite and even misleading; yet so strong a hold has it acquired in the popular language that it is doubtful whether it will ever be supplanted. And, indeed, it is not necessary that it should cease to exist as a synonym for disease of the kidneys, for popular medical nosology knows as little of, as it cares for, pathological distinctions. It is, however, exceedingly desirable that the name should be dropped from scientific nomenclature, as its retention only serves to create confusion in the minds of students and to obscure the subject, at its best not a simple one, of the pathology of renal diseases. No modern writer would publish a work on pulmonary diseases and call it a treatise on "Consumption," yet it would be just as proper a term for diseases of the lungs as "Bright's disease" is for those of the kidney.

Writers have of late come to realize the inconvenience of this term, and have endeavored, after freeing themselves from the bondage of the name, to study renal diseases as distinct affections and group them scientifically, for a proper classification is essential to a clear comprehension of these different affections. The favorite method of grouping these diseases has usually been according to the part of the kidney involved, and we have therefore had such terms as "parenchymatous nephritis," "arterio-sclerosis," "glomerulo-nephritis," etc.—unsatisfactory enough, since the same inflammatory process may involve widely different parts of the organ, or the same parts may undergo varied and dissimilar pathological changes. A much better classification of diseases of the kidneys is one according to the nature of the morbid process, such an one as was proposed a few years ago by Professor Francis Delafield, of New York, which has commended itself to many pathologists and clinicians by reason of its simplicity and reasonableness, and which has already been adopted by many teachers and writers on renal diseases. A request had been made of the editor of this HANDBOOK that, in case a supplementary volume should be issued, place might there be given to an exposition of this mode of classification; and although Dr. Delafield was unable to prepare such an article, he very kindly placed his material at the disposal of the present writer, with permission to draw therefrom freely. He has also revised the article, so that the views here expressed may be regarded as his own. No attempt at originality of composition has been made, since the object of the writer was simply to give a *résumé*, as brief as might be consistent with clearness, of Dr. Delafield's published writings on the subject; and therefore the author's arrangement has been closely followed throughout, and in many places his very words have been borrowed. Any long extract taken bodily from his article in the *American Journal of the Medical Sciences* for October, 1891, has been marked by inverted commas.

There are three morbid processes concerned in the production of the various pathological changes in the kidneys formerly included under the term "Bright's disease," viz., congestion, degeneration, and inflammation. These three processes may be further divided according as they are acute or chronic, or as the inflammation is exudative simply, productive, suppurative, or tubercular. The Bright's diseases of the kidneys may therefore be classified as follows:

I. Congestion.	Acute.	
	Chronic.	
II. Degeneration.	Acute.	
	Chronic.	
III. Inflammation.	Acute exudative.	
	Acute productive or diffuse.	
	Chronic productive or diffuse.	With exudation.
		Without exudation.
	Suppurative.	
	Tubercular.	

I. CONGESTION.—*Acute congestion of the kidney* is a transitory condition caused by the ingestion of certain poisons, by traumatism, by operations, especially those on the bladder or urethra, by extirpation of one kidney, by over-exertion, or by taking cold.

There are no alterations in the renal tissues, the only change in the organ being the engorgement of the blood-vessels. Congestion may occur, however, not only in a normal kidney, but in one previously diseased, and in this case the lesions of the pre-existing disease will, of course, be present.

The urine is diminished in quantity, or, at times, even suppressed. It may contain albumin and casts, and occasionally blood: the specific gravity is, as a rule, unchanged. Usually constitutional symptoms are slight or absent, but in cases following surgical operations on the urethra or bladder, or extirpation of the other kidney, there may be considerable depression of the vital forces, ending in collapse, or a typhoid state with mild delirium may supervene. Acute renal congestion is usually recovered from, though it may in rare instances cause death. Repeated attacks, however, may lead finally to inflammation of the kidney.

The treatment consists in confinement to bed and in securing free action of the bowels and skin, the latter being accomplished by means of heat applied to the surface of the body.

Chronic congestion of the kidney is a secondary condition of engorgement of the renal vessels, following long continued interference with the venous circulation. It may be due to aortic or mitral disease, dilatation of the heart, excessive pleural effusions, pulmonary emphysema, or other obstructive diseases.

The kidneys are smooth, with non-adherent capsule, and are usually enlarged, though exceptionally they may remain of normal size; they are heavier than healthy kidneys and are also darker in color. The capillaries of the glomeruli are dilated and thickened; the veins of the pyramids are always, those of the cortex rarely, distended. There is commonly either swelling or flattening of the epithelium of the cortex tubes, although it occasionally appears to be unchanged.

The urine varies in quantity, but is usually diminished, the proportion of urea, however, being commonly increased. The specific gravity is ordinarily about 1.020 to 1.025, but may vary all the way from 1.010 to 1.035. There is little or no albumin, and casts are generally absent, though both may at times be found. The general symptoms are those of the primary disease, and the treatment is to be directed to this almost entirely.

The prognosis is grave, chiefly because of the tendency of chronic congestion to pass into chronic inflammation of the kidney.

II. DEGENERATION.—*Acute degeneration of the kidneys* is a secondary condition caused by the action of arsenic, mercury, or phosphorus, or of one of the toxines formed

in the body during the course of certain of the acute infectious diseases.

The lesions are confined to the renal epithelium, being most marked in that of the convoluted tubes. Here we find the epithelial cells simply swollen and irregular in outline, infiltrated with granular matter, disintegrated, containing hyaline masses, or in a state of coagulation necrosis. The kidneys are usually somewhat enlarged, with smooth surface and non-adherent capsule. When the degenerative process has been very rapid the blood-vessels are irritated and we then have congestion and exudation of serum, and thus a secondary exudative inflammation is added to the degeneration.

The urinary changes and general symptoms are in proportion to the extent of the degenerative process. In mild cases, such as occur with the acute infectious diseases, there are no symptoms beyond a moderate amount of albumin and some casts in the urine. But in severe cases, such as accompany yellow fever, or follow poisoning by arsenic, mercury, or phosphorus, albumin and casts are found in large quantities, white blood-cells are present, and the urine is scanty or even suppressed. The specific gravity of the urine is normal and there is no dropsy. In mild cases recovery is the rule, but in the more severe ones the kidney lesion is a direct menace to life.

There is no treatment for the degenerative changes, but if secondary exudative inflammation occurs the indication is to cause free movement of the bowels and diaphoresis.

Chronic degeneration of the kidneys, like the acute form, is a secondary process. It results from the same causes that may produce chronic congestion, or from alcoholism and vicious modes of life, or it may occur in the course of certain chronic diseases.

The degenerative changes are confined to the epithelium of the convoluted tubes which is swollen and the seat of fatty infiltration. When chronic congestion coexists the lesions of the glomeruli associated with that condition—dilatation and thickening of the capillaries—will be present. The kidneys are usually increased in size, though they may be normal or even smaller than in health; the surface is smooth. The pyramids are red, while the cortex may be whitish, yellow, or pink in color.

The urine may be increased in amount, scanty, or suppressed, the quantity varying in different cases and at different times in the same case. It frequently contains albumin and casts, but the specific gravity is not lowered and the relative proportion of urea is not decreased. The health of the patients is impaired; they fall away in flesh and strength, become anæmic, and finally pass into the typhoid state with delirium and stupor. Dropsy is not a symptom of chronic degeneration of the kidneys.

Treatment is usually ineffective, and the disease progresses steadily to a fatal termination, at best retarded only by the therapeutic measures employed. Of course, the exciting cause (alcoholism, irregular mode of life, etc.), should be removed or minimized as far as possible.

III. Inflammation.—The varieties of inflammation of the kidneys are:

Acute exudative nephritis.

Acute productive or diffuse nephritis.

Chronic productive or diffuse nephritis with exudation.

Chronic productive or diffuse nephritis without exudation.

Suppurative nephritis.

Tubercular nephritis.

Acute Exudative Nephritis.—This is one of the forms of kidney disease known as acute Bright's disease, acute parenchymatous, tubal, or desquamative nephritis, etc. It is "an acute inflammation of the kidney, characterized by congestion, exudation of the blood-plasma, an emigration of white blood-cells, and a diapedesis of red blood-cells from the vessels; to which may be added swelling or necrosis of the renal epithelium and changes in the glomeruli." The disease occurs as a primary inflammation or may complicate any of the acute infectious diseases or the puerperal state.

In mild cases there are no marked changes in the kidneys, the inflammatory products in the Malpighian bodies and tubes being discharged with the urine as fast as they are exuded. In more severe cases we find the red and white blood-cells, serum, and coagulable matter from the blood-plasma in the tubes, Malpighian bodies, and stroma, especially in the cortical portion. The kidneys are increased in size, smooth, and intensely congested. The epithelium of the cortex tubes is often flattened, as in the chronic congestion secondary to heart disease, or it may be swollen, or more rarely degenerated and detached. In some cases there is, in addition to the flattening of the cells, a uniform dilatation of all the convoluted tubes. Irregular masses, formed of coagulable matter from the blood-plasma, and hyaline casts are found in the tubes, the latter being more abundant in the straight tubes, the former in the convoluted ones. Red and white blood-cells may also be found in the tubes. When there is an excessive emigration of white cells these are usually found collected in foci in the cortical portion, and not uniformly distributed throughout the kidney.

In the glomeruli the capsular epithelium is swollen and there is also a swelling and growth of the cells covering the capillaries. In consequence of this latter change, although the outlines of the main divisions of the tufts may be visible, those of the capillaries are lost. In some cases the walls of the branches of the renal artery within the kidney are seen to be thickened, a result chiefly of the swelling of their muscle-cells.

The urine in mild cases of acute exudative nephritis is somewhat diminished in quantity, of normal or high specific gravity, and contains albumin and hyaline, granular, and epithelial casts in moderate numbers, and occasionally blood. The constitutional symptoms are often insignificant, consisting merely of a slight malaise, headache, and some aching in the back and limbs. The constitutional symptoms last from one to two weeks, the urinary changes from four to five.

In severe cases the changes in the urine are much more pronounced. The quantity is greatly reduced, or it may even be suppressed; the specific gravity is not lowered and may be raised; there is a large amount of albumin, casts are abundant, and epithelium and white and red blood-cells are often present. The amount of albumin and casts in the urine is usually, though not always, proportionate to the severity of the disease. The constitutional symptoms are also more marked. "A febrile movement with more or less prostration; stupor, headache, sleeplessness, restlessness, muscular twitchings, and general convulsions; dyspnœa, loss of appetite, nausea, and vomiting; a pulse of high tension with exaggerated heart-action, or hypertrophy of the left ventricle, dropsy, and anæmia—these may be called the characteristic symptoms of acute exudative nephritis. Of these symptoms a certain number—the fever, the prostration, the loss of appetite and nausea, the anæmia, the diminution in the quantity of urine, the albumin and casts in the urine—are such as would naturally accompany an acute inflammation of the kidney, and very often they are the only symptoms which do accompany it."

In a certain number of cases there are, in addition to these features, cerebral symptoms, dropsy, and changes in the heart and circulation. That these do not, in all cases at least, depend upon the diminished excretion of urine is evidenced by the fact that they are often absent in patients who are passing very little urine, and are often present in persons who are passing an abundance of urine of normal or high specific gravity. It is not improbable that they depend upon some morbid state, whether spasmodic or inflammatory, of the arteries and capillaries, whereby the passage of blood through them is impeded.

In cases in which there is an excessive production of pus-cells the symptoms not infrequently resemble very closely those of acute meningitis. "The invasion is sudden, with a high temperature and marked prostration. Restlessness, delirium, headache, and stupor are soon developed and continue throughout the disease. The patients lose flesh and strength and pass into the

typhoid state. Dropsy is slight or absent altogether. The urine is not so much diminished in quantity as one would expect; its specific gravity is not changed; albumin, casts, and red and white blood-cells are present in considerable quantities, but not always early in the disease, and may even be absent altogether."

This form occurs in children or adults as a sequel of diphtheria, measles, or scarlatina, or it may be a primary inflammation. It is uniformly fatal, but fortunately is not of very common occurrence.

The prime indication for treatment is to relieve the congestion of the kidneys, avoiding as a rule the use of diaphoretics or cathartics. This congestion is relieved partially and temporarily by means of the hot-air bath, dry or wet cups, hot applications to the lumbar region, or the exhibition of small doses of calomel or magnesium sulphate repeated at short intervals until the effect upon the bowels begins to be manifested. In order to prevent the cerebral symptoms the condition of the circulation should be closely watched. As soon as signs of increased tension of the arteries and labored action of the heart become evident, drugs to relieve this state should be given. These are aconite, nitro-glycerine, chloral hydrate, and opium; they should be given in small doses at regular intervals, but if the cerebral symptoms appear threatening then large doses by the rectum or subcutaneously are called for. The patients are to be kept in bed and put on a fluid (milk) diet until the disease begins to subside; then solid food may gradually replace the milk, and iron and oxygen will be indicated to overcome the anæmia.

Acute Productive or Diffuse Nephritis.—This is an acute exudative inflammation of the kidneys, to the lesions of which are superadded certain characteristic changes in the glomeruli and a growth of connective tissue in the stroma; its lesions are of a permanent character, and it is frequently associated with circulatory disturbances. It is very often met with as a primary disease, or it may complicate scarlatina, diphtheria, or the pregnant state.

The kidneys are smooth in the early stages of the disease, later roughened; the pyramids are red, and the cortex is thickened, white, mottled with yellow and red, or congested. The lesions are those of exudative nephritis with the addition of a growth of connective tissue in the stroma and of an increase in the capsule-cells of the Malpighian bodies. These additional changes, which are present from the first and are characteristic of this form of nephritis, are not uniformly distributed throughout the organ but are confined to strips or wedges following the line of the arteries. These wedges may be small, symmetrical, and few in number, or large, irregular, and numerous. Each wedge contains one or more arteries running up into the cortex and terminating in the tufts of the glomeruli; the walls of these arteries are thickened, there is a growth of cells upon and in the capillaries forming the tufts, and the corresponding Malpighian bodies show an excessive growth of the capsule-cells; in the stroma around these arteries, and parallel to them, is a growth of connective-tissue cells and basement substance. The growth of the cells lining the capsules is so great as to compress the tufts, the capillaries of which then become obliterated, and the glomeruli are finally changed into little balls of fibrous tissue. The new growth of connective tissue in the stroma leads to compression, and finally to atrophy, of the tubes around which it is formed.

The urine is scanty or suppressed, of high specific gravity, and contains a large amount of albumin, many casts, and red and white blood-cells. Later, the urine becomes more abundant, of lower specific gravity, and contains fewer casts and less albumin; or it may be that these less pronounced changes are present from the first. The general symptoms are headache, sleeplessness, muscular twitchings or general convulsions, anorexia, nausea and vomiting, dyspnœa, neuro-retinitis, diarrhœa, hypertrophy of the left ventricle of the heart, increased arterial tension, loss of flesh and strength, dropsy often extreme, and finally delirium, stupor, and coma. These symptoms vary according to the intensity of the morbid process, and there are often remissions simulating complete recovery. The disease is, however, a progressive one, and although life may be prolonged for a considerable period by appropriate treatment a fatal result comes sooner or later.

The treatment is essentially a climatic one, residence in a warm, dry, equable climate being most important. In some cases, during the early stages, a measure of relief may be obtained by the plan of treatment followed in acute exudative nephritis. For the dropsy, diuretics, diaphoretics, and cathartics are indicated; sometimes puncture of the skin or tapping of the serous cavities becomes necessary; but occasionally this condition refuses to yield to any mode of treatment. The arteries should be watched, as in acute exudative nephritis, and if they begin to show signs of increasing tension the appropriate remedies mentioned above are called for.

Chronic Productive or Diffuse Nephritis with Exudation.—This is a chronic inflammation attended with growth of connective tissue in the stroma, changes in the glomeruli, degeneration of the epithelium, exudation from the vessels, and sometimes changes in the walls of the arteries. The amount of exudation varies at different times, occasionally being so slight that little or no albumin is found in the urine. It should be remembered that the two forms of productive nephritis here described are essentially the same disease, differing only as there is or is not an exudation of serum from the blood-vessels in addition to the lesions of the productive inflammation. The disease may occur as a primary affection, may follow acute diffuse nephritis or chronic congestion or degeneration of the kidneys, or may complicate syphilis, tuberculosis of the lungs, bones, or joints, chronic endocarditis, or prolonged suppuration.

The kidneys are usually large, but may be small or of normal size, and are smooth, roughened, or nodular; the cortex is the seat of an extensive growth of connective tissue, its tubes being atrophied in some places and dilated in others; the straight tubes contain coagulated matter, cylinders, or blood; the renal epithelium is swollen or flattened, broken, granular, or fatty. "The glomeruli are changed in several different ways: 1. There is a growth of the capsule-cells in such numbers that they compress the tufts. The cells covering the capillaries are also increased in size and number. The capsule-cells may finally be changed into connective tissue and the tufts become atrophied. 2. The glomeruli are of large size, the cells covering the capillaries are increased in number so that the outlines of the capillaries are lost, but yet the capillaries are not compressed nor the glomeruli atrophied. 3. There is a growth of the cells which cover the capillaries and of the cells within them. Of the cells which cover the capillaries the cell-bodies become very large, the capillaries are compressed, and the glomeruli eventually become atrophied. 4. The walls of the capillary vessels become the seat of waxy degeneration, while the cells which cover them are increased in size and number. 5. If the nephritis follows chronic congestion, the capillaries are dilated and there is an increase in the size and number of the cells which cover the capillaries. The arteries remain unchanged, or they are the seat of obliterating endarteritis, or there is a symmetrical thickening of all the coats of the artery, or all the coats of the artery are thickened and converted into a uniform mass of dense connective tissue, or there is waxy degeneration of the walls of the artery."

During the exacerbations of the disease the urine is generally diminished in quantity or suppressed, but during the quiescent periods it may be normal; when the patients are doing badly, and often when they are dropsical, the quantity is greatly increased. The specific gravity slowly diminishes as the growth of connective tissue in the stroma of the cortex increases or when the capillaries of the glomeruli become the seat of waxy degeneration. Albumin and casts are present, usually in large quantity, but varying according to the activity of the inflammatory process in the kidney. Dropsy is of very constant occurrence in this form of renal disease,

being either continuous or coming and going from time to time. Other symptoms are marked anæmia, headache, sleeplessness, neuro-retinitis, cough, anorexia, nausea and vomiting, and dyspnœa. The latter when due to contraction of the arteries or to failure of the heart's action, is often the first thing that attracts attention to the kidney lesion; it comes on in attacks, especially at night and when the patient is lying down. The most constant symptoms are anæmia, dropsy, and albumin in the urine.

The course of the disease is almost infinite in its variety: "1. There are cases in which the symptoms are nearly continuous, the patients get steadily worse and die within one or two years. The anæmia, the dropsy, and the albumin are constantly present, and the patients die with dropsy or with chronic uræmia. 2. There are cases in which the anæmia, the dropsy, and the dyspnœa come on in attacks which last for weeks or months. Between the attacks the patients are comparatively well, often able to work, although the urine always contains albumin. 3. There are cases in which a number of years before death the patient has an attack of dropsy, etc., from which he apparently recovers and goes on able to work, but with urine of low specific gravity, which sometimes contains albumin. After an interval of many years comes the fatal attack, with all the characteristic symptoms. 4. There are cases which for years have no symptoms but pallor of the skin and urine of low specific gravity containing albumin. These patients often for a long time feel so well that they cannot understand that they have a serious disease. 5. There are cases in which the first symptom is the attack of spasmodic dyspnœa, the patients otherwise feeling well. It may be months or years before the other symptoms are developed. 6. There may be a history of chronic endocarditis lasting for years before the renal symptoms are developed. 7. There are cases which apparently recover from the disease."

The best results are obtained by sending these patients to a warm, dry climate where they can be much in the open air. As the urine contains a proportionately small amount of urea, its quantity must be maintained above the normal, if possible. The dyspnœa, convulsions, coma, and other symptoms due to arterial contraction will call for nitrite of amyl, nitro-glycerine, chloral hydrate, or opium.

Chronic Productive or Diffuse Nephritis without Exudation.—This form of nephritis is usually secondary to alcoholism, chronic lead-poisoning, gout, chronic congestion of the kidneys, hydronephrosis, or chronic pyelitis, or is brought about by the same conditions as those which cause emphysema, endocarditis, endarteritis, and cirrhosis of the liver.

The kidney is usually diminished in size, the two together often weighing only about one-half as much as one normal kidney. The surface is roughened or nodular, the cortex is thin and red or gray in color. In not a few cases there is no diminution in size, and there may even be an increase, but in all cases the capsule is adherent and the surface roughened. There is a progressive formation of new connective tissue in the cortex and pyramids, compressing and finally obliterating the tubes. The tubes not involved in the new growth become dilated, sometimes forming cysts of considerable size; the epithelium of these dilated tubes may be flattened, swollen, cuboidal, degenerated, or fatty. When the disease follows chronic congestion the glomeruli are large and there is a marked growth of cells covering the capillaries of the tufts; in other cases many of the tufts are compressed by the excessive growth of their cells and of those lining the capsules, and finally become converted into little fibrous balls. The capillaries of the glomeruli may also become the seat of waxy degeneration. The changes in the arteries are the same as those described as occurring in chronic nephritis with exudation.

Among the complicating lesions of this form of chronic nephritis we find hypertrophy of the heart, valvular disease, pulmonary emphysema, cirrhosis of the liver, pericarditis, bronchitis, or gastric catarrh.

The urine is usually increased in quantity, of a specific gravity of about 1.010, with little or no albumin or casts, except during exacerbations of the nephritis, and containing a diminished amount of urea. This is the typical urine of chronic non-exudative nephritis, but it is subject to important modifications. The specific gravity may remain constantly as high as 1.023, or it may fall almost to 1.000. In some cases several quarts of urine may be passed in the twenty-four hours, in others the secretion may amount to only a few ounces, or may even be suppressed entirely.

Dropsy is ordinarily absent except in cases complicated by chronic endocarditis or cirrhosis of the liver. Headache is sometimes a most distressing symptom, and neuralgic pains in various parts of the body are not uncommon. Sleeplessness is often complained of. Muscular twitchings and convulsions may appear early or late in the course of the nephritis. Hemiplegia may occur early and continue up to the end, or may disappear after a few hours or days; there may be several such attacks accompanied by aphasia or coma, or there may be periods of delirium with elevated temperature and contracted arteries—acute uræmia. Instead of these acute attacks the uræmic symptoms may come on gradually; the temperature is then usually low and the pulse rapid and feeble. Neuro-retinitis, bronchitis, emphysema, cardiac hypertrophy, valvular disease, chronic gastritis, and vomiting, one or more, are observed with more or less frequency in cases of chronic non-exudative nephritis.

"Dyspnœa is a very frequent symptom, often the first symptom noticed by the patient. It is a spasmodic dyspnœa coming on in attacks which last for minutes, hours, or days. It is regularly made worse by mental or bodily exertion, or by the recumbent position. It does not resemble pulmonary asthma. It is apparently due to the association of changes in the arteries and in the heart. With contraction of the arteries alone, or with a feeble heart alone, no dyspnœa may exist; but if the contraction of the arteries is so great that the hypertrophied and laboring heart is unable to overcome the obstruction, or if with the contracted arteries the heart becomes dilated or feeble, then the attacks of dyspnœa begin. At first the attacks are not severe and are of short duration, but if the mechanical conditions which cause them cannot be controlled they become longer and more distressing.

"Perhaps the most striking examples of this dyspnœa are in the patients in whom it is the first symptom of the nephritis. They are apt to be middle-aged or elderly men, often engaged in large financial or commercial enterprises. They profess that they feel quite well and that they can attend to their affairs perfectly, but that they are very much annoyed because early every morning they have an attack of asthma. In spite of their professions of good health, it is evident that they are pale and that they have dyspnœa on exertion. The heart is found to be enlarged, with or without a murmur; its action is either labored or feeble. The pulse is tense. The urine is of a specific gravity of 1.010 to 1.030; it contains no albumin, or only a trace. In the earlier stages of the disease this dyspnœa can be controlled, but later on it is more distressing and difficult to remedy."

While chronic diffuse nephritis, like the chronic productive inflammations of other organs, may be a serious and fatal disease, like them it may also exist as a lesion which does not interfere with general good health and a long life; and it is not at all uncommon to find evidences of the disease in persons who have died from other causes. The subjects of this lesion are, however, in constant peril, for though they may appear to be in fair health they are liable to succumb speedily to an attack of pneumonia or pericarditis, or to the shock of a severe injury.

"A very common form for the disease to take is that of attacks which are repeated a number of times, each attack worse than the preceding, and the general health more and more impaired between the attacks. During the attacks there are cerebral symptoms more or less severe—headache, sleeplessness, delirium, stupor, coma,

convulsions. Dyspnœa may be present or absent. The arteries are contracted, with a tense pulse. There is loss of appetite, nausea, and vomiting. The urine is of low specific gravity and usually contains albumin. Between the attacks the patients at first seem to be fairly well, but later they gradually lose flesh and strength. The urine between the attacks is of low specific gravity and contains little or no albumin. They finally die in one of the attacks, feeble and emaciated.

"In some of the patients spasmodic dyspnœa is the first symptom. This can often be controlled for months and years, and the patients then seem to be well. But after a time it is more difficult to manage, and other renal symptoms are added. In some cases there are no symptoms for a long time, so that persons apparently in good health are attacked without warning by convulsions, coma, delirium, or hemiplegia. They may die in the first attacks or live to go through subsequent ones. In some cases the only symptoms up to the time of the patient's death are gradual loss of flesh and strength and disturbance of digestion, the patient dying feeble and emaciated. These cases are hard to make out, unless the specific gravity of the urine is low and a little albumin is present. Otherwise there is nothing to draw attention to the kidneys as the cause of the illness. Loss of eyesight from nephritic neuro-retinitis may be the first symptom."

The treatment consists mainly in a regulation of the diet and mode of life, and in change of climate. The use of alcohol and tobacco should be stopped, and starches and sugars should be removed as far as possible from the dietary, the ingestion of fats on the other hand being encouraged. Residence in a climate that will permit of regular out-door exercise is advisable, and a change of scene and air occasionally is most desirable. The condition of the heart and arteries should be most carefully watched, and any signs of beginning tension should be at once met by the exhibition of the arterial dilators. A weak heart calls for cardiac stimulants. The use of opium is apparently safe when the arteries are contracted, but if they are not, a very little opium may prove fatal. In general convulsions or sudden coma, hypodermic injections of from one-eighth to one-quarter of a grain of morphine may be of decided benefit; and in cases of restlessness or wakefulness, with persistent arterial contraction, much relief may be obtained by an injection of one-eighth of a grain of morphine every three hours.

The other forms of inflammation of the kidneys, namely, suppurative and tubercular, do not call for consideration here, as they are not properly included under the designation of "Bright's diseases."

Thomas L. Stedman.

BROMOFORM (Terbromide of formyl, $CHBr_3$). In chemical composition it is analogous to chloroform, $CHCl_3$, and iodoform, CHI_3. It is formed by the action of brominated lime on alcohol in the same way that chloroform is made from chlorinated lime and alcohol. It is a bright clear liquid, specific gravity 2.9, taste sweet, without causing any irritation to the mucous membrane of the mouth; it has an ethereal odor, is almost insoluble in water, but is soluble in alcohol and ether. It is very volatile and is rapidly decomposed by light, bromine fumes being evolved which impart a pink color to the liquid.

Bromoform possesses anæsthetic properties, but in a less degree than chloroform, the period of excitement is less pronounced, and the anæsthesia is of shorter duration. It is also a powerful antiseptic.

A new application of this drug was brought to the notice of the profession in 1889 by Dr. Stepp, of Nuremberg, who advocated its use in whooping-cough. He claimed that the course of the disease was shortened in every instance, that the paroxysms were diminished in number and severity, and that complications were less frequent, and when present were benefited by the treatment. The dose he gave was as follows: From six months to one year, 2 minims three times a day; from one to two years, 3 minims; from two to three, 4 minims; from three to four, 5 minims; and from four to seven, 6 or 7 minims. In prescribing the remedy its high specific gravity must be remembered, one minim being equal to five drops. When administered internally no deleterious effects have been observed beyond an occasional sense of depression and lassitude. Two cases of poisoning have been recorded. In each instance the child had taken a large dose of the pure drug; it produced profound depression and collapse, from which both children recovered.

The drug is best given in a teaspoonful of water; it forms a "bead" in the water which is easily swallowed. It may be given in solution in water to which a small amount of alcohol is added, but should always be freshly prepared on account of its instability. How the drug acts is uncertain—whether as a specific, or on account of its germicidal properties, has not been determined. Dr. Stepp thinks bromine is excreted by the lungs after the drug has been decomposed in the system. The reports of others who have used it for this purpose corroborate the views of Dr. Stepp as to its efficacy in whooping-cough and its freedom from bad effects. *Beaumont Small.*

BROMOL (Tribromophenol). Is formed by adding bromine water to a solution of phenol. It is deposited in white crystals, taste is sweet and astringent, odor resembling bromine; it is nearly insoluble in water, soluble in alcohol, ether, oils, and glycerine.

It has been introduced as an antiseptic in the treatment of wounds, ulcers, etc. Applied in its pure state it has a slight caustic action and favors the removal of sloughs. As a dressing it is applied in solution in oil or as an ointment, one part in thirty. It has been used in diphtheria as a local application to disinfect the throat and remove the membrane.

When administered internally it is not acted on by the gastric secretions, and in the intestines is but slowly decomposed. Its action is therefore slow and prolonged. It is given in doses of 3 to 5 grains a day, and has proved of service as an intestinal antiseptic in cholera infantum and typhoid fever. For infants $\frac{1}{4}$ to $\frac{1}{3}$ grain may be given at each dose. *Beaumont Small.*

BUSSANG. A watering-place in the Vosges Mountains, France, used chiefly for "after-cures," although it boasts of several mineral springs.

Location.—The situation of Bussang in the Vosges Mountains, about two thousand feet above the level of the sea, is decidedly attractive, on account of the hills and fine forests in the immediate vicinity. The climate is, on the whole, bracing and tonic. The air is pure mountain air, as Bussang is right among the higher mountain peaks of the Vosges, at the foot of the Drumont and Rouge Gazon. The Moselle River rises near the principal hotel of the place. Near the German frontier is the *Col de Bussang*, "one of the most picturesque points of the entire Vosges." Mr. Wolff states ("The Watering-Places of the Vosges") that, as a watering-place, Bussang owes its reputation to three chalybeate springs, only two of which are at present worked. The principal is the *Source de Salmade*, which is used only for drinking. There is not very much bathing, but the baths are well organized and clean, and very refreshing. Massage is often combined with them. In fact it could not be spared for bathing, because in the busy time something like ten thousand litres is sometimes bottled in a day. The annual sale exceeds one million two hundred thousand bottles. The water is only slightly mineralized, containing about 1.5 gramme of solid matter in a litre. On the other hand, it is so strongly impregnated with carbonic acid, that carbonic acid intoxication has been known to result from too free use.

The Bussang water is not, like many other chalybeate springs, constipating, having, on the contrary, a mild aperient effect.

Access.—The village is reached from Paris, by way of Epinal, thence by stage or carriage.

Analysis.—Two springs are found, both almost iden-

tical in chemical composition. In one thousand parts there are found:

	Salmade. Parts.	Marie. Parts.
Silica	0.0641	0.0536
Oxide of iron	0.0059	0.0024
Red oxide of manganese	0.0019	0.0020
Alumina	0.0012	0.0011
Calcium	0.1519	0.1880
Magnesium	0.0506	0.0540
Carbonic acid (in combination)	0.7390	0.7277
Arsenic	0.0005	0.0004
Sulphuric acid	0.0904	0.0806
Chlorine	0.0507	0.0497
Sodium	0.3495	0.2890
Potassium	0.0346	0.0264
Lithium	0.0012	0.0010
Phosphoric acid / Boracic acid, fluorine	traces	traces
Total of solids	1.5414	1.4759
Free carbonic acid	2.8719	2.4934
Temperature	54° F.	50° F.

INDICATIONS.—Mr. Wolff is authority for the statements that, "the treatment at Bussang is not a very serious affair. There is no restrictive diet of any sort. You go to Bussang mainly to gather strength, and pick up the crumbs dropped at more exhausting watering-places. Durand-Fardel, the acknowledged authority on French waters, recommends Bussang water for dyspepsia, gastralgia, and chlorosis, and as a capital substitute for Vichy in the case of people who cannot stand the strongly mineralized spring of that place. Dr. Onimus, the doctor of the spa, also speaks of excellent results obtained through its contracting action upon the bladder. Constantin James places it, for its effects, midway between chalybeate and alkaline springs. Its main use is as what the French call a *reconstituant*, and for this effect there could not be a happier combination of water and high position than is actually found at Bussang."

ACCOMMODATION.—The village hotels are primitive. There is a good new *Hôtel des Sources*, in close proximity to the bathing establishments. There are no particular amusements, and the place is decidedly "quiet."

Edmund C. Wendt.

BUXTON. One of the most popular thermal stations in England.

LOCATION.—Buxton is pleasantly situated in a picturesque part of Derbyshire, about thirty miles northwest of Derby. It is nine hundred feet above sea-level, and surrounded at some distance by hills of moderate elevation. The mineral springs are the most noted in England, and the town resembles in its newer sections the fashionable Continental spas. The air is pure and bracing, but like other English resorts, the place is visited by too many damp and rainy days to be always enjoyable. The springs were known to the Romans. There are many public and private baths, and there is a large public hospital, the Devonshire Hospital, where the waters are much used. Season, June to October.

ACCESS.—Buxton is reached from London (St. Pancras Station) by the Midland Railroad in four hours.

ANALYSIS.—The principal ingredients of the Buxton waters are, carbonate of lime, carbonate of magnesia, chloride of sodium, chloride of calcium, silica, all in relatively small proportion. Indeed the efficacy of the springs is scarcely due to their mineralization, but almost wholly to systematic external use and the diluent action of pure water. The temperature of the springs varies from 60° to 82° F., and the water contains a large amount of nitrogen.

There is also a chalybeate spring at Buxton, known as St. Anne's Well, but it is only sparingly used.

INDICATIONS.—The Buxton waters are employed almost exclusively in gouty, rheumatic, or lithæmic conditions. But dyspeptics, and sufferers from genito-urinary troubles are also sent there. Patients with hysterical palsies also go to Buxton in large numbers.

ACCOMMODATION. — The Buxton thermal establishments are good, though less perfect in their appliances and comforts than many Continental places. The hotels are clean and typically English, which means that they are inferior to many French, German, and Swiss ones in point of food and furnishing. *Edmund C. Wendt.*

CACTUS GRANDIFLORUS. This is the well-known plant, night-blooming cereus, of the order Cactaceæ. A native of Jamaica and the West Indies. It has been introduced as a cardiac tonic, and is said to have certain advantages over digitalis. A fluid extract and a tincture are prepared. The dose of the former is from 1 to 5 minims. The tincture is made of the strength of one part in six of alcohol, and the dose is 5 to 10 minims, which may be increased to 30 minims. It has been recommended to have the preparations made from the fresh plant. An alkaloid, *cactina*, has been separated which possesses all the active properties of the plant.

The advantage that cactus grandiflorus has over digitalis is its continuous stimulating action on the heart. Digitalis, it has been shown, acts first on the pneumogastric nerve, stimulating the heart and increasing the blood-pressure; this is followed by a relaxing of the vaso-motor vessels and depression of the vagus. The new drug, on the other hand, is supposed to be free from this secondary effect, and may be given for a prolonged period without producing exhaustion. It is likely to prove useful in asthenic rather than sthenic cardiac troubles.

It is supposed to act on the medullary centre and through the pneumogastric and sympathetic on the heart. It is a stimulating tonic and invigorates the cardiac plexus, and promotes the nutrition of the heart. No ill effects have been observed from its use. It has been employed as a substitute for digitalis in cardiac dropsy and acted most favorably, its use being continued for some time, supporting the heart and circulation; and in some cases in which repeated tapping had been required, this procedure was found to be no longer necessary.

Its greatest use, however, appears to be in functional and neurotic affections of the heart, palpitation, irregularity, fluttering, slow or rapid action, and other conditions arising from debility, worry, dyspepsia, the excessive use of tobacco or tea, and such other conditions, where no organic disease exists. It has also been used with success in pseudo-angina pectoris and in exophthalmic goître, relieving the sense of oppression and pain, and producing a more regular action of the heart.

Beaumont Small.

CÆCUM AND APPENDIX, DISEASES OF. Since the first edition of this article our knowledge of diseases of the cæcum and appendix has been increased greatly by observations made during the course of operations undertaken for relief of inflammatory conditions. It is recognized that more than ninety per cent. of all inflammatory conditions in the right iliac fossa commence in the appendix, and in a large number of these the starting-point is an aggregation of probably dried fæces within the appendix; hence the term appendicitis has replaced the various other terms applied to inflammations in that region—typhlitis, perityphlitis, paratyphlitis. As our pathological information increases, unquestionably other terms will be coined, but, for the present, appendicitis is a good working word and suggests the origin of the trouble. Inflammation in the right iliac fossa occurs under many forms and much the larger proportion do not fall under the care of the surgeon, being curable by medical means alone.

On the other hand, a certain number require prompt and immediate attention from the surgeon, and the question of diagnosis is one of paramount importance. It is not very difficult to lay down rules as to what cases should be subjected to such and such treatment, but when face to face with the patient it may be safely said that with our present knowledge an accurate diagnosis is not obtainable. Much better are we now able to recognize the condition of affairs about the appendix than a very few years ago, but much still has to be done, and no doubt the observations made during life and the conditions recognized during operations are the factors upon which we shall have to depend for future improvement.

Increase of knowledge, based on clinical observation

during the past few years, justifies the opinion that appendicitis occurs in females nearly as often as in males, and from very early childhood to middle life.

The starting-point usually is the appendix, in exceptional cases only is it the cæcum, and then probably tuberculosis exists. The inflammation appears to begin in the lining membrane of the appendix, and may be catarrhal in character, without obvious cause; but a concretion is found in very many cases, and this is probably the foreign body spoken of under the name of "prune-stone, date-seed, coffee-berry," etc., which have been occasionally referred to in the medical periodicals of the day. It is likely that a piece of fæces has entered the appendix and, remaining for a certain time, has become dried more or less by absorption of the watery constituents; or perhaps retained by a fold of mucous membrane it has become embedded and hardened by the process already mentioned. Certain it is that a foreign body has been found again and again to be present in cases of appendicitis, more often than could possibly happen by accident; hence, a place in the causation of the disease is to be given to the more or less large mass of hard substance—probably fecal—so often present. The coats of the intestine may give way gradually until the actual rupture takes place, or the thinning of the wall of the bowel may occur with successive attacks of inflammation. It would be expected, as the intestinal wall becomes thinner, that adhesions between adjacent coils of bowel would take place, and that this does happen is testified to by the many cases of circumscribed suppuration about the appendix; but occasionally the failure of adhesions to take place permits general septic peritonitis to occur. Just why an inflammation should take place in the appendix without the presence of the foreign body as an exciting cause, we are unable to say, but so many cases are met with at post-mortem inspection which give evidences of cured inflammation about the appendix that the fact has to be admitted. As the appendix is probably the relic of a large cæcum existing formerly, it would be proper to consider this part of the intestine as an organ not capable of resisting disease to the same extent as do the other portions of the bowel; hence it would be the place of least resistance. The formation of pus is thus to be looked upon as an intra-peritoneal, not an extra-peritoneal formation. It has been my fortune, on one occasion, to be able to lift such an abscess, circumscribed by coils of the bowel, out through the abdominal incision and open it outside of the body. The point where the inflammation begins may be at the apex or at the base of the appendix, or between the two. When it is situated at the base of the appendix, the cæcum is also found to be inflamed, but so soon as the pus forms it is not a matter of much consequence what is the extent or the exact locality of the abscess, for everything is tied up together. It may of course happen that the peritoneal adhesions are very dense, and the pus may make its way into the connective tissue about the cæcum or other organ.

The onset of an attack may be either sudden or gradual. In the latter case there will have been attacks of bowel disturbance, constipation and diarrhœa, with abdominal cramps, for a certain period; not enough, perhaps, to have caused the patient to seek the services of a physician, but sufficient to have caused a certain anxiety on his, the patient's, part. Perhaps the physician may have been consulted, but if so, it has been for indigestion or some slight disorder. In a certain number of cases the onset of the disease is acute, pulse and temperature both rise, acute pain is present and is referred to the right iliac fossa, although possibly elsewhere. The patient may be cognizant of a certain stoppage in the bowel, as he describes it, and he becomes anxious. Pain, while generally referred to the locality mentioned, is not always so by any means. Sometimes the epigastric region is indicated, sometimes the navel, and sometimes a corresponding point on the left side of the abdomen. In one or two of my cases the pain has been referred to the right loin, not far from the spine. On one occasion, where the pain was referred to the epigastric region, it could be mitigated or often made to disappear by pressure of the hand on the right groin. The place of greatest sensitiveness has been referred to a point inside the right iliac spine, about two inches distant on a line drawn from the anterior superior spinous process to the navel, which point is supposed to be over the base of the appendix. I have found this to be the case, and while pressure in that region causes pain I have not been able to locate it so accurately as has been done by others. Rigidity of the abdominal muscles is very constant, and more often seen on the right than the left side, but it sometimes requires pressure to induce it. Temperature shown by the thermometer is generally not high, unless in the late stage of the trouble. Purulent septic peritonitis may exist with subnormal surface or mouth temperature. Rectal temperature is higher by several degrees than mouth or surface temperature. I attach much less weight, in forming my opinion of the patient's condition, to the amount of fever than I do to the condition as shown by the pulse. This latter is a vastly better index. Constipation is often present, and may be so marked as to be mistaken for obstruction; indeed a certain number of cases have been treated for obstruction. Doubtless the cause is paralysis of the intestinal wall in consequence of the presence of the inflammation, but a change from constipation to diarrhœa, brought about by medicine, is seen in cases of abscess rather than in diffuse peritonitis. When, therefore, frequent passages are induced by medicines following an apparent obstruction, I am inclined to think that my patient has escaped a general septic peritonitis. Tympanites, occurring early during an attack, is not favorable; continuing constantly, it is not a favorable symptom, and if associated with constipation it indicates loss of power in the intestinal wall. Shock is marked when perforation takes place, otherwise it is not a prominent symptom. Vomiting of the contents of the stomach, and subsequently of the contents of the upper part of the small intestine, suggests peritoneal involvement; in general peritonitis the material vomited is apt to resemble finely cut spinach in color. The color changes to brown as the scene closes, and is apt to be very profuse in the last hours of life. Œdema of the abdominal wall is met with where an abscess is immediately adjacent. Tumor in the right iliac fossa is not found at the commencement of the attack, but may appear shortly. At first it is probably due to an adhesion of the intestines around the focus of primary inflammation or the swollen appendix. Later, as pus forms, the tumor naturally becomes larger if walled in by adhesions. Where the inflammation is not shut off by adhesion from the rest of the peritoneal cavity the tumor is wanting; such cases are rapidly fatal and call for active interference at an early day. The rigor and chill may occur with the commencement of the inflammation, or later, but they are rarely wanting at one time or another. Free extension of the thigh often causes pain. Digital examination by the rectum is occasionally useful and should not be neglected, but will be of especial use when the intra-peritoneal tumor has acquired a certain volume or where it extends downward toward the rectum. An appendix which hangs over the brim of the pelvis, if inflamed, may be recognized early in the disease by the rectal touch. In cases where inflammation extends into the pelvis, involvement of the peritoneal covering of the bladder may occur; hence, frequency in passing water is a symptom of value. It is usually accompanied by scalding along the urethra, with pain at the meatus, and spasm of the bladder, sometimes very severe. Fluctuation is not to be expected, although occasionally met with; its presence indicates a large amount of pus situated superficially, and certainly is wanting in the early stage of the trouble. Its presence should not be expected, either for diagnosis or treatment. Percussion is rarely dull, for often, if pus is present, it will either be overlaid by intestine or so closely in relation therewith that dulness is wanting, and pus may be under the abdominal wall so that it can be cut into without difficulty, yet a tympanitic note will exist. The countenance is apt to indicate the gravity of the trouble moderately well; dark circles about the eyes are not a hopeful sign, and apparent receding of the eyes within the sockets suggests ex-

treme illness. The introduction of the needle of a hypodermic syringe into the affected area, with a view to the discovery of pus, is most unwise. I believe incision to be safer. There is no knowing just what the needle may reveal, and it may conceal much.

A large number of cases recover from appendicitis, usually the catarrhal form, and they do not fall under the notice of the surgeon. A few days' rest and gentle purgation, and the patient recovers. Some cases, on the other hand, are not followed by perforation, but they induce suppuration within the peritoneal cavity, which becomes promptly circumscribed and walled in by adhesions of adjacent intestinal loops, thus shutting off the general cavity from infection. In another class of cases perforation does take place, but this also is walled in as in the preceding class. Finally, another class exists in which perforation occurs, but without the walling in just described; whereupon a general infection of the peritoneum follows. These latter cases die, with few exceptions. The difficulty which presents itself to the physician is the recognition of those cases which will be circumscribed and those which will not, and it is to be regretted that at present it is impossible to certainly differentiate between them. They are apt to be alike in commencement, for a certain number of hours, at all events, and yet early operation will prevent the rupture and general peritonitis in the one class, while in the other surgical interference is not needed.

The term "early" used here is not intended to apply to the length of time that the attack has lasted. It does refer to the pathological condition, and refers especially to perforation, so that an operation undertaken soon after the commencement of the pathological condition which would eventuate in rupture, may be in the one case a few hours and in the other case several days after the commencement of the illness. The term "early," then, as ordinarily used, is a misnomer in my opinion.

Probably a position of armed neutrality is the proper one for the physician to assume, and when I say physician, I mean that the attending physician, if not a surgeon, should promptly call in a surgeon, and together the two should conduct the case. It is right that the surgeon should see the case from the start, but equally he should know how to withhold his hand, and not think, because he is called in, that he should at once operate. In no class of cases is good judgment of more value to the patient, and equally may it be said that in no class of cases is a correct judgment more difficult to form. Perforation usually takes place, if it takes place at all, in the first three or four days after the onset of the disease; hence the necessity for forestalling a fatal rupture is apparent. Where the abscess is circumscribed, the operator has time to open and drain, and general peritonitis is then very rare. Where perforation takes place without formation of adhesions, fatal peritonitis results. Such a condition should be prevented by prompt operation and removal of the appendix, which is the starting-point of the trouble. Only careful and continuous observation will enable the surgeon to recognize the necessity for interference. The pulse progressively increasing in frequency, the temperature rising or remaining high, acute pain on pressure in the right fossa, perhaps near the point already referred to, constipation present, with or without a swelling in the right fossa, rigid right rectus—these are the indications which may be held to call for an operation. The pulse not frequent, diminishing pain, moderate temperature, absence of tympanites, will justify the surgeon in waiting. The incision, when made, should be as long as may be necessary to give free access to the seat of disease, and the centre of the incision should fall on a line drawn from the navel to the anterior superior spinous process, about two inches from the bone. The peritoneal cavity should be opened to the same extent as the skin incision; unless the operator finds adhesions closing in the seat of inflammation, these should not be disturbed. The coils of bowel are to be pressed aside, the seat of inflammation found, and the pus evacuated. In circumscribed cases the adhesions should not be ruptured, but the appendix should be sought for and explored by touch and sight, if possible; if a concretion be present it should be removed and the appendix tied off, but not if by such action the general peritoneal cavity is likely to be opened. On the other hand, where no abscess exists and the appendix is the cause of the trouble, with or without contained concretions, the appendix is to be tied off by a ligature applied close to the cæcum. It is well to apply pure carbolic acid to the stump. This removes the cause of the trouble, and is an operation essentially different from the one referred to first. The wound is to be lightly filled with gauze which will be removed later, and healing by granulation allowed. Whether it is necessary or not to flush the general peritoneal cavity, will depend on the condition found. If suspicion of septic peritonitis exists it would probably be wise to do it. I do not think that it is necessary to remove the appendix in all cases, especially in cases where pus is circumscribed. The appendix in these cases is generally closed by adhesive inflammation, and I believe that much injury is done by indiscriminate search for this organ by rupturing adhesions, rather than by leaving them alone after the pus is evacuated, and permitting the cavity to heal by granulation. A perforated appendix heals without difficulty.

Opium I give rarely; it produces quiet on the part of the patient without arresting the progress of the inflammation; hence it masks symptoms which might necessitate an operation. On the other hand, saline purgatives I use freely, for reasons already stated, hoping to produce frequent evacuations from the bowels. Irritants or blisters to the abdominal wall have yielded, in my hands, no good results; more comfort follows the application of ice over the seat of inflammation.

Recurrent Appendicitis.—Appendicitis is met with occasionally as a recurrent trouble, and the question will be raised as to treatment. It is impossible to say, first of all, whether the attacks are dangerous or not, or whether a person having escaped one, the next attack may not be fatal. Such a disease generally calls for operation, the chosen time being the period between two attacks. The operation which should be done will be the uncovering and the removal of the appendix, in which the cause of the trouble exists. Undoubtedly such an operation carries with it a certain amount of danger, but probably not so much as would be present with an attack of appendicitis. Generally speaking, it may be said that where attacks of appendicitis recur with sufficient severity to cause much inconvenience, or imperil existence, then an operation is proper. On the other hand, slight attacks of cramp in the right fossa, unless there be some special indication, may be considered as a trouble which will cease without operative interference.

Louis McLane Tiffany.

CAFFEINE. This alkaloid and its salts continue to be used for their stimulant and diuretic properties, and numerous communications indicate that it still proves of service in headaches, migraine, neuralgia, cardiac debility, and dropsy due to heart disease. It has latterly been advocated as a cardiac stimulant and restorative in the prostration and debility of typhoid fever, pneumonia, and post-partum hemorrhage. Two to four grains are advised to be given every four hours; in the latter condition, where a more prompt action is required, eight or ten grains may be administered hypodermically. It also has been found that its diuretic properties are increased and its general effect improved by combining with paraldehyd. Four or eight grains are to be used with thirty or forty-five minims of paraldehyd. Its diuretic action has been clearly shown to be due to a direct effect on the secreting tissue of the kidney, which, in addition to its action on the circulation, makes it a most effective and rapid diuretic. It differs from digitalis by this promptness of action. The influence of digitalis is not exerted until the blood-pressure has been raised and then succeeded by a relaxing of the renal vessels, which may not be effected for some days. The influence of caffeine is much more rapid, and may be noticed in a few hours.

Notwithstanding the extent to which it has been em-

ployed and the success attending its use, our knowledge regarding the *modus operandi* of caffeine is meagre and unsatisfactory. To a very great extent it has been of an empirical character, and not based on any very precise data. Researches during the past few years have thrown some light on its effects on the circulation and metabolism, and on the ultimate effects produced by its administration, and as a result our views regarding its action on the heart must be greatly changed, and its continued use in cardiac debility must be guarded and cautious. In 1890 Professor Germain Sée presented to the French Academy of Medicine the result of some experiments made by himself and M. Lapicque, to verify its reputed restorative and stimulating properties. These experiments, which extended over a period of twelve months, demonstrated very clearly its influence over the muscular system. He found that untrained men could perform long journeys and enter races without enduring fatigue or exhibiting any sign of distress. By the means of registering apparatus it was found that there was no alteration in the respiratory or circulatory rhythm, and numerous other facts proved that the use of caffeine enabled a trained or untrained person to perform muscular efforts that otherwise could not be undertaken. He concludes that small quantities, amounting to about ten grains in the day, may with advantage be given to soldiers on the march, or where any muscular effort is required, as it prevents shortness of breath and palpitation and supplies vigor and endurance. He considers that the caffeine acts on the cerebro-spinal centres, stimulating the motor nerves, favoring the combustion of nitrogenous elements, and promoting the excretion of carbonic acid and other products of tissue change. By this means strength is furnished, not by supplying anything new, but at the expense of the individual by enabling him to draw upon the energy that is latent in the system. In no sense does it replace food, and unless this drain upon the system is replaced an unfavorable result follows. Professor Sée likens its special stimulating power to that possessed by food which will prove a source of stimulation by its presence before it is in any way acted upon by the gastric juices. As to its action on the heart and blood-vessels, he considers that but little is known and cannot be properly understood until xanthin and its series of products has been studied, caffeine being chemically tri-methyl-xanthin.

The experiments of Dr. Reichert, of the University of Pennsylvania, on animals, form a valuble corollary to the views of Professor Sée, and add much to our knowledge of the action of caffeine on the heart and blood-vessels. Reichert's experiments were instituted because he considered that the drug was but little understood, and because the very prevalent idea that it was a beneficial cardiac stimulant, was based on experiments that were incomplete and open to serious objections. He benefited by the experience of others and avoided their sources of error, with very satisfactory and important results. In a series of experiments on the production of heat during the administration of caffeine, he shows conclusively that the amount of heat produced and the amount dissipated are augmented, and in consequence with the increased energy a corresponding drain on the system takes place. Its reputed stimulating properties he considers to depend on a general excitation of the cerebral centres, the effect of which he likens to the energy and force exhibited by persons when the subject of a fright, hysteria, or mania, during the influence of which unusual deeds of endurance and strength are performed, but at the expense of the system.

His experiments to determine the condition of the blood-pressure and the effect on the heart were very complete. Solutions of caffeine were introduced into the external jugular vein and also hypodermically; the pressure was recorded by a manometer in the carotid artery and the action of the pulse carefully observed. The effect was noted in dogs in their normal state, in others with the pneumogastrics severed to cut off the influence of the inhibitory centres, and in a third series in which the upper spinal cord was cut to determine the influence of the accelerator centres. The results of his observations are given in the following conclusions:

1. The pulse-rate may be diminished during the first and last stages of the poisoning, but is generally decidedly increased. During the first stage the diminution is due to a stimulation of the cardio-inhibitory centres in the medulla oblongata and heart, and during the last stages to a direct depression of the heart. The increase in the pulse-rate is due to a depression or paralysis of the above cardio-inhibitory centres.

2. Arterial pressure during the first stages of poisoning is generally unaffected or diminished, but occasionally a trifling increase is noted. The increase is due to a direct stimulant action upon the blood-vessel walls, increasing vascular tension. The diminution is due chiefly to a direct depression of the heart, and to some extent, doubtless, to a secondary paralysant action on the vessel-walls.

3. The acceleration of the heart-beats may be accompanied by no appreciable alteration in blood-pressure, but generally by a more or less decided diminution, which is dependent upon cardiac depression.

4. Caffeine diminishes the heart's efficiency for work, arrests it in diastole, sometimes induces sudden paralysis, and is therefore a cardiac depressant.

5. The asserted stimulant action upon the circulation is doubtless subjective and dependent upon an excitation of the cerebral centres. *Beaumont Small.*

CAMBO. A popular thermal station in the department of Basses Pyrénées, France.

Location.—Cambo is charmingly situated, not far from fashionable Biarritz, to which fact, as well as to its mineral springs and a well-managed bathing establishment, it owes the growing favor with which it is regarded. Although it is open all the year round, there are really two seasons, one from April to June, and the other from September to the latter part of October. The climate is soothing. Cambo is 200 feet above sea-level.

Access.—By railroad to Bordeaux, and *viâ* Dax to Bayonne. Three hours by stage from Bayonne.

Analysis.—There is an alkaline sulphur spring, having a temperature of 80° F., with the following chief ingredients: Sulphate of lime, sulphate of magnesia, sulphate of sodium, small quantities of arsenic and lithium. It is rich in free carbonic acid. There is also a cold chalybeate spring.

Indications.—Cutaneous affections, lithæmia, chronic diseases of the organs of respiration, catarrhal affections of the alimentary canal, scrofula, and anæmic states are chiefly treated at Cambo. It is a good place also for convalescents from acute diseases, there being pleasant and sheltered promenades and fine scenery.

Accommodation.—The Grand Hôtel d'Angleterre, and the Hôtel de Paris are good hotels. The thermal establishment has the usual appliances.

Edmund C. Wendt.

CAMPHORIC ACID, $C_8H_{14}(COOH)_2$, is formed by the oxidation of camphor, and may be prepared by heating camphor with nitric acid. The acid forms in small colorless needles or plates, odor faintly aromatic, taste acid and bitter, very sparingly soluble in cold water, more soluble in hot, soluble in alcohol and ether. Ten per cent. of alcohol added to hot aqueous solution prevents it from being deposited on cooling. This acid has long been known, but it is only during the last two years that its therapeutic properties have been utilized. Its latest use is for the treatment of diseases of the respiratory tract and as a preventive of night-sweats.

For the latter purpose it promises to be one of the most valuable additions to our materia medica. Compared with atropine its effect is more certain and more prolonged, while it does not produce the difficulty in swallowing, dryness of the pharynx, disturbed sleep, and vertigo, which often accompany the use of the latter drug. Compared with atropine its mode of action differs, as its beneficial effect is thought to be due to its power of de-

stroying the ptomaïnes in the blood which cause this distressing symptom.

The dose as an anhydriotic is thirty grains at bedtime, or fifteen grains during the afternoon and the same dose repeated at bedtime. The action is not rapid, and in some instances no effect has been noticed until the following day. The effect of a single dose often continues for several days. The reports of cases treated show beneficial results in a great majority of them; it does not in any way interfere with the appetite or digestion, and in most instances a quiet sleep followed its use. As the taste is somewhat disagreeable, it is best administered in wafers or capsules. In diseases of the mucous membrane of the respiratory tract, camphoric acid is used by applying locally and as a spray. In acute coryza, pharyngitis, and laryngitis a half to one per cent. solution may be used every three hours, or tampons saturated in the solution may be introduced into the nasal cavities; in ulcerated throat, a solution of two to six per cent. may be applied. This drug has no corrosive action; it possesses antiseptic properties and produces contraction of the blood-vessels of the mucous membrane. Internally, it is also used for intestinal diarrhœa of a catarrhal character, and where intestinal antisepsis is desired, the dose is from five to ten or fifteen grains. It is excreted by the kidneys and renders the urine clear and acid in two or three hours.

In cystitis, when the urine is alkaline, it has proved of benefit. In this condition it is also used as a wash in a half of one per cent. solution. The bladder is to be irrigated twice a day, about an ounce of the solution being left behind. *Beaumont Small.*

CANADA, CLIMATE OF.* The climate of a country must ever be considered of the greatest moment to human welfare. What is climate? It is not obliquity of the sphere with respect to the horizon, from which results the inequality of day and night; it is not the imaginary circles parallel to the equator; nor is it the weather peculiar to a given country; nor its heat, nor its cold, nor its dryness, nor its moisture; nor the course or character of the winds; nor the changes of the seasons; but all these combined, together with its salubrity and insalubrity. It is, in a word, according to Humboldt, "the changes in the atmosphere which sensibly affect our organs, as temperature, humidity, variation in the barometrical pressure, the calm state of the air, or the action of opposite winds, the amount of elastic tension, the purity of the atmosphere, or its mixture with more or less noxious gaseous exhalations, the degree of ordinary transparency and clearness of the sky, the organic development of plants, and the ripening of fruits." But to these must be added the feelings and mental and social condition of man as affecting and modifying the influence of climate everywhere. Distance from the equator and height above the level of the sea are not therefore the only conditions comprised in the function of climate.

Climate is influenced markedly by the physical geography of a country. The Registrar-General for Scotland, in explanation of certain phenomena, the causes of which are not quite obvious to the reader, generally describes Scotland to be of extremely irregular figure, and attributes the disturbance of the mortality tables to that cause. Writers generally admit that there is neither conceit nor irrelevancy in the matter. Climate affects our stature, our strength, and complexion; causes and cures disease; prolongs or shortens life. Its influence may be seen in the great variety of races which inhabit the earth, presenting every tinge and hue of complexion, from the pale white to the ebony black; and in the vast variety of intermediate races—all descended from one common parent,—the theories of the pluralists to the contrary notwithstanding.

There must be added a third element, which affects man in health and disease, and which influences the tables of mortality, viz., the ordinary condition of wealth and comfort, or the reverse.

Before entering upon the subject of the paper it may be well to state the conviction that the influence of climate upon man and upon the brute creation is marked, —more marked, indeed, upon the lower animals than upon man,—for the latter is not so completely exposed to the influence of climate as are the former. A few generations will so change many animals as to make them scarcely recognizable; while man requires a period so great that some are disposed to doubt that any amount of intra- or extra-tropical influence can convert a white into a black man, or a negro into an Esquimau.

As has been said, climate generally has an intimate relationship to the physical geography of a country, and the climate of Canada is not an exception. Its vast extent of country, from the Atlantic in the east to the Pacific in the west, and from the Arctic Ocean, Baffin's Bay, and Davis's Strait on the north and northeast, to the boundary line, forty-fifth degree, and the great chain of lakes in the south and southeast, would necessarily give it a varied climate.

Canada occupies a great portion of what has been styled the Interior Valley of North America—a valley which may be said to occupy six million square miles, beginning with the tropics and terminating within the Polar Circle, traversing the continent from north to south and passing through the entire northern zone. This valley rests upon, and is indented by, the Gulf of Mexico on the one side, and by Hudson's Bay on the other; a valley which is protected from the Pacific Ocean on the west by the Rocky Mountains—mountains varying from ten to fourteen thousand feet in height, which greatly modify the distribution of rain, the direction of winds, and in many ways influence the climate. The Appalachian chain of mountains—a chain interrupted only at the forty-second degree of latitude by the Great Lakes and the St. Lawrence—bounds this valley in the east. The distribution of these chains of mountains permits a more direct oceanic influence on the Atlantic or eastern side than on the western or Pacific side.

The enormous fresh-water lakes within that valley influence most materially the climate of Canada. The basin of the St. Lawrence alone has an area of upward of half a million square miles, and contains lakes having an area of one hundred and thirty thousand square miles. The St. Lawrence basin is hemmed in on both sides by mountain ranges: the Laurentide on the north, the mountains of Notre Dame on the south. The latter form the Vermont Mountains, mountains which exert so potent an influence upon the climate of both the United States and Canada. The ranges of these mountains vary in altitude from a few feet to four thousand feet above the sea. At different heights along these mountain ranges numerous watersheds are met with, in addition to those in the basins already alluded to—the Lacustrian chain, which begins in a cul-de-sac formed by the Arctic Ocean and the Rocky Mountains. So great in number are these fresh-water lakes that many of them have not yet received names. Some of these lesser watersheds have not been fully explored, yet their genial influence upon the climate of the country is admitted. The low altitude of Canada is favorable to its climate and to its vegetation. Were the plateaus on the north coast much elevated, vegetation would be confined to the mosses, and animal life to a few hardy, thick-furred animals. But all the long gentle slopes descend toward the Atlantic and the Frozen Ocean; while all the short and rapid slopes, or counter-slopes, are directed toward the Pacific. The land in Canada ascends in a series of plateaus as we approach the interior, and we reach the height of tableland, as it is termed, on the south side of Hudson's Bay.

Canada consists for the most part of laurentian, devonian, and silurian rocks.

The size and shape of this country operate in controlling the distribution of heat. It is admitted that the greater the land surface the greater the measure of heat; and as the continent of America widens as we ascend in

* The present article is, in considerable measure, a condensation of my work on "The Climate of Canada, in its Relations to Life and Health," to which I refer the reader for ampler information.—W. H. H.

latitude we find the centre of the system of atmospheric circulation north of the geographic equator.

The series of vast lakes and rivers exerts unmeasured influence on the climate of Canada. It would be entering upon too elementary a question to discuss it at length. I may say, however, that the influence which large areas of fresh water exert is in a measure proportioned to their depth rather than to their surface. If the collections of water are deep, their surfaces are steadily maintained at a higher or lower temperature than the surrounding air. In summer the surface waters are heated, and when heated become specifically lighter, and in consequence continue to float upon the surface; during the night a portion of surface water, cooled by the withdrawal of the sun's rays or by the low temperature of the air, becomes denser and sinks, while the warmer water ascends to take the place of the colder; but at no great depth from the surface of these great bodies of water the temperature is uniformly cold, being scarcely modified by our summers and winters.

Canada without its lakes would be like the north of Europe in being both continental and oceanic. But its oceanic features are limited. The cold air from the lakes affects vegetation near their shores, but not at a great distance from them. It is to the lakes and rivers, on the other hand, that we are indebted for so great a range of animal and vegetable life. Thus vegetation in longitude 110° and latitude 54°, upward of seven hundred miles from Toronto, has nearly the same character as it has in the capital of Ontario.

The climate of Canada is more uniform than is that of Europe—the meteorological differences being such as are produced by position alone. It is regarded as a dry climate, yet more rain falls in Canada than in Britain; but it falls in a shorter period, and in larger quantities at a time. The average fall in Canada is fifty inches a year; while in Great Britain the rainfall is but thirty inches. If we seek comparisons in Europe, we find a parallel to the Canadian winter in St. Petersburg, and to the Canadian summer in Paris. But the sky of Canada rivals those in clearness—a clearness which is obscured only for a short period every few days.

It is customary elsewhere to divide the year into seasons of three months each; but this division, arbitrary at best, is totally inapplicable to Canada. Spring and autumn are here of short duration. A line of forty degrees mean temperature, according to Blodgett, passes through Nova Scotia, near Halifax, Montreal, then parallel with the St. Lawrence, north of Kingston, through Toronto, south of Penetanguishene to the Red River of the North. That is the temperature of April, but advance in temperature is uniform for the next two months. The advance is illustrated by corresponding changes in the animal world. The earliest birds, as the song sparrow, begin to sing in the month of March; the robin, also returning from the South while snow yet dapples the ground, makes short and frequent attempts at song; the moose deer leaves his winter haunts about the same period, and approaches the marshes, ponds, and rivers, in search of food; wild-geese move northward about the 22d of April; and the frog, with a regularity that is surprising, begins in the last week of April in Eastern Canada its harsh guttural croaks.

The mean summer temperature ranges from 55° F. in the northern to 65° F. in the southern parts of the country; but the extremes of heat are very great, the thermometer sometimes indicating a temperature more exalted than that of the blood. The mean distribution of rain for the three months of summer is ten inches.

The early part of autumn is a season of peculiar beauty; the transition from the heat of summer to the temperature of autumn is very sudden; the autumn coloring of the leaf in various tints is but the prelude to the rustling of its dry, lifeless form. While the first of these autumn months—September—might be claimed by summer, the last, November, is in reality a winter month; the mean temperature of the latter may be stated at 43° F.

The regularity of the advent of birds from the North, in springtime, is equalled by the regularity of their departure in autumn. A mysterious influence—which has been variously explained by some as the advancing heat, or by others as the demand of impending ovulation—seems to lead various classes of birds to take their departure for the more congenial influences of the South at about the same time; and birds of strongest wing and most rapid flight are very often those which leave the northern portions of Canada with the greatest regularity. Thus the wild-goose, which, according to Dr. Rae, visits the extreme North on April 23d, comes back again to us about the 25th of October.

A foretaste of winter is afforded us by sharp frosts, piercing winds and snowfall, interrupted for a day or two by soft balmy breezes, which we call "Indian Summer," but which the French *habitant* styles:

> "L'été St. Martin,
> Du Soir au Matin."

This is a short period, of uncertain occurrence and of uncertain duration.

In winter the snowfall does not bear a direct ratio to the cold. The largest amount of snow usually falls in the months of December and February, and although occasionally the temperature of those two months falls below that of January, it is only in the aggregate, as considerable allowance must be made for what is termed the "January thaw."

The snow crystals which fall in different months, and in various parts of the country, are very different in form. The aggregated flakes vary in their combination, but in whatever part of the country they are met with, they present as distinct a mathematical form of crystallization as that which characterizes the more lasting crystalline gem from inorganic nature. The snow-crystals are well-defined hexagonal or six-sided prisms, very commonly of a stellar or star form; but the electrical conditions of the air influence the form. Vitreous or positive electricity gives a result different from that given by negative or resinous electricity, but chiefly in the matter of the grouping.

As forests or herbage which cover the surface influence climate, that of Canada is certainly undergoing important modifications. Forest trees cannot be cut down, and the earth cannot be upturned or pierced with drainage-tubes without the climate being sensibly affected.

From the oak and elm and beech and maple on the one side, to the pine and cedar and still hardier lichens, the mixed forest is met with in Canada in rich luxuriance. In some districts the pine and spruce are interspersed with beach and maple; but plants with slender shrunken leaves and feeble stems are nowhere to be met with in Canada. The wild grape flourishes as far north as fifty-two degrees of north latitude, and is abundant in the Kaministiquoia.

As a wheat-growing country Canada equals Russia. From the valley of the Saskatchewan, and from far down the Mackenzie River in the northwest, along the chain of lakes and rivers, wheat of the finest description is grown—inferior in gluten only to that cultivated near the shores of the Mediterranean. Were it not for untimely frosts the wheat-producing power of the northwest of Canada would be greatly increased.

The climate of Canada is highly stimulating. It is a matter of observation by residents and travellers that the thermometer cannot register this quality, though Europeans, accustomed during their lifetime to the use of stimulants, quickly perceive that if they wish to preserve health in Canada the quantity must be diminished: temperance is almost a matter of necessity.

A residence in Canada is attended with certain physiological changes. The transition from youth to manhood is often sudden, the period of childhood being short; but not to climate alone, but to domestic education as well, and to social influence, must be attributed this most unattractive feature. Many of the tissues of the body, as the skin, hair, etc., become drier by a residence in Canada, and physicians recognize still further changes in some of the

internal organs ; but these changes are not prejudicial to life or to health. On the contrary, the maritime and continental features, harmoniously blended in a Canadian climate, are favorable to the highest development of a hardy, long-lived people.

It is generally admitted that a change takes place in the European's constitution after a longer or shorter residence in this country. Between the emigrant of to-day and the children of emigrants of fifty years ago we observe marked differences. The high color which flushes the cheeks and reddens the lips of Europeans fades somewhat, and the skin becomes less soft and moist ; the hair becomes drier and straighter ; the fat, which cushions the cheeks' muscles and gives roundness to the general outline, disappears to some extent ; and the teeth, thanks to a pernicious mode of living, decay sooner.

The various seasons influence persons differently ; but it is, perhaps, the great heat of summer which influences most. The temperature of winter comes next. The milder seasons of spring and autumn exert less influence, being more like those seasons in Europe. In Canada it is not alone the hot weather which acts so severely upon the human body, but, apart from the relaxing influence of heat *per se*, it indisposes to take food in large quantity. It is during the hot weather that mortality is greatest in Canada—very different from what it is in the north and west of Europe, where the mortality is higher in cold than it is in warm weather.

The cold of Canada in winter is severe, but it is not destructive ; the sharp, clear, bracing temperature is more easily and more agreeably borne than is the humid, raw air of a higher temperature. It is remarked that the cold during winter seems to be more superficial, as it were, and to call into activity the capillaries of the surface of the body. A marked difference is noticed between the influence of the cold of Canada, with its low altitude, and the same temperature in high altitudes elsewhere. If, for instance, we ascend Mount St. Bernard till we reach a temperature equivalent to that of a Canadian winter, the air is found to be too vivifying ; respiration becomes too hurried, and among those who permanently dwell there great longevity is rare. In Canada the cold is indeed exhilarating, but not for early destruction. The exhilarating influence of a Canadian winter depends much upon its peculiar electrical condition. The sensations of cold in winter are but relative : when the body is inured to severe cold a moderate degree of elevation is easily felt. It is surprising how easily we adapt ourselves to a climate where the changes in temperature pass through a cycloid very much greater than exists, perhaps, in any other part of the world. Europeans, if sheltered from the piercing winds, inure themselves readily to the severest cold in winter.

The rapidity with which the country has been recently opened up, especially the west and northwest, makes any attempt at correct vital statistics impossible ; but the reports furnished by the surgeons of the American and British armies supply that want to a considerable extent. It has been found that stations improve in salubrity in direct ratio to their proximity to the frontier and to the great chain of Canadian lakes. Canada is the healthiest station in the British Army, Malta alone excepted,—much more favorable to life and health than Great Britain itself ; much more favorable than those favorite stations, Gibraltar or the Ionian Islands or the Bermudas ; and immensely more favorable than Ceylon or Bengal, or any other Indian station.

There are no diseases known in Canada which are not met with elsewhere, though many diseases are greatly modified by residence in Canada.

The selection of climate is oftentimes a matter of some difficulty ; thus, portions of Canada are singularly favorable to consumptives ; but this must be taken with some qualification. The climate is favorable to persons in whom tubercles are being deposited, or are already deposited, or to those who have a condition of lung which seems prepared for the reception of tubercle. But for those in whom tubercular softening exists, or in whom large or even small cavities are found, Canada is not a favorable climate, except, perhaps, that of its western extremity at the Pacific Ocean. The air in the north, otherwise so healthy, is too stimulating under these circumstances ; while that of the east is too humid. Writers on the diseases of hot climates were formerly in the habit of recommending consumptive patients to visit warm regions—to pass a winter in the South of Europe, or in Africa, or in the warmer portions of the American continent ; but there has for many years past been a change in the opinion of physicians on this question, and patients are sent to cold rather than to hot regions. Sometimes patients are sent on whaling expeditions off the coast of Greenland. But whaling expeditions are not easily arranged for, and are attended with risks and discomforts of a nature to counterbalance, in great measure, the advantages of change of air.

The varieties of climate in Canada differ widely, embracing almost every moderate degree of heat and every still more moderate degree of moisture, and affording greater differences than are to be found perhaps in any other country. Its vast extent of territory would account for so great a range ; but, as I have said, north and south are not the only questions where climate is concerned ; and even the poles and the equator are but elements in its formation.

As in Canada we have almost every variety of climate, and as we are not restricted in selection, places must needs be chosen where comfort, which is so essential to enjoyment, may be most easily obtained. Since there has been direct railway communication between the Atlantic and the Pacific coasts through Canadian territory, where the mosses at one end, the umbrageous foliage at the other, and the variegated forests along the route give evidence of the great variety of climate traversed in the eight days' rapid journey, a choice of locality is not difficult. With a country joining two oceans ; with every variety of physical configuration ; with every degree of temperature, and with a moderately varying dew-point, a choice may easily be made by those conversant with the subject, for it must be borne in mind that not temperature alone, nor dryness, nor equability is exclusively to be considered, nor yet the all-important question of comfort, but all these taken in connection one with another. It is pleasing to add that the condition which the medical authorities of the United States Army wisely object to—high temperature and with it a high dew-point—is not met with in Canada. One must be prepared, however, to lay down general rules for the guidance of patients in special cases. The many hundreds of miles of the Atlantic coast afford a selection for one class ; the more sheltered parts of the St. Lawrence valley will suit another class ; the hilly districts in Eastern Canada would benefit a third ; the western lakes would suit others ; the large basins of water, the Saguenay or Gaspé, or Baie de Chaleur, a fifth ; the shores of those inland seas of purest water, another class ; the western regions from Winnipeg to the base of the Rocky Mountains, especially the neighborhood of Banff, another class ; spots here and there on the Rocky Mountains themselves, another class ; the western slopes of the Rockies, another class ; and the varied shores of the Pacific coast, still another class ; and when chronic bronchitis or pleurisy is under consideration, the more genial influence of the Pacific will be found more beneficial. In the months of December, January, and February, and the first two weeks of March, in almost any of these districts, but especially in Eastern Canada, generally as far as the Rockies, the advance of phthisis is checked in persons who have strength enough to live much in the open air.

The healthiness of the climate has been a matter of observation by every writer from Charlevoix to the present day. The early French writers in sending accounts to their "Mère Patrie" were enthusiastic over the purity of the atmosphere, the magnificence of the forests, the transparency of the waters, and the health-giving qualities of the air.

Old age, in Canada, is a green, an active, a vigorous old age. The census shows a large number of persons living from eighty to one hundred years of age. Life assurance companies have found it to their advantage to

change the scale so that Canadian lives may be accepted at a lower rate than British lives. This continues till the age of thirty-six, when the rate is the same; after which it gradually increases, as insurance companies have to take cognizance of a life of greater wear and tear in Canada, which *tells*, in the course of time, even upon the sturdiest.

The healthiness of the climate is, moreover, manifest in the natural increase of the inhabitants. A section of the population—the French Canadian—has increased at a ratio infinitely greater than that of any other country, not even excepting that of Russia. Canada, in this respect, presents a marked contrast to many other countries, where the birth-rate is sometimes alarmingly small. The increase in Canada is, no doubt, due to a considerable extent to early marriages, which are in every way encouraged, and also to an absence, among the married, of that nameless, shameless, crime of marital limitation, which unhappily obtains in many places elsewhere.

A circumstance not generally known may here be mentioned, viz., that the weight of children born in Canada is nearly a pound more than that of the children born in the maternity hospitals in London. If, then, Canadian children are so favorably handicapped at the start, may it not be presumed that they will continue it to the finish? Certainly, up to a certain period in youth they grow more rapidly, and attain greater height at an earlier age than they do in Great Britain; but this may be due, to some extent, to that forcing process which certainly develops but may not solidify. This question, however, is of too extensive a nature to be dealt with here, but this may be stated, that the colonist is superior in strength and height and weight to his progenitor, and the French Canadian markedly so. The Teuton, the Irish, and the Scotch are not yet long enough in possession of the soil to enable one to make trustworthy comparisons between them and their ancestors; but, following the figures furnished by Professor Forbes, of Edinburgh, some years ago, I, on two occasions, established the height, weight, and strength of the students attending the medical schools of Montreal, and I found that the British Canadian, though he could count but one or two generations born in Canada, had gained over his ancestors in height, weight, and strength. The French Canadian could count seven, eight, and sometimes ten generations born in Canada, and the advance in height, weight, and lumbar strength was greater. It is undeniable that the French, in France, have diminished in stature; that wars have carried off the taller; and that revolutions and wars have cut off many of the generators of tall men, till the standard is much less than formerly. In France dynasty has followed dynasty, sometimes with feverishness and unrest; sometimes with violence; sometimes with bloodshed; but always with disturbance of the quiet of the people. And that disturbance of the people's quiet is as prejudicial to development as it is to gestation. In Canada, on the other hand, it has been one almost unbroken chain of undisturbed quiet.

There remains the question of acclimatization, and with this must be considered the habits of the people. In Canada acclimatization has gone on without affecting prejudicially those who are subjected to its operation. There is no sign of decay in those who are in the progressive state. Those coming from Europe to Canada have, it is true, to clothe themselves differently, to take food of somewhat different character, and, very often, to diminish the quantity of stimulants to which they may have been accustomed. It has been pointed out by those who are not favorable to the country that there are local exhibitions of that more general decay which Dr. Knox of evil omen prophesied is the lot of the denizen of the North American Continent, when he says: "Were the supplies from Europe not incessant, a European could not stand his ground in those new countries. A real native, permanent, American or Australian race, of pure Saxon blood, is a dream which can never be realized. Man cannot ever exist permanently in any country to which he is not indigenous; cannot ever become native true-born American; cannot hold permanency in any portion of any continent but the one on which he first originated." The prophet has passed away, and in the country, too, to which he was indigenous, and, notwithstanding his prophecy, the descendants of the Saxon and the Celt present, seemingly, all the characteristics to fit them for the permanent occupation of the soil.

It has been claimed, on the other hand, by writers, that had the aborigines of the country been left to themselves they would eventually have disappeared without hostile action on the part of the white man, on the hypothesis that new-comers are victors in every great struggle for existence. It is claimed to be with men as it is with European plants transferred to Canada. They take vigorous hold of the soil and attain a vigor unknown in Great Britain; and when taken back to the soil whence they came, they there again comport themselves with modesty. The aborigines are rapidly disappearing, but has not the white man changed for them their surroundings? Or had they their own period of active infancy and vigorous age, as they now have that of decay? For are they not representatives of a race much older than the races which have supplanted them; and have they not been associated with the flora that is passing away?

The low birth-rate among the aborigines is pointed out as an evidence of the baneful influence of this climate upon natural increase. But it must be borne in mind that climate is not the only factor in determining prolificness, and that the procreative power in a country has a certain degree of relationship to the ability of the soil to support its inhabitants and to the precarious living of these scattered tribes, some trusting entirely to hunting, some to fishing. Fishing necessarily implies temporary abode, in moderate numbers, at the borders of lakes and rivers; while hunting necessarily implies still more moderate numbers, and a still greater extent of country to roam over. As food is limited in quantity, and cannot be brought along with the natives, and as the necessities of the wild animals impel them to move hastily from one part to another, it follows that food is often insufficient. Scarcity and insufficiency are not less hindrances to population than are the enforced scattering of the tribes, and the enforced neglect of the women by the men of the tribes. Where food is scarce, the men are obliged to keep greatly in advance of the women, and the latter are little valued. There is another cause of limitation among the aborigines: The deformed, among the children, are invariably sacrificed, except where Christianity has stepped in to save. The healthy, strong, vigorous, and well-formed are alone permitted to live. The mother suckles the child, five, six, and seven years, sometimes for a longer time; and during the whole period of lactation the husband does not disturb her. Ante-natal life has its dangers also: the severe toil of the mother; exposure to the inclemency of the seasons; forced marches, etc., are so many risks to the unborn. Among the young children the absence of ventilation, the habits of gormandizing after enforced fasting, and all those hindrances to increasing population inseparable from a nomadic existence, are met with. Add to these, polygamy. Abbé Lacombe states that wherever it exists among the aborigines, the number of births is *smaller* than among the monogamous. This is quite in accordance with what is met with in Eastern Europe, where Christian families, where monogamy exists, consist of a greater number of children than do Mahommedan families in which polygamy is met with.

It is true that the teeth, among the whites, decay at a much earlier period in Canada and in the northern United States, and that has been seized upon as a partial fulfilment of Knox's prophecy. I have fully admitted, in my work on the climate of Canada, the general prevalence of an earlier decay of the teeth; but I have also asserted that the climate has nothing whatever to do with that decay. The aborigines, throughout Canada, have remarkably good teeth. In the extreme north, toothache is unknown. The teeth of the Esquiman, by constant trituration, are sometimes worn away; or a disease in some measure equivalent to rheumatism may cause an occasional crumbling; but toothache is unknown. The Iro-

quois and the Huron Indians have teeth beautifully regular and equally strong. Teeth decay early with us because there is an impairment of the function of digestion. Functional disturbance is the common cause of decay. The Canadian child subjects his digestive apparatus to an ordeal to which it is not equal, and for which it is not prepared. I have elsewhere reduced the causes of this decay of the teeth to several: Taking too much food—therefore decomposition of a large portion of it; taking too hot articles of food into the mouth—therefore cracking the teeth; taking too cold articles—therefore a like result; taking acids and a variety of condiments, vinegar especially—therefore dissolving them; chewing insufficiently—therefore allowing them to rust; drinking while eating, therefore washing food out of the mouth by fluids of various kinds before the first and most important stage of digestion is accomplished; spitting, therefore robbing the food of its first and chief chemical solvent and leaving it unfitted to be acted upon by the gastric juice later on;—in a word, forgetting that the purposes of food are to nourish the body, and to sustain its heat, and not, by the tricks and refinements of the gastronomic art, to spur the appetite beyond its own better sense. *William H. Hingston.*

CANARY ISLANDS. The "Canaries" (*Insulæ Fortunatæ*) are situated in the North Atlantic Ocean, about sixty miles from the west coast of Africa. They lie between lat. 27° 4′ and 29° 25′ north, and long. 13° 25′ and 18° 16′ west. There are seven principal islands in the group, which are named as follows: Teneriffe, Grand Canary, Palma, Lanzarote, Fuerteventura, Gomera, and Hierro. The islands cover an area of 4,000 square miles. They are supposed to be, like Madeira and the Azores, of volcanic origin, but their climate is warmer and drier than that of the islands named. "Their coasts are bold, abrupt, and rocky, and their surface is broken up by mountains, of which the loftiest, *Pico de Teyde*, in Teneriffe, is 12,182 feet high. There are no rivers in the islands, but after heavy rains torrents pour down the mountain slopes and ravines" (Scoresby-Jackson, "Medical Climatology").

Teneriffe is the largest of the Canary Islands, and its capital, Santa Cruz, is annually visited by many invalids. It is, however, less attractive and offers fewer comforts to those in search of health than Orotava, on the northwestern side of the same island. The climate of Orotava is "softer" than that of Santa Cruz. Laguna, on a lofty plain in the northern part of Teneriffe has a much lower range of temperature than Orotava and Santa Cruz. Scoresby-Jackson gives the following table of temperature in degrees of Fahrenheit:

	Santa Cruz.	Laguna.
Annual	71.15	62.63
Winter	64.85	56.42
Spring	68.87	59.75
Summer	76.68	68.29
Autumn	74.17	66.06

While the Canaries are popular as health-resorts, they are, nevertheless, exposed to east and southeast winds, which are hurtful to certain invalids. The climate of the islands is, on the whole, less relaxing than that of Madeira, but it is not by any means bracing.

The class of cases likely to do well at Teneriffe are the early stages of phthisis, asthma, winter bronchitis, gout, rheumatism, and neurasthenia. Apart from Teneriffe and Grand Canary the accommodations for invalids are inadequate. It is the clear skies and dry atmosphere of the Canaries, together with the (in general) mildness and equability of the climate which have given these islands their title to rank as climatic stations of some importance.

In the Grand Canary, *Las Palmas* has recently been made much more attractive than formerly. There is now a good steamboat-landing at this resort, a fine sandy beach, comfortable quarters, and almost daily communication with England. The Canaries may be reached from England by the steamers of the Cape and New Zealand lines. There is also a line of steamers plying between the different islands of the archipelago, thus affording good opportunities for pleasant excursions. Although the Canaries belong to Spain, there are plenty of English residents, and in the chief resorts the English language is sufficient for all practical purposes. Finally, it may be worth mentioning that the more hardy and adventurous can find a variety of "local climates," owing to the difference in altitude of many of the smaller settlements. Invalids should not arrive before November, unless they intend to visit the higher altitudes.

Edmund C. Wendt.

CANNABIS INDICA. This drug owed its introduction as a therapeutic agent to its reputation in the East as an exhilarating and intoxicating drug. It was shown to possess active medicinal properties as an hypnotic and anodyne, and retains its position in the Pharmacopœia, but has never been received with much confidence. The objection to its use has been the great variation in the quality of the drug and the uncertainty of the effect to be produced. This arises from several causes, among which may be mentioned the different seasons in which it is collected, the want of care displayed in the cultivation of the plant, and the age and preservation of the drug, and its preparations. Of late the attention of the profession has been directed to its value, and it has been utilized to a much greater extent than formerly. Greater care has been given to the drug itself and more precision in its preparation; in consequence the old objection to its use is to a great extent removed, as a reliable and trustworthy preparation may now be obtained.

It was formerly thought to be a very powerful toxic agent, but recent investigations have shown that although it may very readily give rise to mild toxic symptoms, it is only where excessive doses have been given that fatal consequences may occur. It has even been said that no well-authenticated instance of a fatal case has been recorded. In experimenting on animals, Dr. Hare found that ten minims of a fluid extract produced the well-marked physiological action in a man, but three to five drachms were given to a dog without a fatal effect, and death was only produced when about one ounce was administered.

Among the many communications that have recently appeared, two particularly deserve attention, as recording the views of careful clinical observers: one by Dr. Russell Reynolds, in *The Lancet* of March, 1890, and the other a report by Professor Germain Sée to the French Academy of Medicine, in the same year. Dr. Reynolds gives the result of some thirty years' study of the drug in mental and nervous diseases. He found it of particular value in the aged when the mental faculties are weakened generally and much restlessness and sleeplessness is an accompaniment. In doses of one-third to one-fourth grain at bedtime a calm and quiet sleep is secured, and the same action may be secured for weeks without increasing the dose. In melancholia and chronic alcoholic delirium of the aged, accompanied by depression, it has acted as an exhilarant, has produced the desired sense of strength, and has secured quiet and rest. In the restlessness of general paralysis and "temper diseases," in both adults and children, it has also been of the greatest service.

In painful maladies it has acted best in those of a functional character, such as neuralgia and migraine, either alone or when combined with constitutional remedies, as iron, quinine, and zinc, when such are indicated. In neuritis it only proves of service when given in addition to mercury, iodine, and other such remedies. It has also proved very serviceable in the formication, tingling, numbness, and other sensory disturbances of the elderly and gouty.

In clonic muscular spasms it has been very successful, such as the convulsions of children and adults due to reflex causes, in epileptiform convulsions due to organic disease of the central nervous system, and in cases of brain tumor accompanied by convulsions and other indications of central irritation. In true epilepsy it has proved useless. In numerous cases it has been given for

a prolonged period until its full physiological action was produced, and yet has failed to influence the disease in the slightest degree. It relieves the distress of spasmodic asthma and has proved very serviceable in spasmodic dysmenorrhœa devoid of metritis or inflammatory causes. In the hands of Dr. Reynolds it failed entirely in chronic and acute mania, sciatica, lumbago, pleurodynia, and in all forms of hysterical pain. It also proved useless in torticollis, writer's cramp, paralysis agitans, and tetanus.

Professor Sée directed his investigations to its use in painful gastric disorders that were not accompanied by any apparent organic change. He considers Indian hemp a true sedative to the stomach without any of the disturbing effects of opiates, chloral, bromides, and similar drugs. Its effect he thinks is due to the sedative action on the pneumogastric nerve. He has used it in all painful dyspepsias and neuroses of the stomach and always found it of value. Its beneficial effect is increased by attention to the state of the secretions and the use of alkalies, purgatives, salines, and antiseptics when such remedies are indicated.

In using this remedy it is advised that the article should always be obtained from the same source. Dr. Reynolds, throughout his many years of practice, obtained the drug from the same establishment and found that although its strength would vary with the seasons, the desired effect could always be obtained. He recommends that the dose, to commence with, should be one-fifth of a grain every four or six hours for adults, and one-tenth of a grain for children, gradually increasing until its effect is produced.

One grain of the extract he has found will produce toxic symptoms in the majority of individuals, if given as an initial dose, but when gradually administered it may be increased to four or five grains with immunity. In some instances a dose of one-fourth or one-third grain has caused mild intoxication. The preparation that he prefers to use is the tincture. The Pharmacopœial strength is one part in twenty and forms a ready means of giving the required dose, especially to children. Dr. Reynolds has also prepared a tincture of double the official strength as more convenient for the fuller doses. This is ordered to be taken on sugar, which is an easy method of administration, and renders unnecessary the disagreeable and uncertain emulsion which otherwise would have to be formed. The pills and solid extract produce an uncertain and delayed action; they are apt to become dry, and are often insoluble. The preparation advocated by Professor Sée is a fatty extract made by dissolving the alcoholic extract in butter by the aid of heat and washing with water. It is given in doses of one-fourth grain three times a day. Other observers are now advocating its use in greatly increased doses, pushing it rapidly to two or three grains if its sedative and anodyne effects are desired. When its action is required in dysmenorrhœa and in pelvic disorders, its use as a suppository produces the desired effects more rapidly.

Analysis of this drug has not produced any preparation that has proved superior to the crude drug. It yields numerous principles, but none of any practical value as a substitute for the drug itself. The poisonous constituent, *tetano-cannabine*, is not utilized and whatever advantage the alkaloid and resin may have is due to the absence of this powerful toxic principle. *Cannabinon* is a resinous, balsamic substance, dark brown in color, of the consistency of treacle; it is insoluble in water, soluble in alcohol and oils. Its taste is disagreeable. It is used as a sedative in mania, hysteria, and sleeplessness, but its uncertainty of action and the production, in many instances, of severe toxic symptoms have led to its disuse. The dose is one-fourth to one or two grains. The alkaloid *cannabine* is a translucent, brown, sirupy liquid with the odor of Indian hemp. Its dose is from one to five grains daily in divided doses, but its use is replaced by what is termed *tannate of cannabine*, which has been recently introduced, and is probably the most useful of all the principles of hemp. In its preparation the poisonous volatile principle is removed and a tannate of the remaining constituents formed. It is a yellow, or brownish yellow, amorphous powder, with a very bitter and astringent taste and a faint odor of Indian hemp. It is slightly soluble in cold water, more so in hot, and freely soluble in hot water that is acidulated with hydrochloric acid; it is also soluble in alkaline solution, and very soluble in acidulated alcohol. The dose is from two to ten grains—which may be increased to twenty grains,—taken an hour before bedtime. It does not produce intoxication and is recommended as an hypnotic of particular service in acute mania and nervous sleeplessness.

Beaumont Small.

CANNSTATT. A watering-place in Würtemberg, Germany.

Location.—Cannstatt is prettily situated in a valley near Stuttgart, from which place it is easily reached by horse-car or carriage. It is less than 700 feet above the level of the sea, has an agreeable, rather warm, and equable climate. It is well sheltered by hills, except toward the south. There are over thirty springs belonging to the saline and chalybeate group. The temperature of the water varies from 50° F. to 70° F. The principal springs are the *Wilhelmsbrunnen* and *Männlein* and *Weiblein*.

Access.—By rail to Stuttgart, and thence by carriage. Cannstatt is also a railroad station, and all the local trains stop there.

Analysis.—In 1,000 parts of the *Weiblein* water there are contained:

	Parts.
Chloride of sodium	2.454
Chloride of potassium	0.031
Chloride of magnesium	0.019
Carbonate of lime	0.893
Carbonate of iron	0.031
Sulphate of sodium	0.581
Sulphate of lime	0.931

A number of springs have been united to feed a large reservoir used for bathing. The prickling sensation of gaseous bubbles on the skin is not unpleasant.

Indications.—The thermal establishments of Cannstatt are modern, complete, and well managed. The waters are employed for every conceivable variety of bath and external application. The resort is chiefly frequented by those suffering from nervous affections, chronic catarrhal troubles, diseases of women, and anæmia. But a great number of other diseases are likewise treated in several special establishments. Thus, skin diseases, scrofula, gout, rheumatism, neuralgias, and paralytic states are said to be treated with satisfactory results. The writer of this article has visited Cannstatt on several occasions and always received a favorable impression of the thoroughness of the methods employed there. The resort is not an international one, however, being little known, and not yet "in vogue" outside of Germany.

Accommodation.—The principal hotel of Stuttgart is the Marquardt, but there are also several moderately comfortable hotels in Cannstatt proper.

Edmund C. Wendt.

CANTHARIDINATE OF POTASSIUM. The application of the cantharidinates to the treatment of tuberculosis was introduced at a meeting of the Berlin Medical Society on February 25, 1891, by Dr. Oscar Liebreich. The value of this drug as a remedy rested on its well-known property of promoting exudation of serum from the capillaries; an effect not only directed to the vessels of the surface of the body, but also produced in various organs, as the kidneys, sexual organs, and lungs, particularly when the drug is administered internally. This is the special action of the drug on the healthy tissues, and he assumed that an irritated condition of any set of capillaries would favor this process of exudation, at which time a dose too small to produce any effect on healthy capillaries would cause an exudation from those inflamed. This would relieve the congested cells and restore the tissues to a more healthy state; and, further, he claimed, as it had been shown that serum possessed decided germicidal properties, it should prove

antagonistic to the growth of tubercle and assist in the effort at repair.

A number of cases treated by his method were shown by himself and some of his colleagues; cases of laryngeal phthisis, lupus, and pulmonary phthisis were all said to be benefited. When the diseased parts could be observed, the action of the drug was such as had been described by Dr. Liebreich, the ulcerated surface being more healthy and showing signs of repair. When the lungs were affected the expectoration became free and profuse, the œdema decreased, and the local condition improved; the fever also diminished, and other constitutional disturbances lessened. Liebreich stated that no reaction followed its use, but other observers reported a slight rise of temperature, headache, disturbed digestion, diarrhœa, etc. If the dose be too great it produces the characteristic symptoms of cantharides-poisoning—pains in the loins, albuminuria, strangury, and hæmaturia.

The cantharidinate of potassium and the cantharidinate of sodium in solution were selected as the salts most suitable for using the drug hypodermically. As the amount of cantharidin in these salts varies greatly, Liebreich advised the use of a certain solution which he had found by experiment to be most suitable. It is prepared as follows: Cantharidinin, 0.2 gramme; potassic hydrate, 0.4 gramme, most carefully weighed and heated over a water-bath in a 1,000 c.c. flask, with about 20 c.c. of water, until a clear solution results; then add water gradually, while still heating, to the full quantity.

Of this solution 8 to 16 minims are administered hypodermically. Its use should not be continued for any length of time; at least every third day should be allowed to intervene without the drug being administered.

The effect on the kidneys must be carefully watched, and the dose lessened, or its administration stopped, should any symptoms of strangury occur. In kidney disease its use is, of course, contra-indicated. To overcome the painful local irritation that frequently follows at the site of injection, it has been recommended to prepare a solution containing cocaine, which prevents the pain. Two parts of the hydrochlorate of cocaine are added to one of cantharidin and two of caustic soda; this is formed into a solution, and $\frac{1}{60}$ to $\frac{1}{120}$ grain is used as a dose. The addition of cocaine is also thought to lessen its tendency to irritate the bladder or kidneys.

This treatment has been extensively applied to all forms of tubercular disease, but it has not proved of sufficient value to warrant its continued use, and it is now rarely resorted to. It undoubtedly produces the action described by Liebreich, causing a freer exudation of serum, etc., but this does not lead to any improvement in the symptoms or tend to any permanent benefit. Post-mortem examinations of patients who have been subjected to this treatment fail to furnish any evidence of repair or beneficial effect on the disease. *Beaumont Small.*

CATARACT. Antiseptic Measures.—The difference of opinion as to the value of antiseptic precautions in cataract operations having disappeared, and their employment having become practically universal, the favorite methods will now be detailed. The precautions to be taken are in regard to the instruments, the operator, and the patient.

It is in regard to the sterilization of the instruments and the manner of bringing this about that the greatest diversity of practice has perhaps obtained and the most different methods have been adopted. The delicate instruments used in ophthalmic surgery must naturally be handled with greater care than many of those employed on other parts of the body. Immersion in solutions of corrosive sublimate corrodes metal and ruins the edge of the knife. A four per cent. solution of carbolic acid has been proved insufficient to destroy the suppurative germs. To bring about this result with certainty, probably no agent is more efficacious than heat, either in the dry or the moist form. Yet each of these has its disadvantages. Steaming or boiling, the latter in simple water or in alkaline solution, is apt to be followed by rusting. Baking at a temperature of 150° Centigrade, continued for an hour or more, is absolutely certain. But all instruments subjected to this must be made with metal handles in place of ivory or bone, and it is doubtful whether the fine knives used for the corneal section would, after such baking, retain a perfect edge. Many operators, influenced by the above considerations, content themselves with immersing their instruments, previously thoroughly cleansed, in a bath of absolute alcohol before the operation, and withdrawing them one by one as they are wanted for use.

The surgeon and his assistant should wear special outer garments. Those made of linen, freshly washed and ironed, answer a useful purpose. The hands should be thoroughly washed in warm water and with soap, scrubbed with a nail-brush, afterwards dipped in alcohol, and, just before proceeding to operate, in a solution of corrosive sublimate, one to three thousand. That the hands are thus made absolutely aseptic is not claimed, the utmost that can be said is that certain sources of danger are averted.

It is well to give the patient a warm bath the night before the operation. The next day the vicinity of the eye is to be carefully cleansed with soap and water, and a compress soaked in a sublimate solution, one to five thousand, should be kept on the eye for at least an hour previous to the operation. Just before commencing, the conjunctival sac may be washed out with the same solution, applied by means of a sterilized glass tube with rubber bulb. Particular attention is to be paid to the state of the lachrymal sac, and its freedom from infectious secretion is to be positively ascertained.

Anæsthesia.—General anæsthesia, brought about by ether or chloroform, has now, in the vast majority of cases, given place to the local anæsthesia induced by cocaine. This agent was introduced and its properties explained by Koller in 1884. Its use has become general. Employed ordinarily in the form of the hydrochlorate, and in a solution varying from two to five per cent. in strength, its contact with the eye brings about anæsthesia of the conjunctiva and cornea, coming on in from one to two minutes and lasting some ten minutes. In an operation for the extraction of cataract it should be applied two or three times. It is well to remember that the sensitiveness of the iris is not materially affected by the cocaine, and to prepare the patient for a certain amount of pain in case an iridectomy forms part of the operation. Besides producing anæsthesia of the surface of the eyeball, cocaine brings about other changes. It contracts the blood-vessels of the iris, and thus gives rise to a temporary mydriasis; it empties also the conjunctival blood-vessels. On account of this double effect the annoying hemorrhage that sometimes so much embarrasses the performance of an extraction is much less likely to occur. There is also noticed a wider opening of the lids and a lessened tendency to wink. Finally, the intraocular pressure becomes slightly reduced.

If the surgeon finds it impracticable to prepare a sterilized solution of cocaine on the spot, he may use a one to five thousand solution of sublimate as a menstruum. It is best to prepare the patient for a slight smarting sensation when the first application is made to the eye. This very rapidly disappears.

Extraction of Senile Cataract without Iridectomy.—Toward the close of the article of which this is a continuation, written some half dozen years ago, the hope was expressed that experience would before the present time have demonstrated the true value of iridectomy in connection with extraction, and have either established the grounds of its necessity or indicated the propriety of its omission. That hope has proved fallacious. Opinion on the subject is still divided, although it is but just to admit that the advocates of simple extraction constantly appear in larger numbers, and assume a bolder front. Unanimity, however, has not been attained. Operators of skill and of established reputation are to be found ranged on either side. At the Heidelberg Congress in 1888 Critchett brought the matter home to all present by propounding a simple question. "If one of you," he said, "were the victim of a cataract, which operation would you wish to have performed, that with iridectomy,

or the simple extraction ?" Unquestionably the majority of the members would have then pronounced in favor of the former, although the minority was large and influential. It is difficult to say which party would, at the present day, be the more numerous.

The advantages of the non-performance of an iridectomy are simply and concisely stated by Professor Pflüger (*Kl. Monatsblätter für Augenheilkunde,* May, 1892, p. 161). He considers the return to simple extraction to be the greatest improvement in the cataract operation that has occurred for twenty-five years, and for the following reasons:

The conservation of the normal pupil combines optical with antiseptic advantages, in regard to the first part it having been proved that the corneal refractive power is at its best in the centre of that membrane; moreover,

(1) There is no wound of the iris, and hence far less likelihood of a depôt for the collection of offensive, that is, infectious material;

(2) There is no bleeding into the anterior chamber, to obscure the subsequent steps of the operation;

(3) The wound is protected by the intact iris from contact with fragments of capsule, the presence of which so often causes slow healing and secondary infection, leading it may be to chronic irido-cyclitis and even to sympathetic affection of the other eye;

(4) There is a certain amount of protection against loss of vitreous;

(5) Pflüger's experience leads him to think, strange as the fact may appear, that there is less danger of secondary glaucoma in the case of a simple extraction.

It is not asserted by either side that the percentage of corneal suppuration is affected by the performance or non-performance of an iridectomy. Stress is laid on the claim that, after successful simple extraction, the excentric vision is better and light better borne. On the other hand, it may be replied that the iridectomy need not be a large one, and that being made directly upward it is largely covered by the upper lid, thus ensuring a considerable use of the centre of the cornea.

Furthermore: 1. Considering the extent of the corneal wound, as well as the frequently large solution of continuity of the conjunctiva itself, the additional terrain afforded by the iridectomy for the collection of infectious material would be a matter of small account.

2. Bleeding is reduced to a minimum by the action of the cocaine, and frequently is entirely absent.

3. If prolapse of the iris, or even dislocation of the pupil occurs, the capsular fragments may yet come in contact with the wound, and these capsular fragments, as well as cortical remains, can be both more perfectly detected and thoroughly removed where the area is laid bare by an iridectomy.

4. That the statistics of simple extraction show a lessened percentage of vitreous prolapse, as compared with the Graefe operation, is not as yet universally admitted.

5. The same may be said in regard to the occurrence of glaucoma. The experience of individual operators is here at variance. Dr. Knapp, in 1890, reported three cases of glaucoma as occurring among one hundred simple extractions (*Archives of Ophthalmology*, vol. xix., p. 299).

There are two serious drawbacks to simple extraction:—

The first is the difficulty in clearing the pupil of cortical and capsular remains, after the lens has been delivered. It is obvious that, with an iridectomy, there is a larger pupillary area in view and a wider aperture for the extrusion of whatever may occupy it. Moreover, the manœuvres we generally employ for the clearing of the pupil, the tilting and rubbing, tend to maintain, if not to produce, the presence of the iris between the lips of the wound, and to render its ultimate reposition more difficult.

This leads directly up to the main objection to simple extraction, the liability to iris prolapse. This accident is met with in from seven to ten per cent. of all cases of this operation. Its disadvantages are the change thereby wrought in the corneal curve, the dislocation of the pupil, the lengthened convalescence entailed, and the tendency to cystoid cicatrization of the wound. It is most likely to occur in consequence of a sudden motion or injudicious effort on the part of the patient within the first few days after the operation, and may be brought about by the forcible contact of the hand with the eye during sleep. The wound being ruptured, the aqueous humor escapes, and carries with it the iris, which remains incarcerated between the lips of the wound. A sudden sharp pain is sometimes felt and arouses suspicion as to what may have occurred. But there are cases where no imprudent motion is known to have taken place, and no warning has been sounded, and yet where the first inspection of the eye, several days after the operation, reveals an extensive iris displacement.

The tendency of the eye to undergo this accident is well illustrated by the statistics of a third series of one hundred cataract extractions without iridectomy, published by Dr. Knapp (*Archives of Ophthalmology*, vol. xix., p. 280).

In seven of these cases iridectomy had to be performed during the operation.

In two cases the iris folded itself over the knife and was excised.

In eight cases prolapse and incarceration of the iris occurred during the healing process.

Eighty-three of these patients therefore recovered with fair, round pupils, fifteen either had iridectomy performed or would have been better off had this been done.

Performance of Simple Extraction.—There is but little to add to the account of this operation given in the article which the present one is intended to supplement. The long, narrow knife of Graefe may be used for the corneal incision, the puncture and counter-puncture being made just above the horizontal meridian of the cornea, in the transparent periphery of this membrane, the apex of the cut alone encroaching on the limbus. This is the course taken by experienced operators like Knapp, who aim at the avoidance of the peripheric section of former years. The capsule opening is made by some at the same time, and with the same knife used in the incision; by others with a special cystitome, and may be central or peripheric, either method having its advocates. Sometimes a piece of the anterior capsule is removed with forceps specially constructed for this purpose. After the delivery of the lens, the pupil, if still occupied by fragments of cortical or remains of capsule, may be freed by judicious manipulation, or irrigated with a sterilized solution of boric acid or common salt, either one-half or one per cent. in strength. These solutions should be slightly warmed and but little force used in their introduction. For this reason the syringe originally employed by McKeown will be found less manageable, as well as more difficult to sterilize, than the apparatus of Lippincott ("Transactions American Ophthalmological Society, Twenty-seventh Meeting." p. 115), or the "undine" of Wicherkiewicz. The writer has modified the latter instrument by attaching to its large aperture a short rubber tube, ending in a glass mouthpiece. Both hands of the operator are thus left free; he holds the mouthpiece between his teeth, and is enabled at will to modify the pressure to any extent, or even to reverse it and withdraw masses of cortical by suction into the apparatus itself. Solutions of corrosive sublimate are no longer used for irrigation, on account of the corneal opacities they were found to occasionally induce. Care must be taken to keep the opening of the irrigator as far from the pupillary edge as possible, prolapse of the iris being readily encouraged by its too immediate contact with this region.

After the clearing of the pupil and anterior chamber have been completed the iris must be carefully replaced, there being no better instrument for this purpose than a flat, narrow rubber spatula. If reduction be found impossible, or the iris shows a tendency to fall back into the wound, a small iridectomy must be made on the spot. In any case a solution of eserine (one per cent.) or pilocarpine (two per cent.) should be dropped into the eye before closing it.

Every operator has his favorite method of dressing the eye after extraction. A circular piece of linen, dipped in a solution of corrosive sublimate, one to five hundred, may be applied directly over the closed lids, the orbital cavity then packed with corrosive cotton, and the whole retained in place by a few turns of a light roller. These dressings may be withdrawn from the steam sterilizer, if one be provided, at the instant they are needed.

It has of late been seriously proposed by certain surgeons that the non-operated eye be left unguarded, that only a light dressing be applied to the other, and that the patient be kept in an undarkened room and allowed much freedom of motion. Good results are claimed from such an absence of treatment. This, if true, would reverse our traditions and revolutionize our practice. But as yet the only evidence in its favor is that of vague assertion, unsupported by definite statistics. Its advocates are at present few.

Iris prolapse being, as has been stated, often due to the sudden escape of the aqueous humor, consequent on a rupture of the corneal wound, an ingenious means of obviating this has been devised by Dr. H. B. Chandler, of Boston, and proposed by him as a modification of the operation. He makes a small opening in the iris in order to allow the free escape of the aqueous, which collects behind this membrane, and claims that this prevents prolapse.

His description of the operation is as follows: "After making a corneal cut, exactly at the cornea-scleral junction, a very small piece of iris, about one or two millimetres from the periphery, is caught up, either by means of a fine iris forceps, with teeth situated on the lower portion of the blade, as near the point as possible, or by means of a sharp hook, the bent portion being at right angles and about one millimetre long, and gently drawn out, is cut horizontally as close to the gripping instrument as possible; this leaves a small round opening, not more than one to two millimetres in diameter" (*Boston Medical and Surgical Journal*, October 16, 1890, p. 366).

For two or three days after a simple extraction greater quiet is necessary than is the case when iridectomy has been performed, the patient being cautioned to avoid straining and all sudden exertion. The occurrence of severe pain in the eye, or even a feeling of irritation, such as might proceed from the presence of a foreign body, should arouse suspicion of prolapse. If this comes on within two days after the operation the eye must be opened and the protruding iris reduced or excised. Otherwise it is better to leave it alone until the wound is thoroughly consolidated. After a lapse of several weeks the prolapse, if it shows no signs of flattening, may be excised or cauterized.

The exclusive employment of one method of extracting cataract would seem unwise. Each case must be taken on its own merits; its history, the condition of the eye, and the disposition of the patient carefully considered, and the operation selected that seems likely to be followed by the best results. Doubtless a successful simple extraction leaves the eye in a more normal condition, and thus affords a more perfect result. To gain this result the operator requires a maximum of experience and skill, while the patient must be prepared for a somewhat more burdensome convalescence, and must also be willing to incur a slightly increased risk of accident.

Hasket Derby.

CHANNEL ISLANDS. This group of islands, belonging to England, although geographically French, has long been favorably regarded as possessing certain climatic advantages.

Location.—The Channel Islands are small, their total area being only seventy-five square miles. The best known of the group are Jersey, Guernsey, Alderney, and Sark. The first-named is perhaps the most popular as a health-resort. These islands are situated in the great Bay of St. Michael, in the English Channel, and at a short distance from the western coast of Normandy.

Access.—The islands are easily accessible from France. From England a steamer, leaving Southampton daily, reaches Jersey in eight hours. The actual distance from Jersey to *Carteret*, in the Department of *Manche*, is only thirteen miles. St. Helier's, the chief town and port of Jersey, lies at the eastern extremity of St. Aubin's Bay.

Indications.—The Channel Islands are resorted to principally by invalids with "weak chests" and neurasthenia. According to Dr. Hooper, the monthly and seasonal variations in temperature are as follows:

	Degrees Fahr.		Degrees Fahr.
Annual mean	50.06	May	57.08
Winter "	43.82	June	61.51
Spring "	50.97	July	63.50
Summer "	62.84	August	63.72
Autumn "	54.63	September	59.82
January	41.58	October	55.65
February	44.02	November	48.42
March	45.75	December	45.27
April	50.09		

The number of rainy days is less than in England, although the actual precipitation of moisture is greater. It is important to remember that the climate, although mild and equable, is very humid. Dr. Scholefield speaks as follows on this point (Scoresby-Jackson, "Medical Climatology"):

"Besides its insular position, the island (Jersey) is everywhere thick set with wood, every little section of ground being hedged in with four rows of trees. The island, moreover, is continually intersected at intervals of a few hundred yards by pathways, beset with their double file of trees, planted on high embankments. Here neither the sun's rays can penetrate, nor can currents of air freely ventilate the earth.

"Of course, in the absence of high mountains, the islands are exposed to every variety of wind, and frequent gales are observed. Westerly winds predominate. The cold northwest winds of spring are apt to annoy invalids. Apart from this the islands enjoy an equable, soft, humid atmosphere, with astonishingly mild days, and very little frost or snow. The day and night variations of temperature are slight. The climate is thus rather relaxing, and patients requiring a vigorous, bracing air and exhilarating conditions should not be sent there."

Edmund C. Wendt.

CHARLOTTENBRUNN. A watering-place in Silesia, Germany.

Location.—Charlottenbrunn is prettily situated in a valley, at an elevation of 1,300 feet above the sea. The hills afford it ample protection against the cold north and northwest winds, and leave it exposed only to the warmer southern breezes. Pine-woods surround it. The springs are cold, alkaline chalybeate ones. But the place owes its reputation quite as much to its climatic advantages as to the mineral waters. It is a quiet spot, and only semi-fashionable. Season, May to October.

Access.—Bad Charlottenbrunn is a railroad station on the Dittersbach-Glatz Railroad.

Analysis.—The *Charlottenquelle* and *Theresienquelle* are both moderately powerful alkaline iron springs, having the usual composition of chalybeate waters.

Indications.—Neurasthenia, heart disease, chlorosis, and all diseases with a tendency to anæmia, derive benefit from a course of these waters.

Accommodations.—Attractive hotels and boarding-houses, modern thermal establishments, with all comforts, are found here. Milk, whey, kefir, and "herb-juice" cures are special features.

Edmund C. Wendt.

CHÂTEL-GUYON. A watering-place in the Department of Puy-de-Dôme, France.

Location.—Châtel-Guyon is charmingly situated in a beautiful region of Auvergne, and at an elevation of 1,300 feet above sea-level. The climate is pleasant and equable. There are over twenty saline chalybeate, magnesia springs, their temperature varying from 50° F. to 110° F. The French lay great stress on the purgative quality of these waters. But they cannot in any way compare with those of Carlsbad. The water contains free carbonic-acid gas, and the baths are said to be both

tonic and soothing. On account of the bubbles collecting on the skin, they are called "Champagne-baths."

ACCESS.—By the Paris, Lyons & Mediterranean Railroad to Riom, *viâ* Nevers. Thence by carriage in fifteen minutes to Châtel-Guyon.

ANALYSIS.—According to Lefort, the Deval spring contains in 10,000 parts of water:

	Grammes.
Hydrochloric acid (in combination)	21.33
Sulphuric acid (in combination)	2.93
Silicic acid	1.26
Carbonic acid (in combination)	10.92
Carbonic acid free	13.50
Potash	1.12
Soda	12.87
Magnesia	6.70
Lime	9.90
Oxide of iron	0.24
Alumina	0.08

INDICATIONS.—These springs are chiefly employed in gastric and hepatic derangements, associated with constipation, as well as in female diseases with a tendency to anæmia. But French physicians also recommend them in gout, diabetes, Bright's disease, and many other chronic ailments. Taken at the rate of about four to six glasses a day, they are purgative, but smaller quantities fail to act on the bowels. The season lasts from the middle of May to the middle of October.

ACCOMMODATIONS.—There are several bathing establishments, with the necessary appliances, but the *Établissement Brosson*, being the most modern, is to be preferred. Hotels fairly good. The place is not a fashionable one. *Edmund C. Wendt.*

CHLORALAMID. Introduced in 1889, by Professor von Mering, of Strasbourg, for its hypnotic properties, it is now looked upon as one of the most useful drugs we possess for this purpose. It results from the chemical combination of two parts of chloral anhydride, CCl_3 CHO, and one of formamide, CHO NH_2; its formula is CCl_3 CH. OH, $CONH_2$. It is not a mechanical mixture, and would be more correctly named chloral formamide, or formiate of chloral. It occurs in white crystals, which have a faint bitter taste, no odor, and are neutral in reaction. It is soluble in cold water, one part in ten, and in one and a half part of alcohol. The salt should never be dissolved in hot water, or heated above 120° F., as at that temperature it decomposes. It is also decomposed by alkalies and alkaline carbonates. It is compatible with weak acids which increase its solubility and render the solution more stable.

Chloralamid is supposed to be decomposed in the circulation by the free alkalies in the blood, and its hypnotic action produced by the chloral set free. The depressing effect on the respiration and heart does not follow, as this is counteracted by the stimulating action of the formamide.

In addition to this absence of depressing action, it has numerous advantages. It is free from any disagreeable taste, and its solubility renders it easy of administration. It does not derange the digestive organs, and no dangerous or alarming symptoms follow its use. It is not followed by headache, giddiness, or any disturbance of the nervous system. The sleep induced is tranquil and easy, and the awakening gradual and pleasant. It follows in from half an hour to one and a half or two hours after taking the dose, and lasts for five or eight hours. Occasionally a drowsiness continues, or the sleep is much prolonged, but it has never been found to be of serious import. The drug does not possess any cumulative action, nor does it give rise to a craving. It may be administered for a prolonged period without it being necessary to increase the dose.

Since its introduction, chloralamid has been used with safety in all forms of insomnia. It has proved of greatest service in the sleeplessness of a purely nervous origin, especially when unaccompanied by pain, or with pain very slight in character; in nervousness, in hysteria, in neurasthenia, in old age, in spinal diseases, and in chronic alcoholism, its effect will be very decided. When pain is very marked its action is not to be depended upon, but reports of its use in such cases show that it may be of much benefit in locomotor ataxia, and in the pains arising from aneurism and neuralgia. In chronic mental diseases, as melancholia, and mania unaccompanied with much excitement, it has proved of marked benefit. In cardiac disease where chloral hydrate cannot be used, it may be given with perfect safety, and in such cases as cardiac asthma, dyspnœa, its happiest results are obtained.

In febrile states, as in phthisis and typhoid fever, it acts favorably; in the former it lessens the cough and night-sweats, and lessens the depression that accompanies these symptoms. The effect is thought to be due to its stimulating action on the respiration which promotes the respiratory changes, and lessens the carbonic acid in the blood. In whooping-cough, laryngismus stridulus, as well as in pulmonary asthma, the drug not only produces sleep, but also allays the disease, the paroxysms becoming less severe, and the intervals more prolonged.

The dose advised when the drug was first used was from twenty to forty-five grains, and this has been very generally adhered to. The average dose employed is about thirty grains. As a rule, it is advisable to begin with a smaller dose of fifteen to twenty grains, when the insomnia is not accompanied by pain or excitement. On account of its solubility in alcohol, it is easily given in solution diluted with some aromatic elixir. Brandy or whiskey is a favorite means and adds to its beneficial action. If alcoholic solution is not desired, dilute hydrochloric acid will be found to serve the purpose. It may also be given in cachets. For whooping-cough and other spasmodic affections, it is given in doses of two grains every two hours. Enemata may also be employed when such a means of administering the drug is desired. The following formula is recommended: Chloralamid, 14 grains; dilute hydrochloric acid, 3 drops; alcohol, 20 drops; water, 3 ounces. *Beaumont Small.*

CHLORALIMID (Trichlorethylidenimide), CCl_3 CH NH. This substance is obtained by the action of acetate of ammonia on chloral hydrate; it may also be formed by heating chloral-ammonia. It is a crystalline acidular powder without taste, smell, or color, insoluble in water, soluble in alcohol, ether, and oils. It is not affected by heat or moisture. It possesses similar properties to chloralamid, but is more active. As an hypnotic, it is given in doses of from five to thirty grains. It is introduced as a substitute for chloral hydrate and chloralamid. It has not the acrid taste of the former nor the bitter taste of the latter. In smaller doses it is said to have an antipyretic and analgesic action. This drug has not been used to any extent, and its superiority to chloralamid has yet to be determined. *Beaumont Small.*

CHLOROBROM is the registered trade name of a combination of chloralamid and bromide of potassium. This combination, which possesses the active properties of both its constituents, has recently been advised by Professor Charteris, of Glasgow, as a remedy for seasickness. He had used it in many cases with very gratifying results. A dose is given after the stomach has been emptied of its contents, the sense of depression is relieved and nausea checked, a quiet sleep follows, from which the patient awakes relieved of all the distressing symptoms. The remedy may be prepared as follows: Chloralamid, bromide of potassium, of each one and a half drachms; water, 2 ounces; syrup, 1 ounce. One to one and a half tablespoonful for a dose.
Beaumont Small.

CHLOROFORM; HYDERABAD COMMISSION. Chloroform during the past few years has received its share of attention (see article on Anæsthetics) and a large amount of experimental research has been devoted to anæsthetics. Perhaps the most important work done on this subject since the use of anæsthetics was introduced, has been the investigations and report of what is known as the Hyderabad Chloroform Commission. In 1888 the Nizam of Hyderabad appointed the first commis-

sion, composed of Surgeon P. Hehir, M.D., I. A. Kelly, L.R.C.P.S. Ed., and A. Chamarette, I.M.S., to perform a series of experiments upon dogs with chloroform, expressing a wish that they should have a practical bearing on the way in which the administration of the anæsthetic ought to be conducted in the human subject. This commission was formed at the suggestion of Surgeon-Major Lawrie, President of the Hyderabad Medical School. Mr. Lawrie had been a pupil of Syme, of Edinburgh, and retained the views of that eminent surgeon regarding the action of chloroform. Professor Syme had always maintained that chloroform was a safe anæsthetic if properly administered; that its toxic action always showed itself on the respiration before the heart was affected, and that no accident would occur if the respiration was carefully watched.

Opposed to this was the very generally accepted view of what is known as the London school, which considers that the heart is the source of danger, and that death during chloroform anæsthesia was due to its failure.

The purpose of the commission was to inquire into the effect of the anæsthetic on the respiration and heart, and the value of artificial respiration to resuscitate when a fatal termination was threatened. A great number of experiments were made upon dogs, to which chloroform was given in various quantities and under varying conditions, to produce a fatal result. The conclusions reached were in accord with the views of Mr. Lawrie; in every instance the respiration ceased before the heart, and where artificial respiration was commenced when danger was indicated by the breathing, recovery followed, but if precautions were neglected until the pulse gave warning, it was too late to resuscitate. The report concludes with the opinion "that death from chloroform narcosis in dogs is absolutely avoidable, and ought never to occur from surcharging of the blood with chloroform. Once anæsthesia is induced, so long as the respiration is kept up there is no fear of a cumulative action—the drug is rapidly eliminated. Interference with this elimination brings about changes in the respiratory mechanism which ought to arouse suspicion and prepare us for artificial respiration."

When the editors of the London *Lancet* became aware of these experiments and the conclusions so much at variance with their own, they criticised the latter rather severely. It was thought that such important conclusions were arrived at rather hastily, and the experiments were not considered sufficiently precise to justify their acceptance.

In consequence, the Nizam, with great liberality, decided to have another commission appointed to repeat the experiments of the former commission in a more scientific and exact manner. A check for one thousand pounds was forwarded to the editors of *The Lancet*, that they might select any one they wished to conduct the experiments in such a manner as they might think necessary. Dr. Lauder Brunton was chosen and sent to India as their representative. His qualifications were all that could be desired: he was an authority in therapeutics and was known to hold views not in accord with the conclusions of the former commission.

The second Hyderabad Commission was composed of Surgeon-Major E. Lawrie, M.B. Ed., Dr. Lauder Brunton, F.R.S., Surgeon-Major G. Bomford, M.D. Lond., Dr. Rustomji of the Nizam's Medical Service, and associated with them were the members of the former commission. The experiments were begun in October, 1889, and continued for some two months. They were carried on in the hospital in connection with the Hyderabad Medical School, and the native government afforded every facility for making the work as thorough and perfect as possible. The most approved apparatus and appliances were provided for observing the action of the pulse, the respiration, and the blood pressure.

The objects kept in view by the commission were the suitability of chloroform as an anæsthetic, the effect of pushing it until dangerous symptoms or death took place, and the modifications of the anæsthesia that were effected by various degrees of asphyxia, by shock, and by the administration of various drugs.

The experiments numbered over four hundred and thirty. The majority were upon dogs and monkeys, but some were made upon horses, goats, cats, and rabbits.

Two methods of administering the chloroform were chiefly employed. In the first a known quantity was allowed to evaporate in a certain amount of air, and the animal made to breathe the mixture, in the other method a certain amount of chloroform was administered without attention being given to the amount of air inhaled.

To keep a record of the blood pressure two tracings were taken on different drums. One recorded the pressure throughout the whole experiment, but was too slow to indicate any variation in the pressure during the diastole and systole of the heart, the other was taken on a rapidly revolving drum and would indicate the slightest variation. The tracing of the latter would have been too lengthy to preserve, but it was so arranged that the pressure could be taken at any moment and for any length of time during an experiment. In certain instances the motion of the heart was registered by a needle inserted through the chest-wall and into the heart, and the movements conveyed by means of a thread extending from the free end of the needle to a lever writing on the moving surface of the drum.

The records of the respiratory movements were obtained by inserting a needle through the chest-wall into the diaphragm, the movements of the free end being recorded. All these records were photographed and reproduced for publication, and, together with the detailed account of the experiments, provide an amount of evidence which any one may inquire into, and by its means corroborate or disprove the conclusions arrived at by the commission. The work of the commission, including the account of the experiments, the tracings, and a large number of letters and papers, has been published in the lengthy report issued. For the report itself, the pages of the London *Lancet* for 1890 may be consulted.

The result of their work was to corroborate the conclusions of the first committee, and these conclusions were fully concurred in by Dr. Brunton, who became convinced that the respiration was the part first affected and should be watched for signs of danger.

The commission agrees, up to a certain point, with many of the views of their opponents. It is admitted by all that there is a gradual fall in the blood pressure throughout the administration of chloroform, and that this may terminate in death. The commission, however, hold that this is due to impoverished blood acting on the medulla and producing vaso-motor paralysis; the others consider it due to a direct depressing action on the heart itself. Both sides also agree that early in the administration of the anæsthetic a rapid fall in the blood pressure frequently occurs. Upon this fall the greatest interest centres, as it is at this period that so many fatal results occur. The commission say this fall is due to accidental causes, producing asphyxia, and that it might always be avoided by care in administration. The asphyxia by acting on the vagus reduces the action of the heart and lessens the supply of poisoned blood. They consider the slowing of the circulation as nature's method of protecting itself. The opponents to this view hold that it is due to a direct paralyzing action on the heart.

A series of very valuable experiments have since been made by Professor McWilliam, of Aberdeen, who demonstrated that with this early fall in blood pressure, a dilatation of the heart takes place, in some instances, even before the reflexes are lost. When this becomes extreme the heart fails to contract, although it may continue to beat in a feeble and uncertain manner. These observations have since been confirmed by many others, among them, Dr. Hare, of Philadelphia.

In consequence of such a diversity of opinion in such an important subject we are left in a very unsettled and unsatisfactory state of mind. Fortunately at this juncture His Highness the Nizam again comes to the rescue, and in a very creditable and liberal manner determines upon another commission, with the hope of reconciling the opposing views. The appointment of Dr. H. A. Hare to conduct the investigation will give general satis-

faction, and is all the more gratifying as his views are known to be in opposition to those of the last commission, thus indicating an earnest desire, on the part of the Nizam, to have all sides generously treated.

The following conclusions of the second Hyderabad Commission are reproduced in full, as they are of historic importance and will be of interest in connection with the work of the forthcoming commission :

1. Chloroform, when given continuously by any means which insures its free dilution with air, causes a *gradual* fall in the mean blood pressure, provided the animal's respiration is not impeded in any way, and it continues to breathe quietly without struggling or involuntary holding of the breath, as almost always happens when the chloroform is sufficiently diluted. As this fall continues, the animal first becomes insensible, then the respiration gradually ceases, and lastly, the heart stops beating. If the chloroform is less diluted the fall is more rapid, but is always gradual, so long as the other conditions are maintained ; and however concentrated the chloroform may be, it never causes sudden death from stoppage of the heart. The greater degree of dilution the less rapid is the fall, until a degree of dilution is reached which no longer appreciably lowers the blood pressure or produces anæsthesia.

2. If the inhalation is interrupted at any stage, the fall of pressure still continues at a rate which depends altogether on the rapidity of the fall while the chloroform was being inhaled. This after-fall is probably due to absorption of a portion of the residue of chloroform in the air-passages after the stoppage of the inhalation. In this way it often happens, if chloroform is given rather freely, that, though the respiration may be going on when the chloroform is discontinued, it afterward stops.

3. If the administration of the chloroform is stopped at an early stage, the pressure very soon begins to rise again, and gradually becomes normal ; but if the chloroform is pushed further, there comes a time, not easy to define, when the blood pressure and respiration will no longer be restored spontaneously, although the heart continues to beat after the inhalation is stopped.

4. If the fall has been very gradual it may occasionally happen that the respiration stops completely, and still the blood pressure rises again, the respiration recommencing spontaneously in the course of the rise. In the same way, when the inhalation has been discontinued, the respiration may stop during the after-fall of the blood pressure and begin again spontaneously. As a rule, if the respiration has stopped, or even becomes slow and feeble at the time when the inhalation is discontinued, and artificial respiration is not resorted to, the fall in blood pressure will continue until death ensues.

5. There are two conditions which frequently disturb the gradual fall of the blood pressure, viz., struggling and holding the breath—and it is only by great care that they can be avoided in animals.

6. Struggling, independently of any change in the respiratory rhythm, appears generally to raise the blood pressure. In one case of a dog much weakened from phosphorus, the pressure fell every time he struggled.

7. When struggling is accompanied, as it often is, by acceleration of the respiration and pulse, especially if the respiration is deep and gasping, it leads to a more rapid inhalation of chloroform, and consequently to a more rapid fall of blood pressure and a greater after-fall. In order to keep the chloroform cap or inhaler in its place during the animal's struggles, the administrator is obliged to hold it down more tightly over the nose and mouth, and this materially assists in hastening the rapidity of the inhalation, and consequently of the fall in blood pressure.

8. The effect of involuntarily holding the breath—which, as anybody can prove by experiment upon himself, must happen when an inhaler saturated with chloroform is first applied to the face—is much more remarkable, the pressure often falling with great suddenness, while the heart's action is markedly slower. As soon as the animal draws breath again, the pressure rises as suddenly as it fell, but the gasping respirations which succeed then cause very rapid inhalation of the chloroform, with immediate insensibility and a rapid fall of blood pressure, which quickly becomes dangerous.

9. The combination of struggling with alternate holding the breath and gasping, which results if chloroform is applied closely to the face without sufficient dilution with air, causes the violent fluctuations, and then a speedy fall of the blood pressure, which very soon leads to a dangerous depression with deep insensibility and early stoppage of the respiration. The after-fall under these circumstances is rapid and prolonged. It is this combination of events which causes struggling animals to go under chloroform so quickly.

10. The effect of holding the breath may occasionally cause a temporary fall of blood pressure after the chloroform inhalation has been stopped, or even when the animal is quite out of chloroform. This fall is recovered from directly the animal breathes again.

11. Slight continuous asphyxia, such as is produced by pressure on the neck by straps, a badly fitting muzzle, or hindrance of the chest movements by the legs being too lightly bound down, give rise to exaggerated and irregular oscillations of the blood pressure, and slowing and irregularity of the heart's action. If it leads to, or is accompanied by, deep gasping inspiration, it is apt, like anything else which causes this, to increase the intake of chloroform, and bring about a rapid decline of blood pressure.

12. Complete or almost complete asphyxia, as by forcibly closing the nose and mouth or closing the tracheal tube after tracheotomy, has an effect similar to, but more marked than, that produced by holding the breath, and the character of the trace corresponds precisely to that produced by irritation of the peripheral end of the cut vagus. The pressure falls extremely rapidly, sometimes almost to zero, and the heart's action becomes excessively slow, or even stops for a few seconds. If the Fick trace of Experiment 148 be compared with the photographic reproduction of Trace A, of the Glasgow Committee, it will be seen that they are identical, and that the slow action of the heart with great fall of pressure, which the Glasgow Committee attributed to some capricious action of chloroform upon the heart, was undoubtedly due to asphyxia.

13. This effect of asphyxia is the result of stimulation of the vagi. The proof of this is (*a*), that the trace corresponds exactly, as stated above, to that produced by direct irritation of the vagus ; (*b*), division of both vagi entirely abolishes it, and (*c*), the administration of atropine, which paralyzes the vagus, also abolishes it.

14. In Trace 158 (Fick 4), which was taken during asphyxia after a full dose of atropine, it will be seen that there is an alternately slow and rapid pulse according to the phase of the respiratory movement, but no continued slowing of the heart, as in vagus irritation. But there was still a distinct fall of pressure after the atropine when the breath was held, and it was thought that the slowing of the pulse above noted in this condition might be due to the disturbance of the heart from tension in the pulmonary vessels in the absence of respiratory movement, rather than to irritation of the vagi. To test this point Experiment 184 was instituted. In this experiment the dog's chest was forcibly inflated with bellows connected by a tube with the trachea, and the effect of this proceeding was to cause a fall of pressure and slowing of the heart exactly the same as involuntary holding of the breath. The dog was then poisoned with atropine, after which inflation of the chest still caused a fall of pressure, but without slowing of the heart. The fall of pressure must be in some degree independent of vagus irritation, which, however, usually accompanies it.

15. It only remains to be considered whether the slow action or temporary stoppage of the heart with great fall of pressure produced by vagus irritation is, in itself, an element of danger in chloroform administration, and if it is not, wherein the danger actually lies.

16. The experiments in which deliberate irritation of the vagi was carried on during anæsthesia, show unmistakably that irritation of these nerves diminishes rather than enhances the danger of anæsthetics. The effect

upon the heart is never continuous, and as the vagus becomes exhausted, or when the irritation is taken off, the blood pressure rises again, as it does when the same result is produced by asphyxia. The slowing of the heart and circulation which is produced by irritation of the vagus by any cause, such as holding the breath in chloroform administration, retards the absorption and conveyance of chloroform to the nerve-centres, just as holding the breath, whether voluntary or involuntary, prevents chloroform from entering the lungs; and of itself, slowing, or temporary stoppage of the heart in chloroform administration, is not dangerous.

17. To answer the second part of the last question in paragraph 15 is easy enough, if it is kept in mind that the effect of vagus irritation upon the heart is never continuous; and in chloroform administration, as the pressure rises again after the slowing of the heart and temporary fall of pressure produced by any form of asphyxia, violent respiratory efforts with bounding heart's action lead, as in the case of struggling, to a rapid and dangerous inhalation of chloroform, and consequent rapid and dangerous decline in blood pressure. It is, in fact, the temporary exhaustion of the vagi after stimulation that is to be feared, and not the actual stimulation, as long as it is continued.

18. In accordance with this fact it will be found that in chloroform administration neither holding the breath, even if involuntary, nor vagus inhibition can be kept up beyond a certain time; and if the chloroform is not removed from the face, one or both of two things may happen: (*a*), When the animal breathes again, it takes deep and gasping inspirations, the lungs become filled with chloroform, and an overdose is taken in with extreme rapidity; (*b*), when the restraining influence of the vagus is taken off the heart, through the irritation ceasing or the nerve becoming exhausted, the heart bounds on again, and the circulation is accelerated in proportion. The blood then becomes quickly saturated with chloroform, and an overdose is at once conveyed to the nerve-centres. The theory which has hitherto been accepted is, that the danger in chloroform administration consists in the slowing or stoppage of the heart by vagus inhibition. This is now shown to be absolutely incorrect. There is no doubt whatever that the controlling influence of the vagus on the heart is a safeguard, and that it is the exhaustion of the nerve which is dangerous.

19. It can be readily understood how a condition in which the pulse is rapid and bounding, with high blood pressure, leads to more rapid absorption of chloroform into the lungs, and a more rapid propulsion of the chloroformed blood to the medulla oblongata, and consequently to a more rapid paralysis of the respiratory and vaso-motor centres, and precipitous fall in the blood pressure. Such a condition is produced in some cases by ether, or by division of both vagi, or by a full dose of atropine. Not only is the poisoned blood carried more swiftly to the vital centres in these cases, but added to this there is the fact that, as the heart is already doing its utmost before the chloroform is given, it is unable to stave off by increased work the fall in pressure that occurs when the vaso-motor centre is paralyzed. On the other hand, it seems clear from Experiment 92 that the direct action of chloroform upon the heart's substance is not the cause of the fall of pressure that occurs when it is inhaled.

20. In Experiment 92, repeated injections of 20 minims of chloroform were made into the jugular vein, and its effect was not to paralyze the heart, but to produce anæsthesia and a gradual fall of blood pressure, exactly as if the chloroform had been inhaled. In Experiment 72, after a considerable amount of ether had been injected into the jugular vein, and a bounding condition of pulse had been produced, the effect of injecting chloroform into the jugular was much greater, and the fall of blood pressure much more rapid and dangerous than in the case where chloroform alone was injected. Granting, then, the truth of Minger's conclusions from experiments on the frog's heart (which have not been repeated and confirmed by the commission) that chloroform has a gradual paralyzing effect upon the heart's tissue, we must conclude that such an effect, in the degree in which alone it could occur in the practical inhalation of chloroform, would rather be a source of safety than of danger.

21. The committee discussed the advisability of cutting the vagi some time previously to experimenting on the blood-pressure with chloroform. The effect of this procedure is to cause continuous rapid action and tendency to exhaustion of the heart, as well as to degeneration of the terminal branches of the nerves in the heart if the animal live sufficiently long.

Such experiments might be of some interest theoretically, and also have had a practical bearing upon the condition of the heart in certain cases of chronic alcoholism; but the committee decided not to perform them, as it considered the end to be gained did not justify the pain they would have inflicted.

22. In Experiment 178, the case of a dog that had had morphine, remarkable slowing, and even temporary cessation, of the heart's action occurred again and again at the same moment as the respiration stopped; but the heart invariably recovered itself, and began again to beat regularly, before any steps were taken to restore the animal, and without any respiration occurring. We find in this case that it was possible to restore the animal even after unusually long intervals had been allowed to elapse between the cessation of the natural and the commencement of the artificial respiration. The failure of the heart, if such it can be called, instead of being a danger to the animal, proved to be a positive safeguard, by preventing the absorption of the residual chloroform and its distribution through the system.

23. The effect of artificial respiration after the natural respiration has ceased, is to cause an alternate rise and fall of small amount in the blood-pressure, the trace thus formed upon the drum being a coarse imitation, altered somewhat by the shaking of the table, of the natural respiratory curve. The difference consists chiefly in the fact that the artificial rise always coincides with expiration or compression of the chest. After artificial respiration has been continued for a certain time, the blood pressure begins to rise again, and a little later natural respiration returns.

24. The effect of artificial respiration in restoring an animal after the respiration had stopped was always marked. In a few exceptional cases, such as Experiment 159—a phosphorus dog—and Experiment 142—a horse which had an enormous overdose, although the artificial respiration was commenced as soon as possible after the breathing was noticed to have stopped, it was not successful.

25. Complete stoppage of the respiration always means that an overdose has been administered, and the overdose may have been so great as to produce a very prolonged after-fall of blood pressure, and may thus render restoration impossible. As it is impossible to say whether, after chloroform has been pushed and then discontinued, the respiration will be restored spontaneously or not, so it is never in any case certain that artificial respiration will restore the natural respiration and blood pressure, no matter how soon it is commenced after the respiration stops. A great deal depends upon the amount of the after-fall; in some cases, even after the respiration has been restored, the pressure continues to fall and respiration again ceases, and artificial respiration then fails. We thus find respiration restored by artificial respiration while chloroform is still being absorbed, and this tends to show that artificial respiration does not merely pump the chloroform out of the blood, but exerts considerable influence in exciting the natural respiration.

26. The time which elapses before artificial respiration succeeds in restoring natural respiration varies very greatly. In one case, Experiment 116, it was continued for eleven minutes before the first natural gasps commenced. This period is undoubtedly prolonged in some cases by a condition of physiological apnœa, which renders it unnecessary for the animal to breathe. Consequently, whenever the pressure rose considerably during

artificial respiration it was stopped, and the animal then generally breathed after a few seconds.

27. The time which may be allowed to pass with impunity before commencing artificial respiration also seems to vary considerably. This point was not particularly attended to in the manometer experiments, except in Experiments 162 and 178, which were instituted to test the truth of the opinion formed by the sub-committee, that morphine had some slight action in impairing the efficiency of artificial respiration. In these cases the commencement of artificial respiration was postponed for more than two minutes after respiration ceased, and was successful; but this is certainly far above the average interval that can be allowed with safety. The success of artificial respiration in restoring the blood pressure is in some cases very remarkable; *vide* especially Experiment 40, in which the heart had apparently ceased beating, and the dog was believed by everyone present to be dead, and yet recovered with artificial respiration. The success in this instance is due to the fact that chloroform had only been administered for a few seconds, and that the depression was the result, not of continuous chloroform administration until respiration ceased, but of a long and severe after-fall.

28. It corresponds to those cases which are so often reported, in which dangerous failure of the heart is said to have occurred some minutes after the administration of chloroform had been discontinued, and which are sometimes restored, and sometimes not, by artificial respiration. There is nothing at all sudden about the failure of the heart in these cases, but the attention of the chloroformist, which has been wandering, is suddenly called to the fact that the patient is apparently dead. When the animal was really dead, it was found in some cases that artificial respiration still maintained a small amount of mean pressure in the manometer. In others the pressure seemed to fall to the zero line between each compression of the chest.

29. The dangers of too vigorous artificial respiration were illustrated in some of the accidental deaths. In one case the liver was badly ruptured, and in another the pleural cavity was full of blood. In these cases—Experiments 80, 92, and 103—rhythmical movements of the diaphragm were noticed after the heart had ceased beating and after the chest had been opened. It is remarkable that in two of these cases the splanchnic nerve had been divided. The third was a case in which chloroform had been injected into the jugular vein, and in this case there was a synchronous movement of the jaw as well. In all, death and stoppage of the heart had occurred gradually, and in Experiment 103 the heart was still irritable. These movements cannot be called respiration, though the last gasp of a dying animal, that ineffective jerk of the diaphragm which is such a fatal symptom, is very likely in many cases a movement of the same character. Similar movements, which were continued much longer, occurred in Experiment 104, after the thorax was opened, while the heart was still beating. Still more remarkable convulsions of the muscles of the jaws, ears, and forefeet occurred in Experiment 167, in the case of a dog that had been poisoned with nicotine. These movements continued at regular intervals for more than ten minutes after death, and were sufficiently forcible to jerk the handles of a pressure-forceps, fixed on the end of the tongue, off the table at each spasm. In a rabbit, in Experiment 153, the auricles of the heart continued to beat rhythmically for three hours after it was supposed to be dead from chloroform and its thorax had been laid open. Irritability of the heart after death was noticed in many cases, but seemed to be most marked in cases where ether had been used.

30. Chloroform injected into the heart through the jugular vein did not cause clotting of the blood, as was the case when ether was injected.

31. In the course of the experiments of the committee various drugs were administered in order to ascertain if they had any effect in modifying the action of chloroform. The result showed that none of them had any effect in preventing the typical descent of the blood pressure that occurs when chloroform is inhaled. Atropine, when given in a dose sufficient to paralyze the vagi, of course prevents the action of those nerves in asphyxia, and by increasing the action of the heart it appears to cause a more rapid descent in the blood pressure when chloroform is inhaled, as has been already explained. Morphine appeared, in Experiment 162, to render the rise in blood pressure, that occurred when the chloroform was discontinued, slower and less complete, and to bring about a more or less permanent condition of anæsthesia. It may be noted that the animal used in this was a monkey; and in other experiments with monkeys, when no morphine had been given, it was remarked that the animal, after a few inhalations of chloroform, would often lie quite quiet, in a state of semi-insensibility, for a long time without further inhalations; still this condition was much more marked in Experiment 162 than in any of the others. No action of this kind was noticed in the dog in Experiment 178, but other experiments (90 and 94) showed that pariah dogs are very indifferent to the action of morphine, and it is probable that the dose of morphine in this case was insufficient to bring about the condition noted in the monkey. The peculiar behavior of the heart in Experiment 178 was not the result of the previous administration of morphine, for a similar phenomenon had occurred in other cases (49 and 60) in which no morphine had been given. Experiments 162 and 178 prove conclusively that morphine had no effect in shortening the period that may be allowed to elapse between the cessation of natural respiration and the commencement of artificial respiration.

32. The other drugs used had no effect on the action of chloroform, except when their own special action became the leading feature in the case—as, for instance, during the vomiting from apomorphine (Experiment 104, Fick 9), or the convulsions produced by nicotine (Experiment 167).

33. In order to test the alleged danger from shock during chloroform administration, the committee performed a very large number of those operations which are reputed to be particularly dangerous in this connection—such as extractions of teeth, evulsions of nails, section of the muscles of the eye, snipping of the skin of the anus, etc. In many cases the operation was performed when the animal was merely stupefied by the chloroform, and not fully insensible. In such cases a slight variation in the blood pressure would sometimes occur, such as one would expect from the irritation of a sensory nerve or from the struggling that ensued; but in no case, in any stage of anæsthesia, was there anything even suggestive of syncope or failure of the heart's action. In thrusting a needle into the heart there was often a momentary but well-marked fall of the blood pressure; but even this was absent in all other injuries. If chloroform really had any power to increase the tendency to shock in operations, it is impossible to believe that it would not have been manifested, to some degree at least, in one or other of these numerous experiments. The commission was, however, not content with this negative result, and determined to ascertain the effect of direct irritation of the vagi during continued chloroform administration. The result of such experiments (65 and others) proved that inhibition of the heart's action prevented, rather than assisted, the fatal effects of prolonged chloroform inhalations. An animal that was put into a condition of extreme danger (from which it could only be restored by means of artificial respiration) by inhalation of chloroform for one minute, recovered spontaneously and readily after five minutes of chloroform inhalation, together with inhibition of the heart by electrical irritation of the vagus carried on simultaneously. In one of these experiments (117) chloroform was pushed for seven minutes; and during continued irritation of the vagus the animal repeatedly came round without artificial respiration. The danger really begins when the irritation is discontinued or fails to inhibit the heart, and thus enables the chloroform in the lungs to be rapidly absorbed and thrown into the system. The danger is certainly increased by deliberately pumping the chloroform into the lungs by means of artificial respiration, for animals in which this was

done, although they showed a tendency to recover when the chloroform and irritation of the vagus were discontinued, afterward died rapidly.

34. On another occasion, during Experiment 117, the animal was very nearly killed by a comparatively short inhalation of chloroform, owing to the electrodes becoming accidentally short-circuited and failing to keep up the irritation of the vagus. Something similar occurred in Experiment 177, the effect of the irritation of the vagus passing off while the chloroform was still being pushed, and thus putting the animal into a condition of extreme and unexpected jeopardy. Nothing could be more striking than these near approaches to accidental death from failure to irritate the vagus efficiently.

35. Other experiments were made to test the truth of the statement that chloroform increases the action of electrical stimuli applied to the vagus, and showed conclusively that it has no such effect. In one instance only the inhibition seemed to be intensified as the chloroform was commenced, and diminished when it was discontinued; but, apart from the fact that the supposed effect ceased much too suddenly, a repetition of the experiment, on the same and other animals, showed that there was in reality no such effect. The increased inhibition in this instance was due to the chloroformist compelling the attendant who was holding the electrodes to change his position, and thus making him unconsciously apply them more efficiently. When the chloroformist withdrew they were restored to their former position. This affords an instance of the care that has to be taken in making experiments, if one is not to be deceived.

36. To test the effect of shock due to vaso-motor change rather than to affection of the heart, Goltz's experiment on the frog was repeated on three dogs. In one there was slight lowering of pressure, which was not extensive, and in the others no effect was produced at all. Other operations which seemed likely to produce shock, such as violent blows upon the testicle, were singularly devoid of effect. Failing to lower the blood pressure by any of these methods, recourse was had to section of the splanchnics; but the low condition of blood pressure which this produced, appeared, like stoppage of the heart from vagus irritation, to be a source of safety rather than of danger during chloroform administration. In this connection Experiment 111 may be studied. There was not much external hemorrhage, but the splanchnics were divided—a proceeding which, as is often said, bleeds the animal into his own vessels. The pressure was after this extremely low, but chloroform was repeatedly given and various other actions taken, and then chloroform had to be pushed on a saturated sponge enclosed in a cap for eleven minutes before respiration ceased.

37. The conclusion, then, is this: Chloroform has no power of increasing the tendency to either shock or syncope during operations. If shock or syncope from any cause does occur, it prevents, rather than aggravates, the dangers of chloroform inhalation.

38. The experiments on dogs that had been dosed with phosphorus for a few days previously, show that the fatty, and consequently feeble, condition of the heart and other organs so produced has no effect in modifying the action of chloroform. The ease with which vagus irritation and the Glasgow trace could be produced in these animals, by even slight degrees of asphyxia, was very remarkable; but this was equally the case in dogs that had been given phosphorus only a few hours before the experiment, and whose organs were not yet fatty. Many of these cases were in the last stage of phosphorus poisoning, and several of their companions died, without any experiment having been performed upon them, before or on the same day as they died (*vide* the low state of blood pressure in Experiment 163). Numerous attempts were made in these animals to produce shock by operations in the recumbent and vertical positions, but without any more result than in those that were healthy.

39. The truth about the fatty heart appears to be that chloroform *per se* in no way endangers such a heart, but, on the contrary, by lowering the blood pressure, lessens the work that the heart has to perform, which is a positive advantage. But the mere inhalation of chloroform is only a part of the process of the administration in practice. A patient with an extremely fatty heart may die from the mere exertion of getting upon the operation-table, just as he may die in mounting the steps in front of his own hall-door, or from the fright at the mere idea of having chloroform, or of undergoing an operation, or during his involuntary struggles. Such patients must inevitably die occasionally during chloroform administration, and would do so even were attar of roses or any other harmless vapor substituted for chloroform.

40. The effect of hemorrhage was tested by opening the femoral artery and allowing a considerable quantity of blood (eight to twelve ounces) to escape. An immediate lowering of the blood pressure results, and this is very slowly recovered from. Such an accident, however dangerous it may be in itself, in no way affects the action of chloroform, except in so far that a patient who has been nearly bled to death would require less chloroform in his system to put him into a state of anæsthesia. The low condition of his blood pressure produced by the hemorrhage would tend to prevent the too rapid intake of chloroform, exactly as in the case of cutting the splanchnics (*vide supra*, subparagraph 36).

41. When the hind feet are lowered on to the floor so as to place the animal in the vertical position, a considerable fall of blood-pressure in the carotid artery occurs; but when the animal is replaced on the table in the recumbent position the pressure is fully restored. Various operations were performed on animals in the vertical position, but in no case was anything resembling dangerous shock produced. Inversion of the body, so that the animal stands on its head, has exactly the opposite effect, the pressure rising in the carotid artery, and again falling to its former state when the animal is replaced in the horizontal position. Inversion of the body failed to restore an animal that was in the last stage of chloroform poisoning, though it raised the pressure in the usual way as long as it was continued. The change in the pressure of the blood of the carotid, which occurs when the position of the body is changed, appears therefore to be due simply to the effect of gravity.

42. As regards the effect of chloroform upon different animals, it may be said to be the same as far as its anæsthetic action is concerned. There are certain peculiarities in its effect on respiration and circulation, connected with its local irritant action on the nostrils and fauces, which are interesting to notice. Thus, when concentrated chloroform vapor is applied to the nostrils of rabbits, they hold their breath, and the heart's action is slowed at once. This is always said to be due to reflex inhibition of the heart from irritation of the nasal branches of the trigeminus reflected through the vagus, and is by no means peculiar to chloroform, but is produced equally by any irritant vapor, such as ammonia or acetic acid.

43. In some dogs, and especially in those to which phosphorus had been given, stoppage of the respiration and slowing of the heart occurred immediately after the application of the chloroform to the face, or on forcibly pulling out the tongue, and this suggests that the mechanism of the cardiac arrest in them is precisely the same as it is in the rabbit. On the other hand, in rabbits, as in all other animals, it is possible to give chloroform so gently that no spasm of the chest occurs, no reflex effect is produced; and then the pressure falls in the same regular curve, and with the same succession of phenomena (anæsthesia, cessation of the respiration, and lastly cessation of the heart-beat) that was above described as typical of chloroform inhalation.

44. Goats have a great tendency to hold their breath while inhaling chloroform, and monkeys resemble dogs rather than rabbits, as when ammonia was held before a monkey's nose (Experiment 98) it did not cause immediate stoppage of the respiration and heart as it does in rabbits.

45. The experiments with ether show that it is impossible to produce efficient anæsthesia with this agent unless some form of inhaler is used which thoroughly excludes the air. If an ordinary cap containing a sponge saturated with ether is applied very closely to the face,

the animal generally holds its breath and struggles, and we at once get the fall of blood pressure and slowing of the heart that invariably occur under these circumstances. If the ether is continued in this way after the animal has recommenced breathing, a condition of semi-anæsthesia results in which the cornea is sometimes sensitive and sometimes insensitive, and the pressure rises and falls alternately to a slight amount and forms a wavy trace, which may be continued right around the drum without any particular change. As soon as the air is rigidly excluded, the pressure commences to fall gradually, exactly in the same way as with chloroform, and with the same succession of phenomena, viz., first anæsthesia, then cessation of the respiration, then of the heart movements, and finally death. How far this is due to ether and how far to the results of asphyxia, it is impossible to say, but an exactly similar succession of events can be brought about by making the animal inhale carbonic acid gas alone.

46. If surgeons continue to be content with a condition of semi-anæsthesia, it can no doubt be produced with perfect safety, though with discomfort, to the patient, by ether held rather closely to the mouth. Such a condition of imperfect anæsthesia would never be accepted by any surgeon accustomed to operate under chloroform. If more perfect anæsthesia is required, it can be procured by excluding the air more rigidly, but then there is exactly the same danger as in giving chloroform. How very suddenly and rapidly the pressure may fall and death ensue, is well shown by Experiment 33. Ether injected into the jugular vein produces a fall of blood pressure and anæsthesia in the same way as chloroform does, but in all cases in which it was so injected large clots were found in the heart immediately after death. It is interesting to note that Claude Bernard seems to have formed a very similar opinion with regard to ether, as the following quotations from his work, entitled "Leçons sur les Anesthésiques et sur l'Asphyxie," published in 1875, show. The first quotation (p. 50) is as follows: "Aussi, un certain nombre de chirurgiens proposèrent-ils d'abandonner le chloroforme pour revenir à l'éther, dont l'usage paraissait moins à craindre. Aujourd'hui encore, les chirurgiens de Lyon emploient préférablement l'éther. On croyait le chloroforme plus dangereux que l'éther parce qu'il était plus actif; mais, en réalité, la fréquence relative des accidents par le chloroforme tenait peut-être tout simplement à ce que c'était cet agent anesthésique qu'on employait dans l'immense majorité des cas. Plusieurs discussions ont été provoquées par les partisans de l'éther, surtout par les représentants de l'école de Lyon, et il a été constaté que l'éther, lui aussi, avait produit un certain nombre d'accidents mortels. Les deux agents anesthésiques usités peuvent donc, l'un comme l'autre, entraîner quelques risques de mort, et la chirurgie humaine a conservé presque partout le chloroforme, dont l'action est plus rapide et plus complète." The second quotation, to be found on p. 101 of the same work, runs: "Quant à l'éther et au chloroforme, leur action est à peu près la même au point de vue physiologique, sauf une différence d'intensité en faveur du chloroforme, ce qui nous fera généralement employer ce dernier corps de préférence à l'éther." *Beaumont Small.*

CHORDITIS TUBEROSA (*Trachoma of the Vocal Bands*). This peculiar laryngeal disorder, which is always associated with catarrhal inflammation of the entire larynx, is characterized by the formation of a small whitish nodule upon one or both of the vocal bands.

It is of special interest to the laryngologist because it occurs almost entirely in public speakers, singers, and actors. It always produces some degree of impairment of the voice, and, as it is a lesion which it is difficult to eradicate, it is well to appreciate its existence and treat it intelligently. Not much has been written about it. Most authors have been satisfied with brief mention of this condition as one of the manifestations of chronic catarrhal laryngitis.

PATHOLOGY.—Türck's[1] description of this lesion, to which he first gave the name "chorditis tuberosa," is the most comprehensive. Almost every author of recent years refers to Türck's article when writing of the pathology and etiology of this disease. Türck had noticed four cases of this peculiar inflammation of the vocal bands in singers, and he gives this description of the appearance of the larynx: "Midway in the upper plane of the bands there is a peculiar uneven surface, and, in addition to redness and swelling, some white opaque spots as large as poppy-seeds." These white spots, he says, become more noticeable as the general congestion subsides. He believes this peculiar lesion to be due to inflammation of the mucous glands.

Von Ziemssen,[2] speaking of the pathological changes of the vocal bands occurring in very protracted cases of chronic catarrhal laryngitis, says: "There is sometimes a roughness of the surface, which seems to be due to a partial *dermoid metamorphosis* of the mucous membrane — a condition called chorditis tuberosa by Türck." Wedl,[3] who examined specimens from a number of trachomatous vocal bands, found only connective-tissue hypertrophy with heaps of nuclei. Bosworth[4] says: "The pathological lesion is probably somewhat analogous to pachydermia, with the addition of a certain amount of connective-tissue hypertrophy;" and Sir Morell Mackenzie,[5] in a very brief description, says: "The lesion appears to consist in a hypertrophy of the connective tissue and a proliferation of its nuclei."

It is somewhat difficult to determine whether Virchow[6] is not describing the same pathological condition in his article on "Pachydermia of the Larynx." Certainly the appearances of the vocal bands in the earliest stages of pachydermia, as Virchow describes them, are quite similar to the nodules of chorditis tuberosa. Later, the infiltration and swelling are much greater in what he designates pachydermia than we see in chorditis tuberosa. He says the swelling is at first localized in the middle of the vocal bands. There are raised points with tissue-thickening about them, the raised points being the swelling of the squamous epithelium and the papillæ. This condition he believes to be due to long-continued congestion—a hyperplastic process, not an irritative one. He thinks it cannot consistently be called a chronic catarrh of the larynx, as there are neither mucus nor pus-corpuscles.

We believe that the essential pathological change in pachydermia laryngis is in kind like that found in trachoma of the vocal bands, but carried much farther from the normal condition; — pachydermia, as Virchow says, "occurring in aged drinkers, and caused by shouting." In an illustration of an extreme case furnished by Ingals,[7] in his article on "Trachoma of the Vocal Chords" (Fig. 68), we see a condition very similar to Virchow's pachydermia laryngis, and a much more advanced stage of disease than we have ever witnessed in chorditis tuberosa. We think mild cases of pachydermia may closely simulate extreme cases of trachoma, but the thickening extending both above and below the vocal bands, and forming polypoid enlargements, as Virchow pictures the later lesions of pachydermia, are not seen in chorditis tuberosa. The writer has had sections from two nodules which were removed from the vocal bands of different patients examined, and the result was the same in both instances: both specimens showed the result of simple inflammatory changes in the hypertrophy and increased number of the small round cells and connective-tissue corpuscles. It is essentially a hyperplastic process due to long-continued irritation and congestion of a moderate grade.

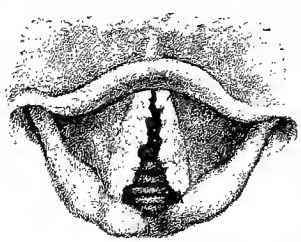


FIG. 68.

ETIOLOGY.—While it is undoubtedly true that a chronic catarrhal laryngitis is a predisposing factor in the causa-

tion of these peculiar nodular formations of the vocal bands, yet the exciting causes to be mentioned have a much more important bearing. The description of chorditis tuberosa should not be buried in a general article on catarrhal laryngitis, as it deserves separate treatment, by reason of its special etiology. The amount of the general catarrhal inflammation in these cases is not excessive, while the pathological changes of the vocal bands are out of proportion to the general catarrh.

The essential exciting cause of chorditis tuberosa is excessive use of the voice, and the lesion usually appears in singers. During the last two years I have seen eight cases of chorditis tuberosa. Six of these cases were in singers; the remaining two cases were in people who used their voices more than in ordinary conversation, one a Hebrew, who read aloud some religious ceremony every week, and the other a foreman of a large number of laborers, who was in the habit of shouting to his men. The six singers were all women and sopranos. It would be interesting to know if any cases of chorditis tuberosa have been seen in people who do not use the voice except in ordinary conversation. I have never seen such a case. This may be explained by the fact that probably none but singers, actors, public speakers, etc., go to a physician on account of the moderate hoarseness which the nodule on the vocal band produces. It is my belief, however, that this nodule is produced by excessive use of the voice in singing and public speaking, and that it is also largely attributable to *a faulty method of singing or an improper manner of using the voice.* It is a significant fact that six of the eight cases observed were singers and sopranos, conditions, as we know, requiring the highest tension and the most rapid vibration of the vocal bands. In writing the histories of these six cases, some attention was paid to the manner in which the voice had been trained, and it seemed to me significant that two of the patients were in the same class at a grand conservatory of music where only the "true Italian method was taught." During vocalization in both of these cases, as the scale was ascended the epiglottis was carried farther downward and backward with each note and the larynx was compressed more and more. One of these women could sing only a short time without becoming quite hoarse. After changing her teacher and using her voice in a different manner, she was able to sing at a theatre every night, although there is still some nodular enlargement on one of the bands.

One of the patients—an operatic singer of great reputation—stated the pathology of the condition known as "chorditis tuberosa" quite accurately when she said, after the laryngoscopic appearances had been described to her, "Why, I should say I had corns on my vocal bands"—the "dermoid metamorphosis" of Von Ziemssen.

These nodular enlargements are produced by the rapid vibrations of the vocal bands, weakened by catarrhal inflammation and over-use. After the chords become congested and thickened the friction of one band against the other is probably a contributing factor, just as the outer layers of the skin of the foot become hypertrophied by the friction of an ill-fitting shoe. This is especially true when the tension of the chords is unevenly controlled. While some congestion of the vocal bands, incident to the general catarrh, precedes the nodular swellings, the larger portion and the general thickening of the bands follow the formation of the nodules on the chords and are caused by the nodular enlargement. The nodular swellings are therefore in a sense primary, and the other changes in the bands secondary.

The irritation caused by the constant friction of the nodular enlargement with the opposite band, and the extra exertion necessary to produce a true tone in singing or a clear voice in speaking—these cause congestion with hyperplastic changes, and eventually an exhaustion of the adductors and tensors of the bands.

Symptomatology.—The nodular enlargements may be situated upon one or both bands. In five of the eight cases I have seen, the nodule was on the left band. It is usually located a trifle more anteriorly than midway between the vocal processes and the anterior insertions of the vocal bands, and it may be on the upper surface of the chord or upon its free margin.

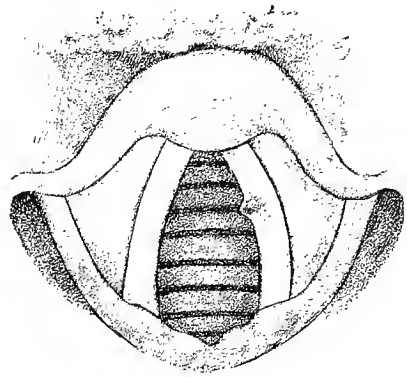


Fig. 69.

A nodular enlargement of one band, if the voice is persistently used in singing or public speaking, will in time produce some alteration in the tissue of the other band at the point of contact. Sometimes there is an appearance of depression in the second vocal band just opposite the nodule.

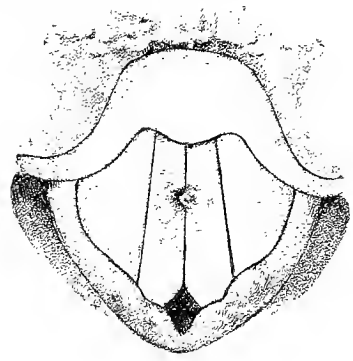


Fig. 70.

If this depression is examined carefully, the mucous covering will present a roughened appearance, a callous spot which has been produced by the protruding point on the opposite band. This callous depression is really raised above the normal surface of the vocal band; but a concavity exists because the edges about the depression are elevated to a still greater degree. After the nodule has existed for some time the depression on the second band is sometimes filled, and later gives place to a second nodule. Two nodules are now seen striking against each other, and the bands are just so much more prevented from approximating during phonation. If these nodules are not removed, and if the person is allowed to continue singing, the irritative friction and the increased effort of the intrinsic laryngeal muscles necessary to bring the bands together cause congestion and thickening of the entire substance of the bands. If a very careful examination of one of the nodules is made in its earliest stages, the mucous membrane covering it will seem to be unaltered, and the millet-like nodule seem to be wholly situated in the substance of the band. It requires strong illumination to correctly appreciate the exact amount of congestion and swelling of the vocal bands. The nodules in this disease are, when first formed, pearly white, but later become a dirty gray. The color of the nodule, however, depends much upon the color of the adjacent vocal bands. When the entire band is congested and thickened, the nodule can be seen with difficulty; when the congestion of the band disappears, the nodule stands

out prominently. With poor illumination the vocal bands will seem to be nearly normal; a better light will reveal enlarged capillaries, running over the surface, and in the substance of the vocal bands, which in color vary from a gray to a pale red. The location of the nodule may always be easily discovered, because the secretions stick to this part of the chord, and when the chords separate during inspiration, a thread of mucus may be seen, stretching across from the nodule on one chord to the point of contact on the opposite chord. The degree of approximation of the bands depends upon the size of the nodule and upon the strength of the adductors of the vocal chords. The size of the interval between the chords varies from day to day, because the nodule changes in size rapidly without apparent cause (Fig. 71). I have seen a nodule develop in forty-eight hours, on a vocal band long affected, because of over-

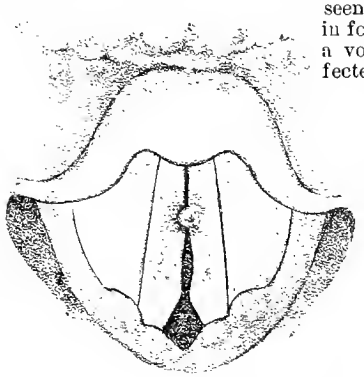


FIG. 71.

singing during a single evening. The chords approach each other more closely in front of the nodule than behind it. The failure of the bands to meet each other throughout their entire length occasions "phonatory leakage," and impairment of voice, which is about the only symptom of this affection.

The degree of hoarseness will depend, not only upon the size of the interposing nodule and the amount of secondary inflammatory changes in the vocal bands, but also upon the skill with which the vocal apparatus is employed. We all know how well some singers vocalize with greatly altered vocal bands.

DIAGNOSIS.—The single pearly nodule, as large as a pin's head, will be, in the early stages, easily diagnosed from other lesions of the vocal bands. When the bands become congested and thickened, a little more care will be required, but the diagnosis is never difficult.

"Chorditis tuberosa" should not be confounded with the uneven surface of the vocal bands seen in long-standing cases of simple chronic chorditis, where the vocal apparatus has been abused for many years, and strong astringents or caustics have been so frequently applied to the larynx that little normal mucous membrane remains. Chorditis tuberosa should be differentiated from the cicatrices following tubercular and syphilitic ulcerations, or from granulation tissue springing from the base of ulcers, and also from benignant growths attached to the vocal bands.

TREATMENT.—In no laryngeal disorder must the treatment be more painstaking. Skilful manipulation will be required to eradicate it. These cases should be treated as early as possible before the second band has been injured by the protruding nodule on its fellow, and before the bands have become congested, thickened, and stiffened, and the vocal tensors exhausted beyond recovery. They should not be allowed to sing or to use their voices except in quiet conversation. The voice should be rested, not only until the nodular enlargement has disappeared, but until congestion has abated and the muscular tone of the larynx has been restored.

It is hardly necessary to say that the nose and pharynx should be put in good condition. Colds in the head and inflammation about the pharynx always aggravate this condition of the vocal bands. The condition known as pharyngitis sicca bears a specially close and injurious relation to a trachomatous vocal band, and every effort should be made to keep the pharynx moist while treating the larynx.

The local remedies are not many which are of use in the judicious treatment of chorditis tuberosa. The nodule must be eradicated first of all. Time can be saved, in rare instances where the nodule is large enough, by snipping it off to the plane of the free edge of the band. I have twice used successfully a small, circular, snap, guillotine-knife, the circle about a quarter of an inch in diameter.

With the aid of cocaine this circle can be placed around the nodule and the band pressed toward the lateral wall of the larynx before the knife is sprung. This instrument can be used more delicately than a laryngeal forceps, and with less damage to the bands. After the nodule has been cut off, a solution of zinc chloride or of silver nitrate, from thirty to sixty grains to the ounce, may be

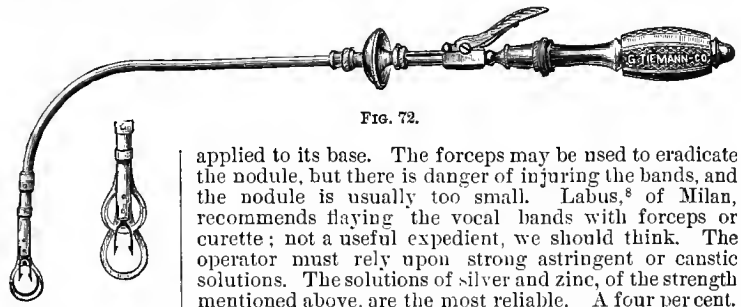


FIG. 72.

applied to its base. The forceps may be used to eradicate the nodule, but there is danger of injuring the bands, and the nodule is usually too small. Labus,[8] of Milan, recommends flaying the vocal bands with forceps or curette; not a useful expedient, we should think. The operator must rely upon strong astringent or caustic solutions. The solutions of silver and zinc, of the strength mentioned above, are the most reliable. A four per cent. solution of cocaine, sprayed into the larynx, will enable the operator to apply the solution to the nodule alone, without touching the remainder of the band. Slight inflammatory action follows this application, which disappears in forty-eight hours. This should be remembered when treating a patient who is obliged to sing at the earliest possible moment. Mackenzie recommends applications of ferri perchlor., ʒ ij. ad ʒ j. Chromic acid crystals may be applied to the nodule by means of some form of the guarded or concealed laryngeal applicator. This application should not, of course, be made until the movements of the larynx are controlled by cocaine. A week or ten days must elapse before the larynx recovers from this application.

A fine-pointed galvano-cautery electrode, exposed not more than one-eighth of an inch, could, in skilful hands, be applied to the nodule as easily as the acids. After the nodule has been nearly eradicated, its return may be prevented by weak astringent solutions sprayed into the larynx, such as solut. argent. nit., gr. v. ad ʒ j.; zinc chlorid., gr. x. ad ʒ j. A very weak solution of cocaine (one per cent.) may be with benefit sprayed into the throat just before the astringent sprays are used. When the entire substance of the band is congested and thickened, absorption can sometimes be effected with a solution of iodol or iodoform in ether (ʒ j. to ʒ j.). I have found that oily sprays are of little value and apt to be drying. It has been mentioned that the adductors and tensors of the vocal bands become fatigued by persistent singing in patients who have trachomatous bands, as much more than the usual muscular strength is required to bring the bands together, on account of the interposing nodule; hence, after the nodule has been removed, the galvanic or faradic current should be employed. I prefer the faradic; the two electrodes may be placed one on each side of the thyroid cartilage, or one pole may be applied to the arytenoid cartilages. The benefit seems to be about as great when the poles are applied externally.

Dr. Gautier's method of applying the galvanic current, called "interstitial electrolysis," might be useful in removing the nodules. He applies a copper electrode positive pole, insulated up to near its tip, to the growth, the negative sponge electrode to the back or chest; a weak current is used—from five milliamperès up. The action of absorption is based upon the fact that oxychloride of

copper is formed at the positive pole, which permeates and causes absorption of the growth. The author says the action produces no burning or destruction of tissue, since the energy of the current is expended in forming the copper salt.

Finally, after the bands have been made as nearly normal as possible, we should insist that our patient, if he is a singer, put himself under the instruction of a proper teacher. This advice is imperative if we would cure this class of patients. A faulty method of using the voice will bring back in a short time the catarrhal conditions and the nodular enlargement.

The points I would place emphasis upon are these:

1. That while chorditis tuberosa is in a sense one of the manifestations of a chronic catarrhal laryngitis, yet its real cause is excessive use of the voice.

2. That the nodule on the band is largely the primary lesion, while the other changes in the bands are secondary.

3. That this condition is almost always found in singers or public speakers, and is occasioned to a great degree by a faulty method of using the voice.

4. That chorditis tuberosa occurs more frequently in women than in men, and is seen most often in sopranos.

5. That a nodular enlargement will in time produce change in the second band at the point of contact; and,

6. That these nodules should be removed as early as possible. Singing should not be allowed until the bands are normal, and faulty methods of using the voice should be corrected by proper teaching. *Clarence C. Rice.*

[1] Türck: Klinik der Krankheiten des Kehlkopfes, Wien, 1866, pp. 164 and 204.
[2] Von Ziemssen, vol. iv., p. 217.
[3] Wedl: Idem.
[4] Bosworth: Diseases of the Nose and Throat, vol. ii., p. 534.
[5] Mackenzie: Diseases of the Throat and Nose, vol. i., p. 294.
[6] Virchow: Verhandlung der Berlin. Med. Gesellschaft, reported in Berliner klin. Wochenschrift, 1883, No. 21.
[7] Ingals: Diseases of Chest and Throat, etc., p. 402.
[8] Labus, Archives of Laryngology, 1880.

CHROMIC ACID. A new use of this escharotic was brought to the notice of the profession by Dr. Edward Woakes, in *The Lancet*, June 21, 1890. He there advocates its use in the treatment of cystic goître, ranula, and other cysts. The cyst or sinus is to be opened and thoroughly evacuated and washed, and all hæmorrhage checked; a saturated solution of the acid is then applied to the secreting surface with a chromic-acid carrier, and the patient kept at rest for a few days. No severe reaction occurs and the cavity is rapidly obliterated. Repeated applications may in some instances be required, four or five days elapsing between each. It is recommended to apply this method of treatment to all sinuses and cavities with a secreting wall. There does not seem to be any danger of absorption of the drug, as it coagulates the albumin of the tissues and forms a thick, dense membrane. Dr. Woakes says "repeated observation points to a complete and rapid amalgamation between the tissues and acid to such an extent that thereafter neither the one nor the other retains its former character." All hæmorrhage should be carefully checked, as it neutralizes the acid and prevents its action on the cyst-walls.

This acid has also been selected to destroy the false membrane in diphtheria. A forty per cent. solution is used and the membrane touched two or three times a day by means of a pencil. The applications are to be made with the greatest care, to avoid injuring the mucous membrane. It does not produce any inflammatory action and is painless. The false membrane alone is destroyed and the production of the toxic ptomaïnes arrested. In addition antiseptic spraying and constitutional treatment are also adopted. *Beaumont Small.*

CINNAMIC ACID. This acid is one of the numerous drugs introduced on account of its reputed value in the treatment of tuberculosis. It is produced by the oxidation of oil of cinnamon in air or oxygen; it also exists ready-formed in balsams of tolu and Peru, and in storax. It may be obtained by the following process: Old, hard balsam of tolu is reduced to powder and mixed with an equal weight of slacked lime; this mixture is boiled for some time in a large quantity of water, and filtered while hot. On cooling calcium cinnamate crystallizes. This is redissolved in hot water, digested with charcoal, and filtered and allowed to cool. The crystals are again dissolved in hot water, and an excess of hydrochloric acid being added, it is again allowed to cool, when cinnamic acid separates in a pure state.

It resembles benzoic acid and possesses many of its properties. It forms small white plates or needle-shaped crystals of perfect whiteness, without odor. It is insoluble in cold water; soluble in hot water, alcohol, and ether.

Cinnamic acid has antiseptic properties similar to salicylic and benzoic acids, and has been used to make antiseptic dressings of gauze, jute, etc.

Its use in tuberculosis has been recommended by Dr. A. Landerer, of Leipsic.

For pulmonary phthisis it is employed only by intravenous injections, the object being to bring the acid in direct contact with the diseased pulmonary tissue. A five per cent. emulsion of the acid is prepared, and from one and one-half to fifteen minims injected twice a week. The veins of the arm are selected. The part is rendered aseptic and the vessels distended by means of gentle pressure. After the injection the part is dressed with sublimate gauze and the pressure removed. No bleeding or inflammation follows the puncture. No immediate effects are produced by this medication, but in the course of a few weeks the sputum changes its color and loses its purulent character, the cough lessens, night-sweats cease, all disagreeable symptoms lessen, and the general health improves. It is advised to continue the treatment for at least three months.

In surgical tuberculosis the acid is injected into the diseased tissue. The injections are made deeply into the part, seven and one-half minims being used twice a week. In fistulous disease, injections of a five per cent. alcoholic solution were used. In lupus vulgaris each tubercle is to be injected with one or two drops of the solution. After the injections there appears redness and tumefaction, which subside in two or three days; the nodules gradually disappear and approach the normal skin in composition. The pain of the injection may be overcome by combining five per cent. of cocaine with the alcoholic solution. Dr. Landerer reports very favorable results from this treatment, but others have not as yet adopted its use. *Beaumont Small.*

CLUB-FOOT. From time to time cases have been reported to both prove and disprove each of the theories previously advanced as to the etiology of congenital club-foot, but no new facts have been added to our stock of knowledge.

TREATMENT.—The treatment consists in correcting the deformity, and maintaining the corrected position until there is no longer a tendency to relapse.

The treatment is commenced at the earliest possible moment, and the retentive treatment may have to be continued for years. Simpler means are always to be tried before the more radical operations are attempted, but the tendency of the profession is very decidedly in favor of rapidly correcting the deformity in place of gradual and prolonged stretching by complicated mechanical devices.

Of the braces used for gradually correcting the deformity by a leverage, or stretching process, none are more simple, and yet effective, than those for many years employed by Dr. Charles Fayette Taylor (Figs. 73 to 76). The sole-piece is of sheet steel, the upright a steel bar joined to the sole-piece by a strong rivet, allowing antero-posterior motion; the extent to which the toe is allowed to drop is regulated by a set screw. Sufficient straps are attached to retain the foot, and these are usually at the places shown in the illustrations. The cuts illustrate the manner of applying the adhesive plaster and adjusting the brace. It will be noted that the upright piece can be bent to exert any desired degree of leverage. This splint will be found of great service as a retention walk-

ing apparatus after forcible correction or operative procedures.

Forcible correction is accomplished by the hand in moderately severe cases in young infants, and by wrenching and crushing with various machines. The simplest

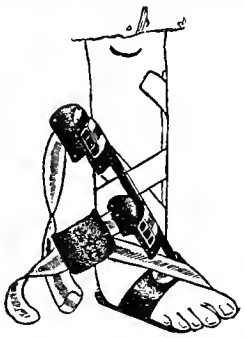


FIG. 73.

FIG. 74.

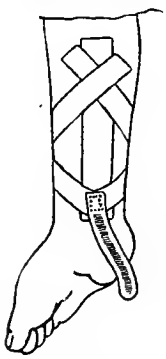


FIG. 75.

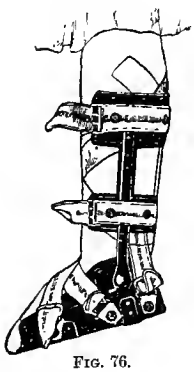


FIG. 76.

FIGS. 73 to 76.—The Taylor Club-foot Brace.

effective machine is the Thomas wrench, Fig. 77. It may be used as the primary procedure, or as secondary to operation. When used as supplementary to a cutting operation the patient is anæsthetized, and the attempt is made to fully correct the deformity at a single sitting.

One of the most powerful devices for forcible correction is Dr. Phelps's machine, Figs. 84 and 85. This machine Dr. Phelps uses only when the patient is anæsthetized, and generally, if not always, as a supplementary procedure to a cutting operation.

Forcible correction by machine should not be attempted in cases where correction can be accomplished by the hand. It may be employed with equal advantage after

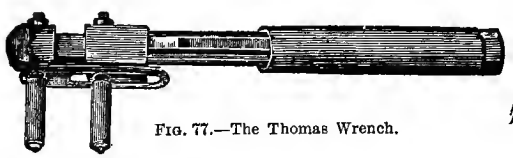


FIG. 77.—The Thomas Wrench.

subcutaneous and open incisions of the soft parts, and after the cutting operations upon the bones.

The choice between subcutaneous and open incisions for the division of the soft parts depends upon the skill of the operator, the severity of the deformity, and the care with which strict asepsis can be carried out. It surely requires more manipulative skill to thoroughly divide all of the shortened parts subcutaneously than openly, and in some cases a satisfactory subcutaneous division cannot be accomplished. In old and severe deformities much time is often wasted in futile subcutaneous operations. An open wound is certainly a safer wound than a subcutaneous one when infected. On the other hand, subcutaneous incisions to which no thought of asepsis has been paid beyond ordinary cleanliness rarely become infected; it is the universal rule that they heal without suppuration, while open incisions rarely escape infection unless treated with the most careful aseptic precautions at the time of the operation and at subsequent dressings, should such be necessary. Strict asepsis demands no little personal care as to the preparation of dressings in private practice, and, in the dressing of these wounds of the feet, demands at least one trusty assistant. Strict asepsis, it must be admitted, is not possible for very many

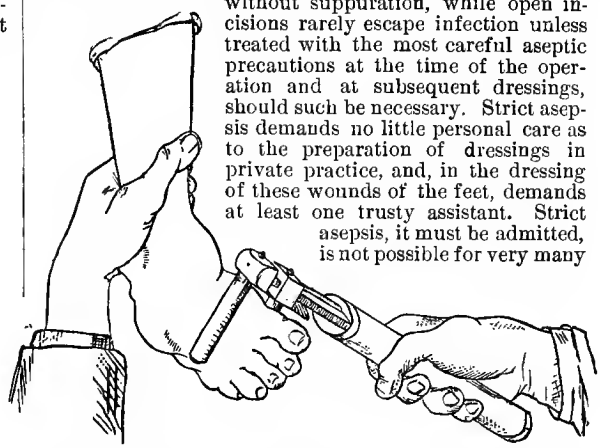


FIG. 78.—The Thomas Wrench applied to a Case of Talipes Equino-varus.

men who are called upon to treat deformed feet. I would not be understood as saying that in the hands of such the subcutaneous operation is the safer, for it is not, but it is reasonably safe, and if successfully performed will result in healing within three or four days as against as many weeks if the wound must heal by granulation.

Thomas's Method. — This method of stretching the foot into a corrected position differs from all other stretching methods for the cure of congenital varus. It takes a middle place between stretching by braces, which on the one hand exert "continuous

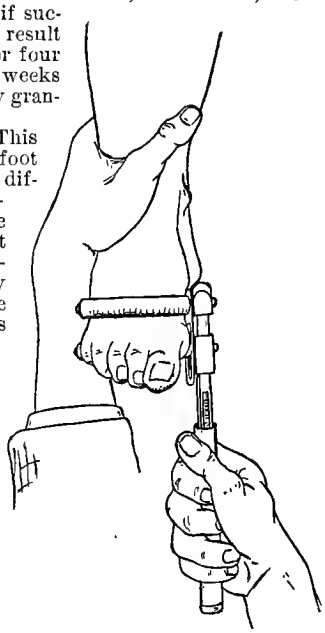


FIG. 79. — The Deformity Partially Corrected by the Wrench.

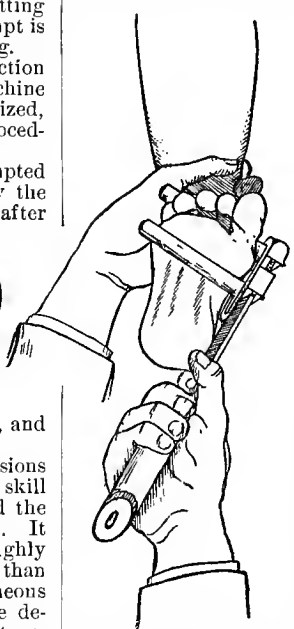


FIG. 80.—The Deformity Fully Corrected by the Wrench.

leverage," or "elastic traction," or "the weight of the body as a corrective force," and the machines which forcibly correct the deformity under an anæsthetic at a single sitting, on the other hand. By the wrench shown in Fig. 77, and applied in Figs. 78, 79, and 80, the foot is stretched, or "wrenched," or sprained to a degree just sufficient to abolish the resiliency of the shortened tissues. The foot is then retained in a simple metal brace (Figs. 81 and 82) until at the end of from two to six days the resiliency be-

gins to return and the foot tends once more to assume its old position; then the wrenching is repeated. These wrenchings are repeated every few days, the intervals becoming longer as the foot comes into a better position, until the deformity has been fully corrected, and shows no tendency to relapse.

Tenotomy.—In doing subcutaneous division of the shortened soft parts, surgeons for the most part proceed as follows:

For the ordinary form of congenital talipes equino-varus the tendo Achillis is first divided about an inch and a half above the point of its insertion. The patient lies on his face, the assistant puts the tendon on the stretch by flexing the foot, the skin is drawn somewhat to one side, and with a pointed tenotome a puncture is made at the side of the tendon, passing beneath it. With this same knife, or with a blunt pointed one in its place, the tendon is then divided by turning the edge of the knife toward the tendon, and moving it with a gently sawing motion. As soon as the assistant feels the snap of the divided tendon, he should instantly relax the flexion. When the cavity left by the incision has filled with blood, the operator attempts full flexion of the foot. In a certain number of cases this will not be found possible, and the choice then is between a section or a forcible rupture of the posterior ligament of the ankle-joint. Section of this ligament is accomplished by a spear-shaped tenotome passed through the middle of the tendo Achillis, then turned half around and swept from side to side. Most surgeons, however, prefer to rupture the ligament by the hand, the wrench, or some other mechanical device. Unless full flexion at the ankle joint be made possible before the anterior portion of the foot is subjected to operation, it will be found very difficult of accomplishment. The next step is a division of as much of the deltoid ligament as may be necessary, and such other shortened tendons as may be reached by the knife through the same incision. The foot being put on the stretch in the direction of outward rotation, a sharp, pointed tenotome is entered flat close to the anterior border of the inner malleolus with its back next the bone, and carried around under the tip of the malleolus. It is then removed and replaced with a blunt knife, preferably convex on the edge; the edge is turned toward the ligament, and as much of it divided as may be necessary. Through the same opening the tendon of the posterior tibial, and the anterior tibial, and astragalo-scaphoid capsule may be divided. By passing the tenotome somewhat deeper and close to the bone, the tendon of the long flexor of the toes may be divided. The tendon of the extensor of the great toe stands out prominently over the metatarso-phalangeal articulation, and here it is divided from within, outward, when required. The abductor of the great toe and the plantar fascia are divided just in front of the inner tuberosity of the os calcis. When all resisting bands that can be made out to the touch have been divided the foot should be forcibly overcorrected by the hand, or the wrench, or some other mechanical device, and should be retained permanently in that position. Strict asepsis should be practiced in these tenotomies, and the wounds sealed with collodion and a small bit of gauze. No permanent pressure should be made to check bleeding. If the bleeding is sufficient to demand pressure, a free incision should be made and the bleeding vessel ligatured. Pressure diminishes the quantity of plastic effusion, and may be the cause of a weak union between the divided ends of the tendons. Dressed without pressure, perfect union may always be confidently expected, no matter how far the cut ends may be separated. The method, formerly in general use, of leaving the foot in its deformed position for a few days until soft union between the divided ends of the tendons had taken place, and then gradually stretching this new material, may be held responsible for many cases of weak union, and even of non-union.

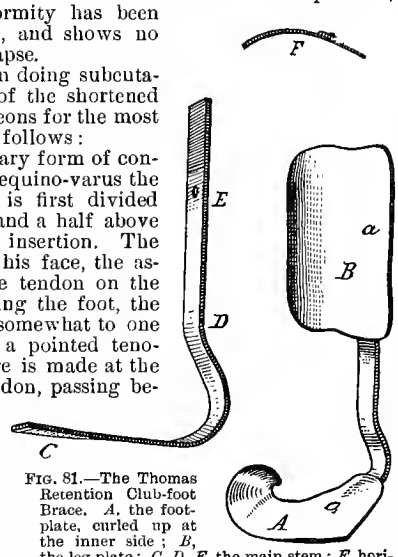


FIG. 81.—The Thomas Retention Club-foot Brace. *A*, the foot-plate, curled up at the inner side; *B*, the leg-plate; *C*, *D*, *E*, the main stem; *F*, horizontal section of leg-plate and main stem, showing the plate extending farther to the inner side of the stem than to the outer.

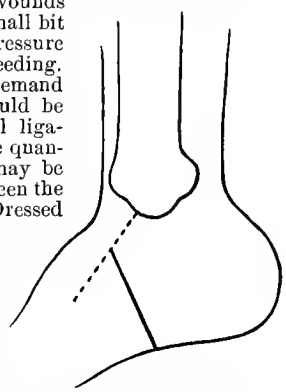


FIG. 83.—The solid line indicates the incision in Phelps's operation.

Phelps's Operation.—This consists in making an open incision commencing in front of the inner malleolus, and extending one-third the distance across the sole of the foot, and carried down to the neck of the astragalus, on its inner side. (Fig. 83.) Through this wound, the adductor pollicis, tibialis posticus, the plantar fascia, the flexor brevis, the long flexor tendons of the toe, and the deltoid ligament, all its branches, if necessary, can be cut. This is done after subcutaneous tenotomy of the tendo Achillis has been performed. Great force is then used by the machine shown in Figs. 84 and 85, to rupture the deep ligaments and super-correct the foot.

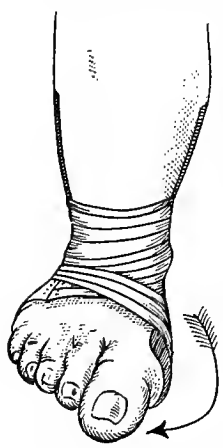


FIG. 82.—The Thomas Club-foot Brace applied.

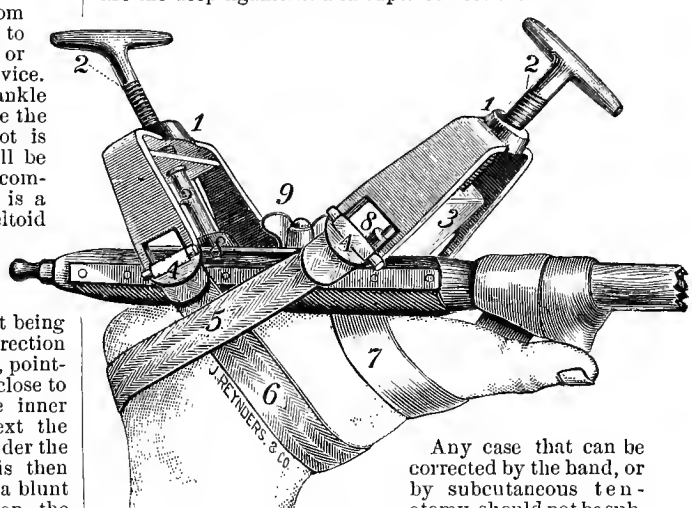


FIG. 84.—Phelps's Machine adjusted.

Any case that can be corrected by the hand, or by subcutaneous tenotomy, should not be subjected to Phelps's operation; and when the operation as described fails to easily supercorrect the foot, a linear osteotomy should be made through the neck of the astragalus. If this fails, a V-shaped piece should be removed from the os calsis, the point of the V meeting the linear osteotomy of the astragalus. This failing, the removal of the cuboid and scaphoid is indicated. And, as a last resort, Pirogoff's amputation should be resorted to.

The wounds of Phelps's operation are sutured or not, as may be possible, and dressed without drainage, with the aim to obtain blood-clot organization. The feet are dressed in the super-corrected position, in plaster-of-Paris.

Phelps first operated in 1879, and to him more than to any other is due the credit of leading the way to perfect results in inveterate cases of club-foot.

Ridlon's Operation.—This is a modification of Phelps's operation, designed to avoid a tender scar on the sole of the foot. In Phelps's earlier operations, the incision was underneath the bones, closely hugging them. As these incisions are made, an assistant constantly keeps the parts on the stretch in the direction of correction of the deformity, and each part as it appears to resist the correcting influence is divided. When any considerable degree of equinus is present, the first incision passes beneath the

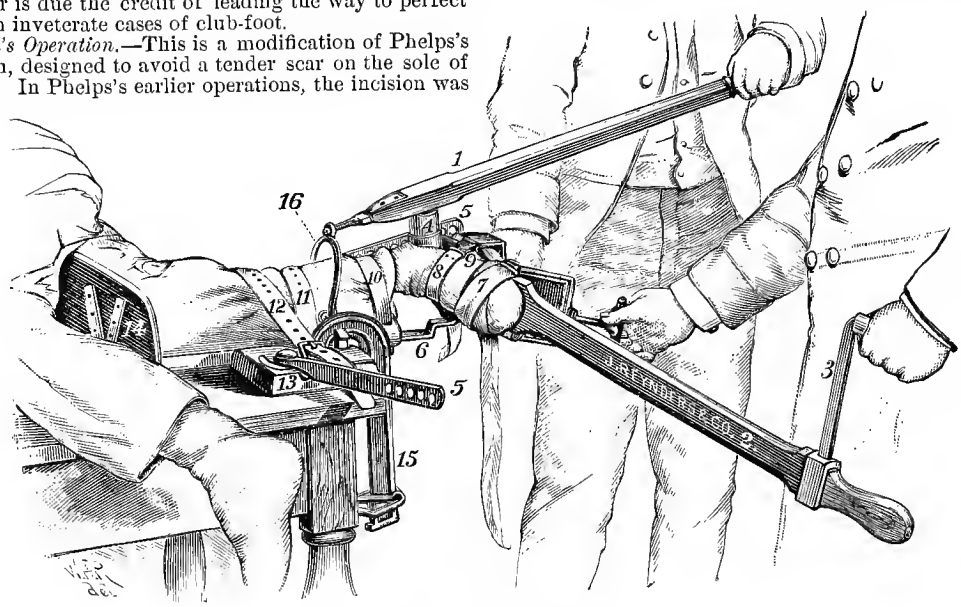


FIG. 85.—Phelps's Machine in Use.

carried two-thirds across the sole of the foot; at present it is carried but one-third that distance, and the objection to a tender scar holds less well than before the modified operation was devised.

The operation which bears the writer's name consists of an incision commencing on the dorsum of the foot just in front of the inner malleolus, at the point where the tendon of the extensor longus digitorum muscle crosses to the inner side of the foot; from here it is carried directly

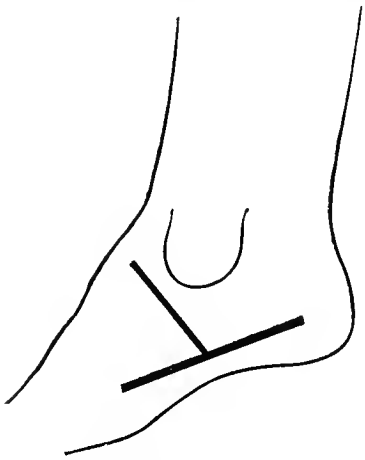


FIG. 86.—Ridlon's Operation; Lines of Incisions.

toward the sole, to meet near its middle a second incision made parallel with the sole from near the inner tuberosity of the os calcis to the middle of the first metatarsal bone, or beyond (Fig. 86). The plane of the first incision leads directly downwards to the bones; the plane of the second incision slopes upwards and outwards to reach the bones at their nearest border; thence it is carried anterior half of the inner malleolus, and in some cases beneath the whole of it. The deltoid ligament, and the tendons of the tibialis anticus, extensor proprius hallucis, extensor longus digitorum, extensor brevis digitorum, tibialis posticus, flexor longus digitorum, and flexor longus hallucis, are readily reached. From the second

FIG. 87.—*A.* Plaster-of-Paris imprint from a boy of eleven, after excision of the astragalus for resistant club-foot. *B.* Drawn from a photograph of a boy of eleven, after osteotomy of the neck of the astragalus for club-foot. (Bradford.)

incision the abductor hallucis, the plantar fascia, and any other resisting structure may be divided. By carrying the second incision in the plane directed, it will almost always be possible to avoid dividing the internal plantar artery and the nerve. The division of all tight bands having been made, the foot is overcorrected by the hand

or by the wrench. As in Phelps's method, we believe it better to divide the tendo Achillis and correct the equinus, rupturing, if necessary, the posterior ligament of the ankle-joint, before commencing the operation for correcting the deformity of the anterior portion of the foot. The dressings are the same as in the Phelps's operation, namely, suturing, in so far as possible without putting the parts at too great tension, and covering the wound with Lister protective and aseptic dressings, with the expectation that healing by blood-clot organization will take place. Over all is applied a plaster-of-Paris dressing with the foot in the supercorrected position. In inveterate cases where the foot cannot be easily held in the supercorrected position, operations on the bones are indicated as pointed out under Phelps's operation.

The principles, first clearly laid down, we believe by Phelps, must never be lost sight of: First, correct all cases possible by hand; second, correct all possible by subcutaneous incision; third, of the remaining cases, divide by an open incision all resisting soft parts, and with the hand or some mechanical device supercorrect the deformity; fourth, when this cannot be readily done, do a linear osteotomy of the neck of the astragalus, followed if necessary by cuneiform osteotomy of the os calcis; if this is not sufficient, enucleate the astragalus, or remove any bone or portion of bone which blocks the way; and if this is not sufficient, amputate.

Dr. Bradford has recently pointed out that in some cases there is elongation of the outer border of the os calcis and a consequent obliquity of the anterior (cuboid) articulating surface which can only be remedied by removing the wedge-shaped piece from its outer side just posterior to the cartilage. In the normal foot a line drawn antero-posteriorly through the centre of the heel and the centre of the front part of the foot meet to form a straight line (Fig. 87, B), while in the foot with a distorted os calcis, the lines meet to form an angle (Fig. 87, A). An imprint of a normal foot is seen in Fig. 89, and of a corrected club-foot in Fig. 90, while Fig. 88 shows a foot with a deformed os calcis which, after tenotomy, could readily be fully corrected, but which at once drops back into inversion because of the obliquity

FIG. 88.—Sole imprint of a case of club-foot corrected by tenotomy with inversion of the foot without contraction. (Bradford.)

FIG. 89.—Imprint of a normal foot. (Bradford.)

FIG. 90.—Imprint of a foot of a child six years old, treated when one year old, for congenital club-foot. (Bradford.)

91.—Imprint of a right foot before operation. (Bradford.)

FIG. 92.—Imprint of the same foot after operation. Osteotomy of the neck of the astragalus and os calcis. (Bradford.)

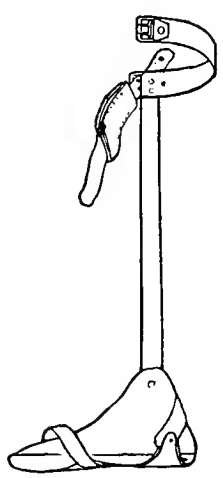


FIG. 93.—Judson's brace.

of the calcaneo-cuboid articulation. In these cases where distortion of the os calcis is present, correction by force, by tenotomy, by open incision on the inner side of the foot, and even by enucleation of the astragalus, fails to permanently remove the inward twist of the anterior portion of the foot. Figs. 89 and 90 show the improvement which may be gained in inveterate cases.

An imprint of the foot as shown in these illustrations will be found a most convenient guide and a valuable record. A sheet of paper is smoked over a piece of burning camphor, and after an imprint has been made by the patient stepping upon it, it is rendered permanent by pouring over it a little photographer's varnish. The composition of the varnish is: Gum sandarach, oz. 1½; alcohol, oz. 8; castor-oil, dr. 2. Mix.

Whatever method be employed to correct or supercorrect the deformity, it is but the first step in the treatment of the case. Suitable dressings must be employed to retain the foot in the corrected position until the slack has been taken up in the elongated tissues of the convex side, and until use has rendered supple the articular surfaces in their new relations. After operative procedures, plaster-of-Paris forms the most convenient dressing until the wounds have healed; after that the Taylor shoe is a simple, inexpensive, and satisfactory dressing.

Valgus.—Pure valgus is an exceedingly rare deformity. In congenital cases the outward deformity is almost in-

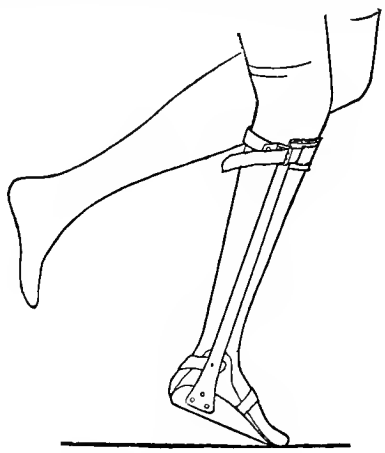


Fig. 94.—Judsons's brace applied.

variably associated with a dropping of the heel—calcaneo-valgus; in the non-congenital deformity the same condition may be present, or there may be drawing up of the heel—equino-valgus. In the congenital deformity the foot can, as a rule, be readily replaced by hand, and only requires a simple apparatus to retain it in that position. Occasionally, section of one or more tendons anteriorly is required. In equino-valgus, tenotomy of the tendo Achillis is indicated. Judson's brace, shown in Figs. 93 and 94, serves the best to retain the corrected foot in these outward deformities, as it also does in pure calcaneus. The brace consists of a sheet-steel foot-piece with a flange running its full length, turned up on the side to which the deformity looks, and on the opposite side a flange from one-half to one inch in width, turned up opposite the heel, to form the heel-cup. To the first flange is riveted an upright piece of soft bar-steel which runs along the side of the leg to the garter-line, where a band encircles the leg. The brace is held in position by straps so placed as to retain the foot in its new position.

Flat-Foot. The treatment of flat-foot, or acquired valgus, has been greatly advanced by the work of Dr. Royal Whitman, of New York. He divides the cases clinically into five groups:

1. Cases known as weak ankles in weak or rachitic children, or accompanying slight knock-knee.

2. The long weak foot seen in adolescence, which, though of little importance at the time, often becomes most confirmed and painful in later life.

3. Weak feet in older subjects, particularly women who have grown stout and are obliged to stand much of the time.

4. The most important cases, usually seen in young adults, where we find marked deformity and muscular

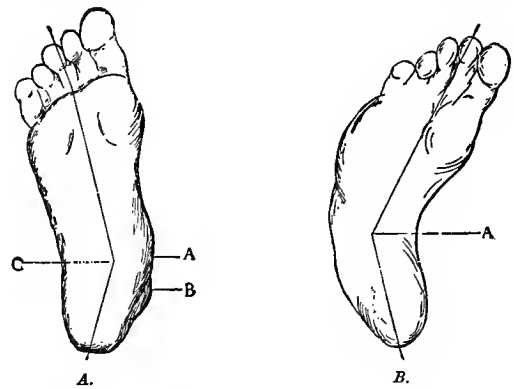


Fig. 95.—*A.* The flat-foot. *B.* The overcorrected foot.

spasm, so that the foot is quite rigid, and cannot be replaced in normal position.

5. True flat-foot, or pes planus, which may be actually inherited or be the result of rachitis in infancy.

The first and second class find relief in well-fitting shoes, the inner border of the soles of which have been built up from one-fourth to one-half inch, from the ball

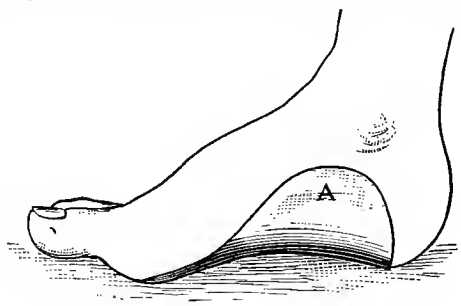


Fig. 96.

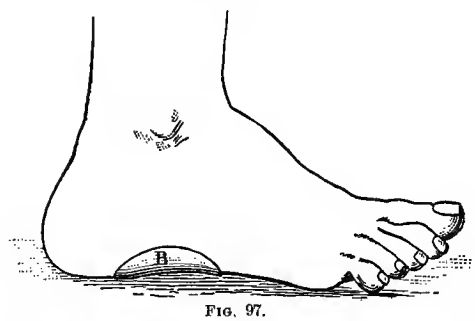


Fig. 97.

Figs. 96 and 97.—Whitman's flat-foot brace. A, the part applied to the inner side of the foot; B, that applied to the outer side.

of the foot to the tip of the heel, so that the weight is thrown to the outer side, and may be permanently cured by learning to walk properly, *i.e.*, with their toes in front so that the inner borders of the feet are parallel, and not with toes turned out.

To this treatment the third class should add hot foot-

baths, manipulations and rubbing, and in some cases Whitman's brace may advantageously replace the tilted shoe.

The fifth class requires no treatment unless pain is present.

It is to the fourth class that Whitman's principles of treatment are especially applicable, and the class in which his brace finds its greatest usefulness.

The procedure with it is as follows:

The deformity is forcibly reduced and overcorrected. This is quite a different thing from remoulding the arch (Fig. 95). Under ether, the foot is grasped by the hands, or the hands and knees, or by the Thomas wrench, and bent and twisted inward until all restriction to normal motion is completely overcome. The foot is then placed in extreme adduction or equino-varus, and retained by a well-padded plaster bandage. In a week, or less if there be no pain in the foot, the bandages are removed and a plaster cast taken for the support which is to be used. The plaster cast of the foot goes to the iron founder, who reproduces it in iron. Upon the iron cast is moulded, from thin sheet-steel while hot, the brace, in the form shown in the illustrations (Figs. 96, 97, 98) and afterwards it is tempered, nickeled, or tinned, and coated with Japan varnish. The brace is not a spring; it is inelastic. It is worn inside, but not attached to the shoe. The shoe recommended is one of the Waukenphast pattern, with a sole broad enough to support the foot, having an inward twist to allow room for the great toe. In advanced cases the inner side is built up after the method of Thomas.

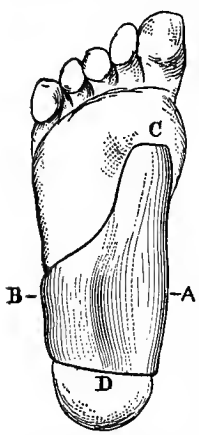


FIG. 98. — Whitman's brace, as seen from below, when applied to the foot.

Meantime the foot is manipulated daily to stretch the contracted and shortened tissues, until every part is free and supple. Voluntary exercises are also made use of to strengthen the weakened muscles. And lastly the patient is re-educated in the proper manner of walking and supporting weights (Fig. 99). The feet should be parallel as

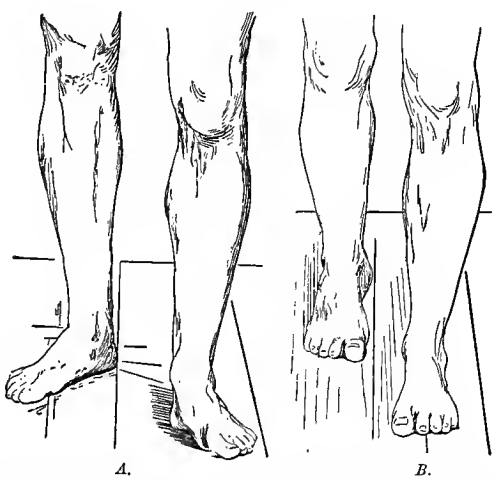


FIG. 99.—*A.* Improper position of the feet in walking. *B.* Proper position of the feet in walking. Each step is a gymnastic exercise.

to their inner borders, so that the weight will not be unduly thrown to the inner side of the foot, as is the case when the toes are far apart; and by walking over the toes instead of over the inner side of the foot, each step becomes a beneficial gymnastic exercise.

John Ridlon.

COCAINE. Since the appearance of this HANDBOOK cocaine has maintained its place as a local anæsthetic, and has gained for itself quite an extensive field of usefulness. It has been incorporated into the Pharmacopœia of all countries. Since attention has been directed toward the anæsthetic properties of cocaine quite a number of other bodies have become known that have local anæsthetizing effects, as for instance, erythrophleine, menthol, and other compounds, part of which belong to the groups of glycocides or resins. All these bodies have that in common, that they act as intense irritants upon the terminations of the sensitive nerves, and that after a longer or shorter period of irritation a period of paralysis (anæsthesia) follows, which is the case also with cocaine. In most of these drugs the primary irritation is very much stronger than in cocaine, a circumstance which did not permit their substitution for it. Some of the alleged rivals of cocaine have been disclosed as downright deceptions, as for instance stenocarpine (mixture of cocaine and atropine). With the increased knowledge regarding the chemical constitution of cocaine (see under that heading), the time does not seem distant when cocaine, or some body of similar constitution and physiological action, will be synthetically manufactured for practical use, as in fact has been done already in the laboratory.

MODE OF MANUFACTURE AND STATISTICS.—Great progress has been made in the manufacture of cocaine, which has led to a remarkable reduction of its cost, the market price at present (end of 1892) being $6 the ounce. The table below (for which the writer is indebted to the courtesy of Messrs. McKesson & Robbins) shows the following decrease in price:

Autumn of 1884 (abnormally high price)	$3.00	per grain.
End of 1884	.50	"
1885	.30	"
End of 1885	.05	"
1886	.05	"
1887	7.50	per ounce.
1888	7.00	"
1889	6.00	"
1890	5.50	"
1891	8.00	"
1892	8.00	"
End of 1892	6.00	"

The former process was essentially the one used by Niemann, only somewhat modified. The alkaloid was extracted from the leaves by means of acidulated alcohol, much ether being used in the further steps of the process, as described in Vol. II., p. 217, of this HANDBOOK. The main improvement consists in dispensing entirely with the alcohol and using ether in very moderate quantity only. Cocaine, like other alkaloids, is soluble in kerosene oil, while its salts are not soluble in it. If ground leaves are moistened with a five per cent. solution of sulphuric acid, percolated, and the percolate is agitated with kerosene and an excess of carbonate of sodium, the alkaloid is held in solution by the kerosene, comparatively free from other matter. It can be washed out of the kerosene by means of acidulated water. For purposes of purifying it is precipitated again by carbonate of sodium, then dissolved in ether, from which it is washed out by dilute hydrochloric acid as the hydrochlorate salt. This process has also been improved upon by doing away with the extraction from the leaves by means of acidulated water. The ground coca leaves are moistened with a solution of carbonate of sodium, and the alkaloid directly extracted from them by percolating with kerosene. From this kerosene solution the alkaloid is washed out by means of weak sulphuric acid, and for purposes of purifying precipitated again by carbonate of sodium in the presence of a small portion of kerosene to dissolve it again. This process of precipitating and redissolving is repeated several times. At last the crystals of the crude alkaloid are dissolved in dilute acid and freed from kerosene by means of ether; then the alkaloid is precipitated again in the presence of ether, the clear ethereal solution (of the alkaloid hydrate) shaken out with hydrochloric acid, and the solution of the hy-

drochlorate evaporated to dryness.* At first all cocaine made was extracted from the leaves in Europe and in this country. The coca-leaves have to be transported a long way from the mountain range of Peru and Bolivia, on the backs of mules, and farther by railway to the Chilean and Peruvian ports. The combined influences of heat and moisture to which the leaves were exposed during this transportation robbed them of part of the amount of the alkaloid they originally contained. This circumstance, and the considerable expense of transportation of the dead weight, have caused the manufacture of cocaine to be transferred to the source of supply in the Bolivian Mountains, where various manufactories have been established to turn out the crude alkaloid. This is exported to Europe and to this country in cakes of several inches in diameter and half an inch in thickness. It is then refined and converted into the hydrochlorate by the process described above. The present import duty, discriminating against the crude alkaloid (twenty-five per cent. ad valorem against fifty cents a pound on the salt), has hampered American manufacturers, so that almost all cocaine here consumed is imported from Germany, where it is manufactured partly from leaves, partly from the crude alkaloid. A small quantity is made here from leaves, of which 90,000 pounds are imported per annum. Cocaine salts are used in the United States to the amount of 100,000 ounces (3,125 kilogrammes) a year (estimate of Messrs. McKesson & Robbins; Dr. Squibb puts the figure at 1,800 kilogrammes, giving this as a crude computation based on the output of his own factory).

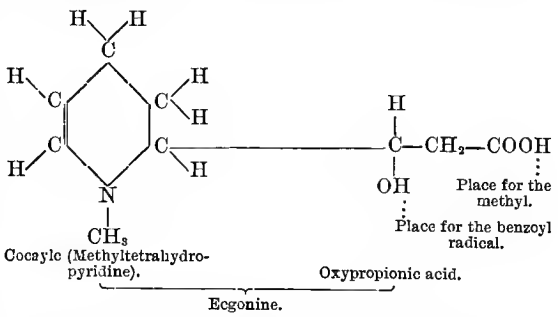
The annual harvest of coca-leaves in South America is estimated to be 10,000,000 kilogrammes, of which about five per cent. is exported, either in the natural condition or in that of the crude alkaloid, extracted in the Peruvian manufactories. The variety best suited for the extraction of cocaine is the great-leaved species cultivated in Southern Peru (Huanuco, Huanta, Santa Anna), containing about 0.5 per cent. of the alkaloid. Bolivia furnishes not very considerable quantities of coca, as the price is fifty to eighty per cent. higher than for the Peruvian. The so-called Trujillo coca, from Northern Peru, is not well suited for the manufacture of cocaine, as it contains hardly half as much of this alkaloid as the Southern plant, but great quantities of other alkaloids, which make the isolation of cocaine very difficult.

Experiments to raise coca elsewhere have been made in the Government of Madras, in the tea-plantations of Bengal, in the Island of Ceylon, on Mount Café, at San Thomé in Africa, and in the cinchona plantations of Java. The latter ones gave the best results, and the coca exported from Java is very similar to Trujillo coca (Northern Peru) in aspect and in the amount of alkaloid contained. It contains 0.2 per cent. cocaine, besides a quantity of other alkaloids that hamper manufacturing. (Information furnished by the firm of C. F. Boehringer u. Söhne, Mannheim, Germany.)

Tests of Purity.—*Maclagan's test* consists in dissolving one grain hydrochlorate of cocaine in two ounces distilled water and adding one to two drops of ammonia solution. If free from amorphous cocaine, on stirring the ammoniated solution a few seconds cocaine hydrate separates out in crystalline form and falls to the bottom, leaving the supernatant solution clear and free from opalescence. If at all milky, the presence of amorphous cocaine is indicated. (Copied from *The* [London] *Chemist and Druggist*, March 5, 1887, p. 297.)

Permanganate Test (Garthier).—When a solution of two centigrammes to half a gramme of hydrochlorate of cocaine is mixed with one drop of a two per cent. solution of permanganate of potash, the resulting fluid must assume a red color and remain transparent. On a subsequent addition, drop by drop, of the permanganate solution, there must appear a red precipitate consisting of permanganate of cocaine, which becomes brown only after heating and that without evolving an odor of bitter almonds. When the addition of one drop of the permanganate solution brings about a brown discoloration or brown precipitate, or when on heating the mixture there appears an odor of bitter almonds, the preparation is impure and unfit for use. (Copied from the London *Med. Record*, 1889.)

Chemical Constitution.—Cocaine, if heated with hydrochloric acid splits into benzoic acid, methyl alcohol, and a new alkaloid, ecgonine ($C_9H_{15}NO_3$), of not well pronounced physiological action. Recent investigations have shed light on the manner in which these parts are arranged in the cocaine molecule and on the constitution of ecgonine (Einhorn, *Berichte der chem. Gesellschaft*, xxi., p. 3029, 3441, vol. xxii.; Stoehr, *ibid.*). As was to be expected, there is an intimate connection between the constitution of the cocaine molecule and its physiological action. There exist quite a series of bodies similarly constituted, with analogous physiological action, facts that have been studied by Ehrlich (*Deutsche med. Wochenschr.*, 1891, No. 32, p. 717) and E. Poulsson ("Beiträge zur Kenntniss der pharmakologischen Gruppe des Cocain," *Arch. f. experimentelle Pathologie u. Pharmakologie*, vol. xxvii., p. 301). In ecgonine a group called Cocayle, $(CH_3)NC_5H_7$, whose constitution is methyltetrahydropyridine, is combined with the radical of oxypropionic acid, thus:



The side chain in this molecule (oxypropionic acid) contains a hydroxyl and a carboxyl, with either of which different radicals can unite.

Whenever an alcohol radical is affixed to the carboxyl group, and at the same time an acid radical enters the other replaceable hydroxyl group, the resulting body in chemical and physiological action closely resembles cocaine. In this latter methyl (CH_3) and benzoyl ($C_6H_5CO_2$) are the two radicals entering into the oxypropionic rest. The coca-leaves contain various cocaines with radicals other than those given above, and by chemical synthesis a great number of them have been formed. So the methyl of the ordinary cocaine has been replaced by ethyl, giving rise to coca-ethyl and the benzoyl has been substituted by the radicals of baldrian-, cinnamon-, or phenyl-acetic acid, thus leading to another series of homologous alkaloids. But this does not exhaust the possibilities for the formation of bodies similarly constituted and with similar physiological action. The radical of the oxypropionic acid contained in the ecgonine molecule can be replaced by other acid radicals, which of course must contain one carboxyl and one hydroxyl group. In fact, by oxidizing ecgonin, Einhorn has succeeded in composing a body which contains oxyacetic acid instead of oxypropionic acid. By introducing the benzoyl and the ethyl in this new combination a body is obtained which is isomeric with cocaine and possesses highly anæsthetic qualities, at the same time surpassing cocaine in poisonous effects, as Ehrlich has found. Experiments with a number of these cocaines and their components have shown that the alcohol radical above mentioned is essential for the anæsthetic effect, and that with its removal from the cocaine molecule the anæsthetizing and poisonous properties disappear (Poulsson, *loco citato*).

* For the information regarding the actual process of manufacture I am indebted to Dr. E. R. Squibb's personal communication; it is drawn partly also from his journal Ephemeris. The process above described applies only to his factory, but most likely a similar one is employed in other establishments.

ELEMENTARY ACTION OF COCAINE.—Our knowledge of the manner in which cocaine acts as a local anæsthetic has been materially promoted by a number of investigations on its action on various living cells and tissues. That the local anæmia observed upon local application cannot be the cause of the anæsthesia, as several authors have asserted, must be apparent to everybody, who applying it to the eye notices that the anæsthesia of the cornea precedes the anæmia of the conjunctiva. Several facts, as for instance the slight cloudiness and the dotted erosions of the corneal epithelium after repeated applications of cocaine, pointed to this drug being a general protoplasma poison, first stimulating and then mortifying it. The writer, who in his first experiments noticed the haziness of the corneal epithelium, was inclined to consider it due to evaporation, in consequence of the arrested secretion of tears and diminished winking of the lids, brought on by the local anæsthesia. When, with the increasing general use of cocaine as an anæsthetic, reports began to come in about opacities of the cornea occurring after operations in which cocaine and simultaneously solutions of corrosive sublimate had been used (Herschel, Bunge), the writer set out to determine this question by experiment. Wuerdinger, of Munich ("Experimentelle und anatomische Untersuchungen über die Wirkung des Cocain auf die Cornea," *Klinische Monatshefte für Augenheilkunde*, 1886), had come by his experiments and his pathological researches to the conclusion that the haze was due to dryness of the cornea. In 1886, while in Utrecht, the writer conducted a series of experiments on rabbits, the results of which, however, were never published. Cocaine was instilled into the rabbit's eye and the lids carefully closed over it with an artery forceps, while the other eye was kept open by means of an eye speculum. The eye that had been kept open (and into which no cocaine had been instilled) showed drying and loss of epithelium after several minutes, while the cocainized eye showed that by carefully protecting it, the hazy appearance and loss of epithelium in it had been reduced to a minimum. Evidently, therefore, evaporation was a factor to be taken into account. [Other experiments established the evidence that the corneal epithelium is especially prone, when cocainized, to become hazy by washing the eye with solutions of corrosive sublimate (of the concentration as used in eye surgery, 1 to 4,000–5,000).] But however careful or however often the experiment was made, repeated instillations of cocaine would always produce some haziness and some dotted defects of the epithelium—a condition, though, that would return to the normal within a few hours. It was nearly certain, therefore, that cocaine, as such, affects epithelial cells in their vitality. This probability became stronger yet by comparison with the action of erythrophleine, an alkaloid extracted from the bark of *erythrophlœum guineense*. This alkaloid, like a number of others, has very strong anæsthetic properties, even stronger than cocaine. The irritation preceding the anæsthesia is much more marked and of longer duration than in the case of cocaine, and correspondingly the inroad upon the vitality of epithelium and corneal tissue is a more vehement one. Two drops of a one-eighth per cent. solution instilled into the writer's eye (Koller, *Wiener medicinische Wochenschrift*, 1888, No. 6, and *Chicago Medical Journal and Examiner*, April of the same year) proved to be sufficient to set up an irritation of thirty-five to forty minutes' duration and to produce a distinctly visible opacity of the cornea, which took two days to disappear entirely. (This property, together with the highly poisonous action of the drug, has prevented the practical use of it recommended by Lewin.*) The initial irritation, the ensuing anæsthesia, and the simultaneous clouding of the epithelium are all proportionate in the action of the two drugs and strongly point toward an intimate, or rather a causal, connection.

Extensive researches on the action of cocaine upon the vital manifestations of various kinds of cell-elements and low animals instituted by Albertoni (Pietro Albertoni, "Azione della cocaina sulla contractilita del Protoplasma," *Ann. d. Chim.*, 1890, p. 305) have shown that cocaine is a protoplasma poison. According to its concentration and the duration of its action it stimulates or paralyzes the protoplasma in its vital functions. For instance a 0.25 per cent. solution applied to the palate of a frog stimulates the activity of the ciliated epithelium, so that particles of coal-dust are moved along with four times the ordinary velocity, while two per cent. solutions slacken the velocity to the fourth or sixth part of the normal. Grubs of butterflies and amœbæ in a physiological solution of ClNa stop their movements upon the addition of one-half to two per cent. cocaine, and so do the large white blood-cells of astacus. Spermatozoids and other ciliated cells stop their movements in strong solutions of cocaine or when subjected to the protracted action of weaker ones. The mucous glands in the membrana nictitans of frogs lose their ability to respond to electrical stimulation. The effects of the electrical current observed in pieces of muscle and nerve disappear soon under the influence of cocaine. So the experiments of Albertoni have established beyond a doubt the view, which was the most reasonable and probable one, that the local anæsthesia is the effect of a paralyzing influence upon the ends of the sensitive nerves. A pathological supplement to this theory is the fact that nerve-fibres in five per cent. solution of cocaine look less bright than they do in 0.6 per cent. ClNa solution (Alms, "Wirkung des Cocain auf die peripheren Nerven," Du Bois Reymond's *Archiv für Physiologie*, 1886). A peculiarly characteristic and deleterious effect is exercised by cocaine upon the cells of the liver. The livers of mice, which Ehrlich ("Studien in der Cocainreihe," *Deutsche Med. Wochenschr.*, No. 32, p. 717) had fed with cocaine (0.01 to 0.02 to the "cake," Prince Albert cracker), and which had perished within a few days under this diet showed considerable increase in volume, and their macroscopic appearance reminded one of the stuffed-goose liver. The microscopical examination showed vacuolar degeneration of the cells; the latter were enlarged, contained many vacuoles, and very small remains of protoplasma about the nucleus. No glycogen was to be found in the cells, nor in fact in the whole liver. The hepatic connective-tissue showed fatty degeneration and "coagulations-nekrose;" the stellated cells and the endothelia of the blood-vessels showed also fatty degeneration.

ACTION UPON NERVE-TISSUE.—The action of cocaine upon nerve-tissue, therefore, cannot be considered as being of a specific kind, but is rather identical with the general action of this drug upon protoplasma, the only difference being that the nerve-tissue responds more readily and more effectively to outside influences. In accordance with this view one would expect that all nerve-tissue would be similarly affected by it, although the action upon the ends of the sensitive nerves is most marked and constitutes the most striking property of cocaine and its main claim as a valuable therapeutic agent.

In order to test the action of cocaine on other than peripheral sensory nerves, the writer devised a series of experiments, with the purpose of deciding the question whether the terminal apparatus of the higher senses could also be paralyzed by cocaine. The field of experiment selected was the retina. In two cases in which an enucleation of the eyeball had to be performed, perception and projection of light being still present, cocaine was injected into the orbita by means of a hypodermic syringe, as near to the eyeball as possible. In one of these cases it was apparent that the perception of light was affected in that part of the field of vision which corresponded to the place of injection. Continued injection in other places around the eyeball blinded other corresponding parts of the field, until after some time nearly all perception of light was lost. The other case did not give any satisfactory result, on account of which these experiments were not published. (The experiments were made in Professor Snellen's Eye Clinic, in Utrecht, in 1887). Experiments on dogs, undertaken in common with Dr. H. Zwaardemaker, in Utrecht, failed, on account of the toxic effect of the doses necessary. Later on, Dr. H.

* Paper read before the Berlin Med. Soc., January 11, 1888.

Zwaardemaker ("Cocain-Anosmie, Fortschritte der Medicin 1. Juli, 1889") tested the action of cocaine on the sense of smell, and by means of the olfactometer, examamined the way in which the smell was affected when cocaine powder of five, ten, and twenty per cent., was blown up the nose. He found that if sufficiently absorbed by the mucous membrane of the upper parts of the nose, it produces anosmia, preceded by hyperæsthesia of smell. The various qualities of smell were equally affected.

Tumass ("Über die Wirkung des salzsauern Cocains auf die Psychomotorischen Centren." *Arch. f. Exper. Path. ü. Pharmakol.*, 1886–7, xxii., 107–126) has shown that cocaine has the same paralyzing influence upon the gray matter of the cerebral cortex. He experimented on dogs, applying from 0.05 per cent. to 4 per cent. solutions to the psychomotor centres of the cortex, which had been laid bare by trephining. The result was that, after cocaine application, stronger currents were necessary to produce just noticeable contraction of the corresponding muscles. The reduction of irritability lasted fifteen minutes, whereupon it slowly increased, but did not reach the normal within forty-five minutes. The trunks of thick sensory nerves were affected in the same way when moistened with a solution of cocaine; they could be cut without the slightest manifestation of pain. Other observers obtained the same results. The experiments of Goldscheider ("Wirkung des Cocain, etc., auf die Sinnesnerven der Haut.," *Wochenschr f. prakt. Dermatologie*, 1886, 2), Kochs ("Wirkung des Cocain auf Freipraeparirte Nerven.," *Centralblatt f. Klin. Med.*, 1886, No. 33), and Alms ("Wirkung des Cocain auf die peripheren Nerven.," *Du Bois Reymond's Arch. f. Physiologie*, 1886), show that the application of cocaine to the trunk of a sensory nerve produces peripheral anæsthesia, so that the cocainized part of the nerve seems to constitute an impediment for conduction. The same experience can frequently be made, when cocaine is applied subcutaneously for surgical purposes, and the place of application is near a sensory nerve-trunk. The action of cocaine upon motor nerve-trunks is essentially the same, although the conditions are here so complicated as to make that fact less evident than in the case of sensory nerves.

If a cocaine solution is applied to the trunk of a mixed nerve of a frog, the limb controlled by that nerve seems paralyzed both in its sensory and motor functions; but upon further examination it is found that the motor paralysis is only a consequence of the muscular and cutaneous anæsthesia (Vulpian "Comptes Rendus," xcix., p. 887, and Alms, l. c.), for reflex-action can be produced by irritation of other points of the body in the apparently paralyzed muscles. Nevertheless, irritation above the cocainized point (experiments made by Alms, on rabbits) discloses a marked decrease in irritability, so that cocaine acts on motor the same way as on sensory nerves; that is to say, it impedes the conduction of a stimulus. The paralyzing action on the terminal apparatus of the motor nerves has been demonstrated by Alms. If cocaine is injected into the arteria iliaca communis of one side in a frog, precautions being taken at the same time to prevent the cocaine from passing into the general circulation, the muscles of the leg of that side become completely paralyzed; faradic stimulation of the sciatic does not cause contraction, while the muscles retain their direct irritability. Cocaine applied in this way has exactly the same effect as curare has when introduced into the blood-circulation.

The Action of Cocaine upon the Organism depends of course upon this nerve-stimulating and paralyzing property. A number of more recent investigations of the physiological action of cocaine have brought to light new facts of great importance. To be complete, the following summing up may be in place:

The *central nervous system* of all animals is paralyzed by cocaine in sufficient doses after a period of excitation, which latter in warm blooded animals is characterized by general convulsions, while in cold blooded animals they are absent. The convulsions are of a general character and of the type of tetanus, and opisthotonus; they are certainly of central origin (not reflex-convulsions, as they occur at a time when the animals no longer react under the strongest stimulants) and their seat is most likely the medulla oblongata (Anrep, Tumass). The animals die most frequently during these convulsions by suffocation due to tetanus of the respiratory muscles—incidentally as it were, for, if they survive the convulsions, finally paralysis of the entire nervous system sets in, sensibility is lost, reflexes disappear, respiration ceases, the heart stops beating. After very large doses of cocaine this paralysis is developed directly without the intervention of convulsions. [According to the statements of Mosso *Arch. f. Experim. Pathologie u. Pharmakologie*, xxiii., 3-4, 1887), 0.005 per kilogram will sometimes produce general symptoms of poisoning, while he puts the fatal dose at 0.03 per kilogram. The fatal dose for men is about half that amount.] Small doses, 0.03—0.05—0.1, produce a decided enhancement of the psychical functions, euphoria, and increased capacity for mental and physical work, as shown by the experiments of Freud ("Beitrag zur Kenntniss der Cocawirkung." *Wiener medic. Wochenschr.*, 1885, No. 5), and many other observers with whom the writer, from his own observations, fully agrees. This effect is most likely due to stimulation of the gray cortical matter. The powerful effect large (but not toxic) doses have in altering the psychical functions (hallucinations, deliria, irresistible impulse to move) is too well known, from Anrep's dramatic description of his experiments on dogs, to be repeated. It will be partly described under the heading, Accidental Poisoning. The exciting effect of large doses is not confined to the cortex. It includes the great subcortical ganglia, the cerebellum, the medulla oblongata, and the spinal cord, as is evident from the forced movements, the vertigo, the convulsions, and the circulatory and respiratory phenomena.

Eye.—The action of cocaine, introduced into the general circulation, upon this organ is very similar to its action when applied locally; the pupil is dilated, the eyeball protudes, the eye is opened wider,—symptoms due to irritation of the sympathetic nerve. We must look for the seat of its action upon the sympathetic nerve (when introduced into the general circulation) in the nuclei of the sympathetic in the cord and medulla, for if the sympathetics is severed in dogs after 0.1 cocaine has been injected into the vena saphena, the above symptoms do not appear on the corresponding side ("G. N. Durdufi, zur physiologischen Wirkung des Cocain." *Deutsche med. Wochenschr.*, 1887, xiii., 172-174). The dilatation of the pupil after general, just as after local application, must be ascribed to the contraction of the iris-arteries, as there does not exist another dilater of the pupil in the human eye.

Respiration.—Cocaine always accelerates the respiration by stimulating the respiratory centrum. Large doses produce very frequent dyspnoic breathing, increasing to tetanus of the respiratory muscles. Fatal doses finally paralyze respiration.

Circulation.—In small and medium doses cocaine increases the frequency of the heart-beat, small doses rendering the contraction at the same time more powerful (Mosso). The increased frequency is most likely due to stimulation of the accelerating nerves of the heart (Durdufi). Large doses finally paralyze the heart (the action is different in frogs, the frequency being diminished instead of being decreased).

Very peculiar and characteristic is the action of cocaine upon the blood-vessels. Local application has a powerful constringent effect upon the small blood-vessels, making the tissue affected almost anæmic, as we can observe every day when applying cocaine to the nose or to the eye. This action upon the blood-vessels is evidently due to a stimulating effect of cocaine upon the nerves of the smooth muscular fibres. The contraction resulting is of long duration (several hours) and is followed by a relaxation. [Again here we find a difference in frogs. Local application of even weak solutions (1 : 4000) to the frog's tongue, produces considerable dilatation of the blood-vessels.] Introduced into the circulation, cocaine has the same constricting action upon the blood-vessels, and this evidently by means of acting upon the cen-

tres of the nerves of blood-vessels, as, for instance, is shown by the dilatation of the pupil (anæmia of the iris) not appearing if the sympathetic nerve has been severed. The pressure in the arteries is increased by medium doses in consequence of constriction of the small blood-vessels. Fatal doses lower the pressure accordingly.

The secretion of urine is materially increased by medium doses (even to the double of the normal) just on account of the increase of pressure in the arteries; very large doses diminish and finally stop urine secretion (Bignon: "Des Proprietés toxiques de la Cocaine," *Bullet. gén. de Thérap*, 1886, ii.).

Intestines.—Peristatic movements are increased; very large doses paralyze the intestines, which at the same time become very hyperæmic.

Secretion of saliva and perspiration stops after local application, and also when the drug acts by way of the circulation, most likely on account of the paralysis of the secreting epithelium, and constriction of the blood-vessels.

Practical Use.—*Eye Surgery.*—Cocaine is used for a threefold purpose: As an anodyne in painful affections; as a local anæsthetic in eye operations; as a dilater of the pupil.

Owing to the short duration of the cocaine anæsthesia (about fifteen to twenty minutes), its use as an anodyne is a limited one. Naturally it would be most useful in pains caused by superficial erosions, or ulcers of the cornea. The weakening effect upon the vitality of cells (as shown in the paragraphs devoted to the consideration of its action on cell elements) does not make a frequently repeated and prolonged action desirable. It is found very useful in the examination of an eye, where pain, photophobia, and lachrymation would otherwise render such an examination almost impossible, as in conjunctival or corneal troubles, cases of superficially seated foreign bodies, scalding by chemicals, etc. In pains which might possibly be of glaucomatous origin the use of cocaine should be carefully avoided, as it has repeatedly been found to hasten the development of a glaucomatous attack previously threatened (Javal). Supra- or infra-orbital neuralgia can frequently be successfully combated by hypodermic injection. The use of cocaine as a local anæsthetic in eye operations is a very extended one, and it has reduced the employment of general anæsthesia by ether or chloroform to a minimum. The objections raised against it in the beginning, of producing sometimes opacities of the cornea after cataract operations, have been silenced by its more judicious application, by prevention of evaporation, and by avoidance of the too free use of sublimate or other coagulating antiseptics. Another objection raised by several writers, that the cocaine anæsthesia renders the eye so hypotonic that the expression in operation for cataract becomes difficult, has not been heard of in the more recent literature. On the contrary, many operators who follow the trend of the time by practising cataract extraction without iridectomy, consider the revival of this more perfect method as partly due to the cocaine anæsthesia, the latter being instrumental in preventing prolapse of the iris. While operations on the conjunctiva and on the cornea can always be made perfectly painless by *instillation* of cocaine solutions, such operations in which the iris is touched or cut, as iridectomies and operations for cataract, cannot always be rendered perfectly painless by instillation, owing to the difficulty of making the iris sufficiently anæsthetic. In a number of cases one does succeed, in another number one does not. The writer has found the following to be the most effective method of instillation: Begin to instil a four per cent. solution, twenty to thirty minutes before the operation (time necessary to reach the iris), instilling at intervals of five minutes each. During the whole time the eye is kept closed to prevent evaporation. The iris can, with certainty, be rendered anæsthetic by instilling cocaine into the anterior chamber after the corneal section. A Daviel's spoon is inserted through the corneal wound into the anterior chamber and a drop of cocaine allowed to run into it along the furrow of the instrument; the spoon is withdrawn, the speculum removed, and the eye closed for two to three minutes. Although this proceeding complicates the operation it has its justification in the great importance of complete anæsthesia of the iris for the safety of the operation. If prolapse of the iris occurs right after the corneal section some of the advantage of this procedure is lost. In a proposed iridectomy it is therefore best not to allow the whole of the aqueous humor to escape during the corneal section. For operations on the tendons and muscles (tenotomies and advancements) instillation is never sufficient for a complete anæsthesia, and therefore, as far back as 1885, the writer resorted to subconjunctival injections in these operations. He proceeds as follows: After repeated instillation of a four per cent. solution, to make the conjunctiva anæsthetic, a speculum is inserted, and, by means of a mouse-toothed forceps, a fold of the conjunctiva at the point of operation is seized. The needle of a hypodermic syringe is inserted into it, if possible, as deeply as Tenon's capsule and a few drops of a two per cent. solution are injected. Then the eye is closed again after removal of the speculum, and the artificial œdema of the conjunctiva is given time to disappear, which it does in five to ten minutes, aided by occasional slight rubbing. In this way the operation can be performed absolutely without pain. The cocaine solution is made aseptic by filtering and boiling, which latter does not affect its efficiency. The syringe is cleaned with alcohol and rinsed with a two per cent. carbolic or three per cent. boracic solution or sterilized water. Recently the writer has used these subconjunctival injections very successfully in cataract operations and in iridectomies, following a suggestion made to him by Professor Snellen, of Utrecht, in a private communication (see also Snellen, "Sur l'Opération de la Cataracte," *Annales d'Oculistique*, Janvier, 1892). The proceeding is the same as that described for squint operations, the point of injection to be selected near the place of intended corneal section.

The *pupil-dilating* property of cocaine is of great value in ophthalmoscopy. While the dilatation is sufficient in the dark chamber to allow a satisfactory examination, it does not have the blinding effect of belladonna, the pupil all the time responding to light. This is due to the fact that cocaine dilates the pupil by constricting the blood-vessels of the iris, but leaves the sphincter intact. Besides, the accommodation is hardly interfered with. The pupil-dilating power of cocaine, if combined with that of atropine, is invaluable in cases of iritis. The mydriatic effect of this combination is stronger than that of any other drug or any combination of drugs; it counteracts both forces that contract the pupil—the sphincter and the blood-vessels. (Hyperæmia of the iris tends to contract the pupil by stretching the tortuous course of the iris arteries, while the blood-vessels, when empty, return to their tortuous course and so dilate the pupil.)

The anæmia of the blood-vessels is a strong check to the inflammation, the pain ceasing mostly after a few instillations, and the duration of treatment being greatly shortened. The writer uses a mixture of equal parts of a one per cent. solution of sulphate of atropine and a five per cent. solution of hydrochlorate of cocaine; at first he instils every ten minutes until the pupil is dilated (three to four instillations necessary), then only three times a day. The combination of the two drugs is also efficient in cases of cyclitis.

Rhinology and Laryngology.—In the examination and treatment of the nasal cavities cocaine has an extensive field of usefulness. By its power of constricting the blood-vessels the mucous membrane recedes and inspection of the posterior parts is facilitated; in chronic catarrh with hypertrophy a proper inspection without its help would be impossible. Medicated applications and the actual cautery or caustics can be employed painlessly. In reflex neuroses starting from the nose the exact locality of the trouble can be detected, inasmuch as by application of cocaine to the starting-point the patient is temporarily relieved (asthma, mimic spasm, etc.). In hay fever it affords relief but has no curative power. Posterior rhinoscopy is facilitated by checking the reflex

action of the soft palate and the tedious practising of the patient is done away with. The solutions are applied either as a spray by means of an atomizer or with a cotton wad on the point of a probe. For spraying, only weak solutions (two per cent.) should be used, in graduated bottles, so that the quantity used is known, to avoid the possibility of poisoning. Weak solutions applied repeatedly at intervals of five minutes will accomplish the same result as strong ones; the first application constricts the blood-vessels and the following ones act more strongly on the anæmic membrane, while at the same time a too rapid absorption, with its poisonous effects, is prevented. For application with brush or cotton stronger solutions (five, ten, or fifteen per cent.) may be used. Nasal surgery has been greatly promoted by the use of cocaine. Operations on the septum and the turbinated bones can frequently be performed painlessly, although not always so. Laryngological examination and operation is made easier by stopping reflex action of pharynx and larynx; the practising of the patient is done away with. For making the vocal cords anæsthetic very strong solutions (twenty per cent.) are required; they are applied with brush or cotton.

Otology.—Comparatively little advantage has been brought to otology by the use of cocaine. The drum-head (covered with epidermis) can hardly be rendered completely anæsthetic, but the sensibility can be lessened by repeated application of a warmed fifteen to twenty per cent. solution (Hedinger). In operations in the tympanic cavity more can be expected from its anæsthetic effects, although, only if the operation is limited to the mucous membrane (Kretschmann: "Communication about the Experiences made in Schwartze's Clinic," *Arch. f. Ohrenheilk.*, xxiii., 4, 1886). Catheterization of the Eustachian tube is facilitated and made painless; the air penetrates in broader current into the tympanic cavity. Hedinger (*Würtemberg. Corr. Blatt.*, lvii., 7, 1887) relates favorable results in cases of inflammation of the middle ear. A few drops of a two to four per cent. solution blown into the Eustachian tube by means of a catheter were in most cases sufficient to stop the pain for several hours. Kiesselbach (*Monatsschrift f. Ohrenheilkunde*, xxiii., 9, 1889) had good success from insufflation of a few drops of a four per cent. solution into the Eustachian tube in cases of subjective ear-noises. The insufflations were made at intervals of three to five days, the strength of the solution being increased to ten per cent. The most various noises disappeared entirely; most cases improved.

General Surgery.—The use of cocaine in general surgery is very extended, and in minor operations has displaced general anæsthetics and other methods of local anæsthesia. It is injected under the skin or into the deeper layers of the skin at the site of the operation by means of the hypodermic syringe. Careful distribution over the field of operation is necessary for full effect. Corning's method of "incarceration" is an important improvement on the simple injection (J. Leonard Corning: "On the Prolongation of the Anæsthetic Effects of the Hydrochlorate of Cocaine when subcutaneously injected —an Experimental Study," *New York Medical Journal*, September 19, 1885, and "Local Anæsthesia in General Medicine and Surgery," in book form, Appleton & Co., 1886). A short time is given to the circulation to distribute the drug over the field of operation, then exsanguination of the limb and application of a tourniquet (especially devised apparatus on other parts) keep the solution in place. By this way of proceeding, the anæsthetic effect can be prolonged indefinitely, while absorption into the general circulation and poisonous effects are prevented.

At present extirpation of small tumors, extraction of foreign bodies, amputations of fingers and toes, operation for phimosis, operations for ingrown nail, incision of abscesses and furuncles, are performed under cocaine anæsthesia. Pernice (*Deutsche Med. Wochenschrift*, 1890, 14) reports more than a thousand cases operated in the Polyclinic at Halle, where one per cent. solutions were used, which were always found sufficient. One to two syringes were injected (0.01–0.02), and thus accidents could with certainty be avoided.

In genito-urinary surgery cocaine is extensively used, not only for external and internal urethrotomy, but also for operations in the bladder (litholapaxy). As the unbroken epithelium of the bladder has hardly any power of absorbing, enormous quantities have sometimes been used (1.00–5.00!!). However, genito-urinary surgery is especially rich in accidental poisoning, the assumption of an unabraded epithelium not always being correct.

Dentistry.—To make extraction of teeth painless it is not sufficient to brush the solution on the gums, as this does not make the alveolus anæsthetic. Even injection between gum and alveolus in one place only will frequently fail. All those who report successful anæsthesia (George Viau: "De l'Anesthésie buccale," Paris, 1886; Bleichsteiner, Congress of Dentistry, Paris) concur in the recommendation to inject the solution under the gum in several places on the inside and outside of the alveolus. A five per cent. solution is sufficient, and not more than 0.05 cocaine should be used. Even then the number of cases where constitutional symptoms occur is large compared with its application in other branches of surgery. Schlenker ("Ueber Cocain als locales Anæstheticum," *Tageblatt der* 61. *Vers. deutscher Naturf. und Aerzte*, Cöln, 1889) had three per cent. of graver and five per cent. of minor cases of poisoning. Bleichsteiner had collapse in five to six per cent. of his cases.

Gynecology.—Apart from the use in minor operations on the vulva, vagina, and the cervix, cocaine is especially valuable in the treatment of vomiting in pregnancy, vaginismus, and sore nipples. In cases of vomiting in pregnancy it has been found successful where all other medication failed, whether administered by the stomach, hypodermically, or by application to the os or cervical canal (Weiss: *Prager Med. Wochenschr.*, 1884, No. 51—0.004 internally every half-hour; Phillips: London *Lancet*, November 26, 1887). It is scarcely used any more at present in obstetrics; in the first enthusiasm it was recommended to alleviate pain in labor.

Dermatology.—Cocaine does not have any effect if applied to the unbroken epithelium. If the latter is macerated or wanting, solutions or ointments can be used to combat itching as in vesicular eczema, especially in the itching eczema of the genitals, in painful ulcers, and after cauterizing. In different operations on the skin, and before cauterizing, the application is the same as described under the heading of General Surgery. Touton reports painless treatment by electrolysis of warts or moles, if a few drops of a five per cent. solution are injected under the little tumor (which fact the writer can confirm). It is of theoretical interest that cocaine, like other substances, can be driven into the skin by the electrical current if applied to the positive pole—cataphoretic action of the galvanic current. (Wagner: "Ueber eine neue Methode Haut Anaesthesie durch Cocain zu erzeugen," *Zeitschr. für Therapie*, 1886, No. 6). The anæsthesia thus engendered may be used for superficial operations.

In *general medicine* much has been expected from the stimulating powers of cocaine upon the physical functions. However, it does not seem to be extensively used for this purpose, perhaps from exaggerated fear of the cocaine habit. From the experiments of Freud, Hammond, and others it is apparent that it has a decidedly stimulating power upon the psychical faculties, and some writers report very good results in neurasthenic patients and in melancholic depression (0.02–0.03 internally several times a day). According to these observers (Freud: "Bemerkungen über Cocainsucht und Cocainfurcht," *Wiener Med. Wochenschr.*, xxxvii., No. 28, 1887) the cocaine habit is not to be feared, as persons, unless they are addicted to the opium habit, can discontiuue the use of cocaine without any symptoms therefrom. Preparations of coca in the form of coca wine are extensively advertised and used as a nerve stimulant.

In whooping-cough applications of two to five per cent. solutions to the tonsils, pharynx, and epiglottis have been used with good result (Schuirer: *Arch. für Kinderheilkunde*). Various neuralgias and the shooting pains in locomotor ataxia are a field for the subcutaneous application of cocaine. In tabes, 0.02–0.03 twice a day is re-

ported to have succeeded in cases where morphine did not have the desired effect. Cocaine has also been recommended in sea-sickness, however with little success.

Opium Habit.—The recommendation (Freud: *Centralblatt für Therapie*, July number, 1884) to use cocaine in the cure of the opium habit did not meet with general approval, on account of the danger of making the subjects of the opium habit victims of the cocaine habit in addition. As Freud ("Bemerkungen über Cocainsucht and Cocainfurcht," *Wr. Med. W.*, 1887, No. 28) believes, cocaine is a very valuable agent to combat the craving for morphine and the collapse incidental to the disuse, provided the physician absolutely controls the administration. Obersteiner considers the use of cocaine admissible if no morphine at all is given. He recommends to administer it only internally, the first dose 24–48 hours after the last dose of morphine, giving about 0.05–0.1 several times a day, and not more than 0.5 per day, gradually diminishing the quantity and stopping the administration on the fifth or sixth day.

Accidental Poisoning.—It is not surprising that a drug which came into such rapid and general use in almost all branches of medicine and surgery, should have given rise to many and even fatal accidents, partly due to lack of acquaintance with the drug, and partly due to recklessness. The history of cocaine poisoning has already developed quite a literature. Its more judicious use in recent years has greatly reduced the frequency of such accidents. Cases of slight poisoning, which are the commoner ones, offer the following objective symptoms: Pallor, cold perspiration, frequent pulse, dilated pupils; subjectively the patients complain of dryness of the throat and the lips, a feeling of heaviness in the limbs, weakness, or even vertigo. This condition does not last long, and after a short time (one-half to one hour) complete well-being sets in, although no restoratives are used. In another class of more serious accidents great mental excitement, with talkativeness, hallucinations, and even delirium, can be present. On the other hand, conditions of syncope and collapse can prevail. In the gravest cases painful dyspnoic breathing, clonic and tonic convulsions occur, which can cause death by tetanus of the respiratory muscles. Or death can result from paralysis of respiration and heart without preceding convulsions. Dr. Paul Mannheim, under the guidance of Leyden, has made a thorough compilation of the accidents hitherto reported in medical literature ("Ueber das Cocain und seine Gefahren in physiologischer, toxicologischer und therapeutischer Beziehung," *Zeitschrift für klinische Medicin*, xviii., 3 and 4, pag. 380, 1891). The discussion in the Société de Chirurgie de Paris of a fatal case reported by Dr. Paul Berger, is also of great interest and rich in information ("Empoisonnement mortel produit par l'injection d'une Solution de Chlorhydrate de Cocaine dans la tunique vaginale à la suite de la ponction d'une hydrocèle," *Bulletin et Mémoirs de la Soc. de Chir. de Paris*, 1889, pp. 751, 757, 761, 790).

Mannheim has collected ninety-nine cases from the literature in which the doses used, the symptoms, etc., were stated with sufficient accuracy, and the following account is based upon these cases. The statement frequently made that weak and nervous women are more inclined to constitutional symptoms cannot be accepted; sex does not show any influence. Idiosyncrasy cannot be proven to play a part (the writer fully concurs in this opinion). Although idiosyncrasy against alkaloids certainly exists as a rare exception, it will not do to assume such peculiarity in every case where a quantity, harmless to one individual, produces constitutional symptoms in another. There are other circumstances that should be taken into consideration, for instance, the velocity with which a given amount is thrown into the general circulation. The same quantity in a more concentrated solution will be more quickly absorbed than if dissolved in more water; a tissue richer in blood-vessels will absorb faster than a less vascularized one, etc. For similar reasons it may be that constitutional symptoms occur with relative frequency in operations on the head, which fact has been especially emphasized by Wölfler ("Zur toxischen Wirkung des Cocain," *Wien. Med. Wochenschr.*, xxxix., 18, 1889) and explained by the nearness of the brain). The sitting posture has been accused as especially aiding the anæmia of the brain, supposed to be the chief cause of the weakness and vertigo in the minor cases. Out of the ninety-nine cases tabled by Mannheim, cocaine was administered hypodermically in fifty-one, instilled in the eye in nine, in the ear in two, brushed on the mucous membrane of the nose in five. Sometimes very small doses produced graver symptoms, sometimes very large doses were followed by very slight ones. The time of appearance of the symptoms varies, being five to ten minutes on an average; sometimes they appeared immediately after administration, or after a few seconds, sometimes only after one-fourth or even one-half hour. In the following the symptoms of poisoning are given as collected by Mannheim from the various cases. (The seeming contradiction in the symptoms is not to be wondered at, if it is taken into consideration that cocaine is a poison with first stimulating and afterward paralyzing properties, and that according to quantity or velocity of absorption the first or the second will prevail.—Writer.)

General Symptoms.—The patients become sleepy and get into a soporous condition; they almost lose consciousness and faculty to articulate, or they fall within a few minutes into a very deep sleep of comatose character. Severe collapse has been observed, preceded by weakness, with complete loss of consciousness of long duration and with reduced respiration. In other cases the patients become very restless and excited, seem dizzy, cry and laugh alternately, gesticulate, and are very talkative, not heeding any questions put to them; incessantly change their position, stand up, sit down; their gait becomes unsteady, like that of a drunken person. This condition grows into intoxication, or a feeling of impending death. There may be sleeplessness, lasting from thirty to forty hours; afterward complete forgetfulness of what has happened.

Central Nervous System.—In mild cases reflexes are increased, cerebral irritation and delirium, lasting as much as an hour, hallucinations. In severe cases epileptiform attacks, with general clonic convulsions, lasting even five hours, tetanus, opisthotonos, death.

Peripheral Nerves.—Sensibility diminished. Complaints of loss of sensation on the whole body or on single parts, limbs, or pharynx. Sometimes only numbness, sometimes complete anæsthesia. Feeling of intense coldness in the anæsthesic parts. Various paræsthesias. On the part of motor nerves twitching of single muscles (or as already mentioned, general convulsions), in other cases heaviness or tired feeling in the limbs, sometimes aggravated to apparent paresis. Gait staggering or complete inability to walk.

Eye.—Pupils dilated, sometimes very contracted; reacting in some cases, in others motionless. Some patients complain of darkness before the eyes, others notice diminished acuteness of vision, complain of mist before the eyes; in some instances complete amaurosis (transient). One lady recovered vision only after four hours.

Other Special Senses.—Buzzing in the ears, various disturbances of smell and taste.

Respiration.—Short, whistling, laboring. Paroxysms of dyspnœa. On the contrary, the frequency can be diminished (even to nine respirations in the minute) and may cease, so that death occurs by asphyxia. Sometimes Cheyne-Stokes respiration has been observed.

Circulation.—Pulse very accelerated, often very weak, filiform, irregular, at last hardly, or not at all perceptible. In other cases, pulse less frequent. Diuresis increased according to some writers, diminished and even suppressed according to others.

Organs of Digestion.—Numbness of the throat, astringed sensation and dryness in the pharynx, dysphagia. Burning pain in mouth and stomach (even after hypodermic administration). Pain in intestines. Rectal and vesical tenesmus.

Cause of Death.—Paralysis of respiratory and vasomotor centres and heart, whereas in other cases death results from tetanus of respiratory muscles.

Autopsy showed, in the few cases examined, intense hyperæmia of the brain and of the inner organs.

Fatal Dose.—In five of the fatal cases the dose was larger than one gramme, whereas only one patient who had been given one and one-fourth gramme recovered. From this Mannheim concludes that one gramme is to be considered the fatal dose.

Of the 99 cases thus compiled, 9 were fatal. Besides, there are 100 cases in literature where no symptoms are mentioned. Of Mattison's 108 cases, 58 are included in Mannheim's table, whereas 50 are not. This makes altogether 250 cases with 13 fatal results, so that of the accidents reported five per cent. proved fatal. (Considering that most of the graver and fatal cases are reported, while the much more frequent minor accidents do not come to general cognizance, the figure five per cent. is certainly too high.—K.)

Treatment of Cocaine Poisoning.—In the minor cases, where weakness and dizziness prevail, horizontal position of the patient and administration of stimulants, like brandy, coffee, ether, are the reasonable measures to be taken. Inhalation of a few drops of amyl nitrite has been recommended, and is the measure generally adopted to combat the supposed anæmia of the brain. For the severe cases, where convulsions occur, Mosso, from his experiments on dogs, comes to the following conclusion: "If it were necessary to assist a human being poisoned with cocaine, one would have immediately to resort to ether or chloroform to prevent tetanus of the respiratory muscles, which is the most frequent and dangerous cause of death. After the first grave and imminent danger has passed, chloral can be given. If respiration stops, artificial respiration must be resorted to."

Dose.—Internally 0.02 to 0.05 gramme several times a day can be considered a safe dose, and even 0.1 may be given. For hypodermic use in operations it is advisable to keep under the 0.05 limit. Weak solutions of one per cent. and two per cent. should be used, well distributed over the field of operation. For spraying (nose, throat) weak solutions (two per cent.) should be used in known quantity. For operations in nose, pharynx, and larynx, brushing with strong solutions cannot be avoided, but in these cases the danger is obviously less, because the quantities used are small. Careful watching of the patient and gradual administration in all cases will increase the safety of continued administration.

Cocaine Habit.—Most subjects of the cocaine habit are victims of the opium habit who have taken cocaine for the purpose of curing themselves, have not succeeded in their efforts, and have consequently become addicted to both drugs. It is therefore not easy to state the symptoms of the cocaine habit pure and simple. Luff (London *Lancet*, September, 1889) tells of a man who used 0.25 gramme daily during three years for nasal catarrh, and who, in consequence, was very much reduced physically, mentally, and morally. He became unsociable, incapable of attending to his business, because unable to come to any decision. Palpitations of the heart, obstinate constipation. Bauer (New York *Medical Record*, November, 1885) tells of a man who replaced the use of alcohol by daily injection of 0.67 gramme cocaine. He became very weak, lost all appetite; had attacks of delirium; ultimately complete physical and mental decay.

From all observation it appears that rapid falling off in flesh is one of the most prominent somatic symptoms of the cocaine habit. Erlenmeyer (*Deutsche Medic. Zeitung*, 1886, page 483) reports a falling off of twenty to thirty per cent. within a few weeks, without diminution of food and with no existing catarrh of the stomach. He lays great stress on the respiratory and vaso-motor disturbances caused by the blood-vessel paralyzing properties of cocaine: frequent pulse, relaxation of arterial system, profuse perspiration, syncope. The psychical symptoms are very marked and characteristic, and in well-developed cases offer the clinical picture of hallucinatory paranoia. They consist, according to Obersteiner, chiefly of feelings of fright caused by hallucinations, especially in the visual and sensory sphere. Either terrible apparitions are seen or great hordes of small animals. These latter hallucinations are most likely based on itching paræsthesias of the skin, giving to the patient the impression of the presence of insects or worms under the skin and causing him to scratch. There exists an interesting observation of Ehrlich's, in his experiments with mice above mentioned, which closely recalls these paræsthesias and hallucinations based upon them. One of his mice, after three weeks' use of cocaine, began to gnaw its limb, so that in the course of the next days the whole right thigh down to the knee was entirely denuded. Ehrlich's explanation of this remarkable fact is that paræsthesias due to degeneration of the peripheral nerves provoke the gnawing, while the simultaneous anæsthesia of the skin leaves the latter without the protection of sensation.

While some writers deny the existence of symptoms due to withdrawal of cocaine in cases of well-formed habit, others, like Obersteiner and Erlenmeyer, affirm the contrary. According to Obersteiner they frequently appear only after the lapse of a fortnight and consist of sudden collapse and a feeling of impending death. Erlenmeyer emphasizes the vaso-motor disturbances as palpitation, weakness of the heart, dyspnœa, syncope, depression of humor, enormous weakening of the will power. According to all writers the prognosis of the cocaine habit is not a good one, as patients very readily relapse.

Carl Koller.

COCILLANA. A plant belonging to the order Meliaceæ, indigenous to tropical America. Its use was advocated for its expectorant properties by Professor H. H. Rusby in 1886. It is obtained from Bolivia, where it is employed as an emetic and purgative. The root is the part used, from which is prepared a tincture, one part in six, and a fluid extract. The dose of the former is from one-half to two drachms, and of the latter five to twenty minims. The powder is not used, as it produces sneezing, coryza, and irritation of the mucous membrane of the nose and throat and pulmonary tract. In overdoses it produces emesis, and causes gastric and intestinal irritation. As an expectorant it acts within half an hour, stimulating the secretion of the bronchial mucous membrane and producing a free flow of mucus; this continues for some hours, and is followed by diminished activity of the glands. It has very little action on the skin. It has proved of greatest service in chronic and subacute bronchitis when the secretion is scanty and tenacious. In such cases it liquefies the secretion and stimulates expectoration. The fluid extract, in doses of ten minims every three or four hours, seems to have been the most serviceable means of securing its effects. In the early stages of acute inflammation it should not be given. In bronchorrhœa and in the aged with profuse secretion it is not advised, as it does not stimulate the respiratory organs, and might produce too free secretion within the tubes. In phthisis it has to be used with caution on account of its irritant action upon the digestive tract, and the danger of producing inflammatory foci in the lungs.

Beaumont Small.

CŒLIOTOMY, DRAINAGE AFTER. As early as 1856 Dr. Peaslee advocated the use, after cœliotomy (laparotomy), of a rubber drainage-tube which should pass from the lower angle of the abdominal wound downward and through an artificial opening made from the bottom of Douglas's pouch into the vagina. He irrigated through this tube, from above downward. His success was satisfactory, but the practice fell into disuse, because a little later a glass tube began to be substituted for the rubber, although it was allowed to pass in only to Douglas's pouch. About this time Lister was teaching us our first lessons in antiseptic surgery. The short or long glass tube, as was needed, proved much more useful than the rubber had in the earlier attempts at drainage, not because of a better principle, but rather because of improvement in the antiseptic methods in doing the work.

Peaslee's ideas of drainage were correct, as we look back at his work to-day. But we know better now how

much to trust to nature and how much to drainage. Later still, in 1886, the method of packing any part of the abdominal cavity which was denuded of its normal peritoneum, with a quantity of aseptic gauze, was advocated. This practice, without doubt, has served to save the lives of many patients.

There are always possibilities of danger in the use of drainage-tubes: (1) In the fact that the operator can, or may, do a hasty or an imperfect operation, with the consciousness that the subsequent use of the drainage-tube will avert all danger; (2) because in the after-treatment sepsis may be conveyed directly to the wound by means of the tube itself; (3) because of the extra liability to ventral hernia when the tube is used.

That a drainage-tube, or drainage-gauze, should ever be needed is clear proof that surgical work in the abdominal or pelvic cavity cannot be done after an ideal method. Any drainage after an operation means imperfect work. In other words, we have not removed all possible sources of sepsis; we have not checked all bleeding from small vessels; we have tied arteries which will destroy the vitality of certain sections of tissue; we have broken up adhesions, and have not protected these raw surfaces in a kindly manner; we have left the pedicle insecure.

These indications existing, and with the very best surgery, it is necessary to reduce the dangerous results of such imperfect work to a minimum. To do this we must not neglect any precaution which, in our judgment, is necessary, or which is well known to be of absolute service. The latest method of operating upon a table which will easily allow the patient to be placed in the Trendelenburg posture, and in a room where a strong electric light can be used in the exploration of the cavity after the tumor has been removed, has rendered the subsequent use of a drainage-tube, in many of its previous forms, quite unnecessary. For with these methods, other things being equal, every bleeding vessel should be detected as surely as though it was on the face of the patient.

This ability to see into the cavity thoroughly also renders the operator far less likely to rupture, in removal, the small or large septic tumor. And so, also, the adhesions are dealt with more gently when all can be seen by the eye as well as felt by the finger; facilities which the new posture and the electric, or strong, light afford. To-day, therefore, when the operator is aseptic, the field of operation aseptic, and the surgical implements aseptic, the table and the light as nearly perfect as can possibly be obtained, we have far less need of the drainage-tube and are nearing our ideal operation. But, as we have not yet attained to this ideal standard, we must, for the present, resort sometimes to the best method for drainage.

The several methods of drainage may be quickly described. The glass tube is the one which has been most frequently and most successfully used during the last ten years. The tube, if needed at all, should be from three-quarters to one inch in diameter and from four to six inches in length; it should be open at the distal end and have several side perforations near this end. It is not necessary for the tube to be curved, as was formerly believed to be important. This glass tube should be placed so that the distal end will rest very near to the probable or possible future location of sepsis, the proximal end resting in the lower angle of the abdominal wound. One suture should always be inserted here, and left untied, for the special purpose of closing this track as soon as the glass tube is removed. The tube should be loosely packed with sterilized gauze, which, at the proximal end of the tube, should be covered with a compress of soft, sterilized, absorbent cotton. The tube should be dressed from time to time, according to the rapidity with which the gauze becomes saturated from within, and should be removed just as soon as the fluid which escapes is found to be scant and benign in character.

The drainage should take place through iodoform gauze in all septic cases, as it will be necessary to retain the glass tube *in situ* for from four to six days. In case the packing is only to check a hemorrhage from small vessels, and surfaces from which the peritoneum has been removed, common sterilized gauze will suffice, as such packing can soon be safely removed.

For pockets beneath the broad ligaments, or low down in Douglas's pouch, counter-drainage should be instituted through the vagina. The gauze should be from one and one-half inch to two inches wide and from two and one-half to ten yards in length. The distal end should be passed through an opening, which can be most easily and directly made into the vagina. The opening can be made with a trocar, or forceps, or scissors, from above downward, the finger in the aseptic vagina indicating the locality of the least amount of tissue to be penetrated, care being taken at the same time to avoid the ureters and uterine arteries. An iodoform gauze tampon should be inserted in the vagina. The proximal end of the drainage-gauze should be carefully and methodically laid in, fold on fold, or coil after coil; and finally it should be crowded into the cavity which is to receive it.

If it is possible, the slit in the broad ligament, or the parts above Douglas's "pouch," should be closed with catgut sutures, thus completely shutting off the gauze from the abdominal cavity. Of course, after making a counter-opening into the vagina there must be a thorough irrigation, with sterilized water, through the lower pelvis and out through the vagina, before the gauze is inserted.

The following are the notes of two of my own cases treated in this manner:

Case 1. Mrs. H., in my service at the Woman's Hospital, 1891. She had physical and symptomatic evidence of a cyst in the true pelvis, under the broad ligament. There had been exacerbation and remission of fever, her physician informed me, before she entered the hospital. I found, on operating, that the left ovary had been displaced backward, and after being completely covered by the broad ligament and an exudate, an ovarian cyst had developed, over three inches in diameter. Splitting through the exudate, I emptied the cyst with the aspirating needle. Its contents were purulent. I then enucleated and cut away the larger part of the cyst, but the lower zone was so tightly adherent to the cellular tissue which formed its bed, that the question of time for removal of all this friable, septic material had to be considered. As there was but a thin wall of tissue between this part of the cyst and the vagina, I quickly decided to drain into the vagina. I placed, therefore, a long piece of gauze in the jaws of a somewhat sharp-pointed pair of forceps, and then pushed this instrument through the lowest portion of the cyst which I had been unable to remove, directly through into the vagina just back of the cervix. I will mention here that in my service the vagina is always made aseptic before cœliotomy. I then irrigated through this opening. The remaining gauze I carefully laid in the cavity just occupied by the cyst and firmly crowded it down.

All went well for two weeks. At the expiration of that time I thought I could safely remove the drainage-gauze, and did so. The temperature and pain soon convinced me that the drainage should be continued for a longer period. I therefore inserted a rubber drainage-tube for an inch and a half into the sinus, and fastened it *in situ* by means of a silver-wire suture. This was retained in place, and irrigation was kept up through it for nearly four weeks, with the result that the patient at the end of that time was discharged cured.

Case 2. Mrs. M., thirty years of age, in my private sanatorium, 1892. A suppurating cyst, three by four inches, was found developed beneath the broad ligament. The ovary and tube on the same side were both diseased and displaced backward, and covered with an exudate. An incision directly through the broad ligament laid bare the tumor. The cyst was so friable that I had to remove it in small pieces, and then I could not be sure but that some portion had been left. To have painted this cavity with a germicide sufficiently strong to kill all possible septic elements remaining, or to have

burned this large surface with the thermo-cautery for a similar purpose, would have exposed the patient to a greater danger than that which the tumor itself would have afforded had it been left undisturbed.

I therefore passed the points of a pair of scissors directly through into the aseptic vagina, irrigated through this canal, then pushed the end of the gauze into the vagina, and carefully coiled the remaining portion of the gauze in the nest formerly occupied by the cyst. The tube and ovary on the same side were then loosened up and removed in the usual manner. I then turned the stump of the pedicle into the incision which I had made in the broad ligament on this side, and closed the slit with catgut, leaving nothing that could possibly cause trouble in the abdominal cavity. The gauze was removed gradually, a few inches at a time daily, and by the tenth day all had been removed. The patient made a perfectly satisfactory recovery, the temperature, after the first day, never rising above 100° F.

The necessities for drainage can be grouped under four heads:

1st. Inability to remove the whole of a septic tumor or tissue, especially when a ligature has passed through such septic tissue.

2d. A large space of granulating surface after enucleation of tumor or separation of adhesions.

3d. A large number of minute bleeding vessels, which, from their location, will require too much time to close.

4th. Fear of secondary hemorrhage.

This last reason should be, and will be, the excuse given only by the timid and inexperienced surgeon. The best surgeon will never leave a pedicle so insecure as to excite fear of hemorrhage, while his catgut or other aseptic ligature material holds out. This fourth excuse for drainage, therefore, may be excluded, and will never be put forward by a judicious operator, when it is understood that any pedicle or ligature can be made absolutely secure at the time of the operation, in one-half the time it will take to prepare the patient for a secondary operation, after the necessity for such operation has been demonstrated by the collapsed condition of the patient, and the other usual signs of secondary hemorrhage; and also when it is remembered that all patients are far better able to remain on the operating-table for the five or ten minutes necessary to strengthen the original ligature—or for additional ligatures, or a half-dozen deep catgut sutures, introduced with a full-curved, round-pointed needle—*before a secondary hemorrhage* than after it has occurred.

Let us carefully consider the other reasons for drainage:

1. The necessity for keeping a drainage-tube, or gauze, at the site of sepsis will be admitted by all. And we all know that sometimes the condition of our patient will not allow us to carefully curette every septic cavity, even if we were absolutely positive of entirely removing the possible source of sepsis; and in the true pelvis or under the broad ligaments we are never absolutely certain that we have removed everything septic. Other things being equal, time is a great factor in the ultimate results of all major operations, especially in abdominal surgery. If, however, such septic surface is far from the abdominal wound, and near the vagina, drainage *through* the vagina, as described, would be indicated and should be preferred.

But when there is need of drainage because of sepsis, or fear of sepsis, and the lowest point of contact for such sepsis is not far from the lower part of the abdominal opening, a glass tube, or a gauze bag, three by six inches, filled with sterilized or iodoform gauze, and inserted in the lower angle of the abdominal wound, will serve best. I am inclined to use the latter method in tubercular peritonitis and tubercular salpingitis, and when a large septic tumor has had to be enucleated from its bed near the normal position of the fundus uteri. The former method, the glass drainage-tube, is preferable where sepsis is feared over only a small space, like the condition present when a very badly diseased tube, or small ovarian abscess, has been operated upon.

2. In really non-septic cases, if there are many adhesions broken up and separated, or when there is a large raw surface left in the cavity after enucleating, we must expect much sweating of serum, and we always fear adhesions of the intestines to the bed from which the tumor has been removed. In such cases, if we cannot close this large raw surface with a few catgut sutures, and thus shut it off from the abdominal cavity, and after dusting the intestines (when adhesions have existed) with aristol powder, we still find the parts too much inflamed to warrant our trusting to nature's efforts alone, then we must place the bag of gauze in the abdominal wound or the gauze in the vagina, choosing the one or the other, as may seem most judicious.

3. In those difficult cases where there is a somewhat threatening, or at least a continuous, oozing of blood from the lower pelvis, after an enucleation of a solid or semi-solid tumor, if these vessels cannot be seen and closed by pressure, or the hemorrhage is not checked by hot water, nor by dusting with sterilized powdered persulphate of iron, then there is nothing to do but to fill the bleeding space with gauze. First the gauze bag, then packing this bag tightly with gauze from above, and, if we are not then satisfied with the state of things, buttressing the gauze with a firm tampon in the vagina.

4. My firm belief, for reasons given above, is that we should never drain simply because we fear secondary hemorrhage from a large vessel in the pedicle.

Too much attention to cleanliness cannot be exercised in managing the tube. In septic cases, after watching the contents of the tube for four or five days, a smaller tube may be used, and generally within a week this can be removed, and the track of the tube be closed by tightening the suture.

When drainage is resorted to for the purpose of removing the serum from sweating raw surfaces, within twenty-four hours the gauze, or the glass tube, should be partially removed, and altogether withdrawn by the end of the second day. In counter-drainage through the vagina a piece of gauze, from three to five yards long and from one and a half inch to four inches wide, should be used, and should be withdrawn through the vagina, little by little, daily, until all is removed. When the last is taken away the cavity should be thoroughly irrigated. If there is still evidence of pus a rubber drainage-tube should be inserted into the blind fistula, and retained by one of the several methods in general use. All tubes and all gauze must be thoroughly sterilized. If gauze is to be kept *in situ* for a week, sterilized iodoform gauze remains less offensive when in use than plain gauze sterilized. But when the gauze can be frequently changed, plain sterilized gauze is perfectly satisfactory.

Horace Tracy Hanks.

CŒLOM. In all vertebrates the primitive intestine forms two sets of diverticula which are destined to become permanent tissues, (1) one toward the medullary groove which forms the chorda dorsalis, and (2) two lateral diverticula which form the body cavities. These latter are later on subdivided into pleural, pericardial, peritoneal, and other cavities. A detailed description of the theory of the formation may be found in Balfour's work, in Hertwig's "Embryologie," in Minot's "Human Embryology," and in Minot's article, "Fœtus," in Vol. III. of this HANDBOOK.

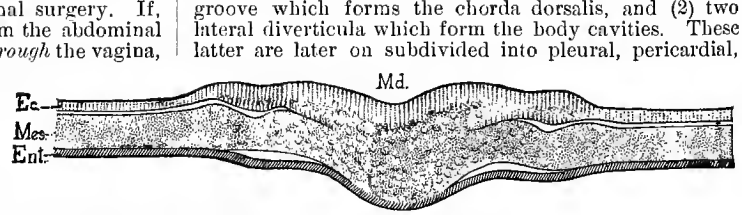


FIG. 100.—Transverse Section through the Posterior Region of a Chick, with Six Pairs of Myotomes. (After Waldeyer, from Minot.) *Ec.*, ectoderm; *Mes.*, mesoderm; *Ent.*, entoderm; *Md.*, medullary groove.

When sections are made through very young embryos of higher vertebrates, just after the blastodermic membranes are well formed, a solid mesoderm is present, as shown in Fig. 100. Although in lower vertebrates the mesoderm is produced by lateral diverticula from the entoderm, which are hollow from the beginning, in higher vertebrates the mesoderm is first laid down as a solid mass of cells. Soon the cells of the mesoderm on either side of the chorda divide into two layers, the somatopleure and the splanchnopleure (Fig. 101, *Som.* and *Spl.*). It is from these two lateral cavities that the peritoneal cavity is formed.

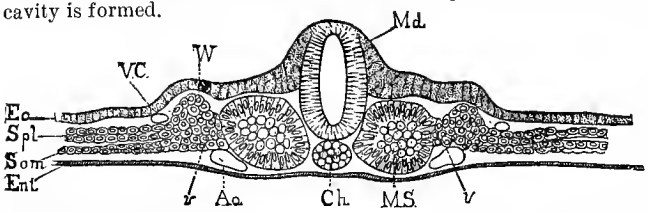


FIG. 101.—Transverse Section of a Chick of the Second Day. (After Waldeyer, from Minot.) *Som.*, somatic mesoderm; *Spl.*, splanchnic mesoderm; *Ec.*, ectoderm; *Ent.*, entoderm: *V.C.*, vein; *W.*, Wolffian duct; *Md.*, medullary canal; *Ao.*, aorta; *Ch.*, chorda; *M.S.*, myotome.

The more accurate early formation of the pleuro-peritoneal cavity, in its relation to the other organs, we find carefully studied by Budge, who by means of injection followed it in the chick. With a fine hypodermic syringe he filled the various spaces of the cœlom as they appeared, thus showing very clearly the extent of this cavity in various embryos. The splanchnopleure, according to Budge, may be split into two layers, a dorsal or lymphatic and a ventral or vascular. As the first blood-vessels are formed, lymph-vessels appear on their dorsal side, which flow together to form net-works and accompany the primitive veins to the axial part of the germinal area. Here the lymphatics form two spaces, one on either side of the body, which are soon united by a bridge, or rather duct, on the ventral side of the heart. In this way, in birds at least, this primitive pleuro-peritoneal cavity appears somewhat as an H, the uprights of which are on either side of the body, and the cross-piece a cross-section from a chick at this stage, and shows that the greater portion of the cavity is now on the outside of the body. The cross-piece of the H is immediately on the ventral side of the heart, and forms the cavity of the pericardium by the heart growing into it. Its communication with the remaining cœlomic cavity is later on cut off in higher vertebrates, while in lower vertebrates it may remain open.

According to Budge two diverticula grow from the cross-piece, one on either side of the chorda, toward the tail of the body, and form the primitive pleuro-peritoneal cavities. Budge's paper was published from fragmentary notes after his death, and I am sure that the above statement is not correct. Professor His has placed before me Budge's specimens, which I think show conclusively that his interpretations of his injections are not correct. Most of his injections were made into the amniotic fold as the amnion was forming. Cross-sections of embryos show that on either side there is a large cavity (Fig. 102, *Som.*) which communicates freely with the pleuro-peritoneal (*Coe*). Before the amnion is complete we have lateral cavities on either side of the body, communicating with each other only by means of the cross-piece on the ventral side of the heart. This is the freest portion of the communication, which also communicates most freely with the pleuro-peritoneal cavities (Fig. 102, *Coe.*). In many embryos the injection passed from the cross-piece into the pleuro-peritoneal cavity and would not extend out into the amniotic portion of the cœlom, thus making it appear as if the pleuro-peritoneal cavities were, so to speak, diverticula projecting directly from the cross-piece or pericardial cavity. Transverse sections, however, give the picture of Fig. 103. Surface views could not decide that these two cavities

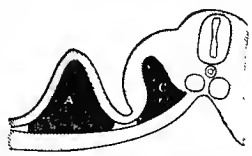


FIG. 103.—Section of a Chick, to show that the Pleuro-peritoneal Cavity is cut off of the Cœlomic, leaving a Portion in the Amnion. The embryo has been injected, but the fluid of the two cavities has not flowed together.

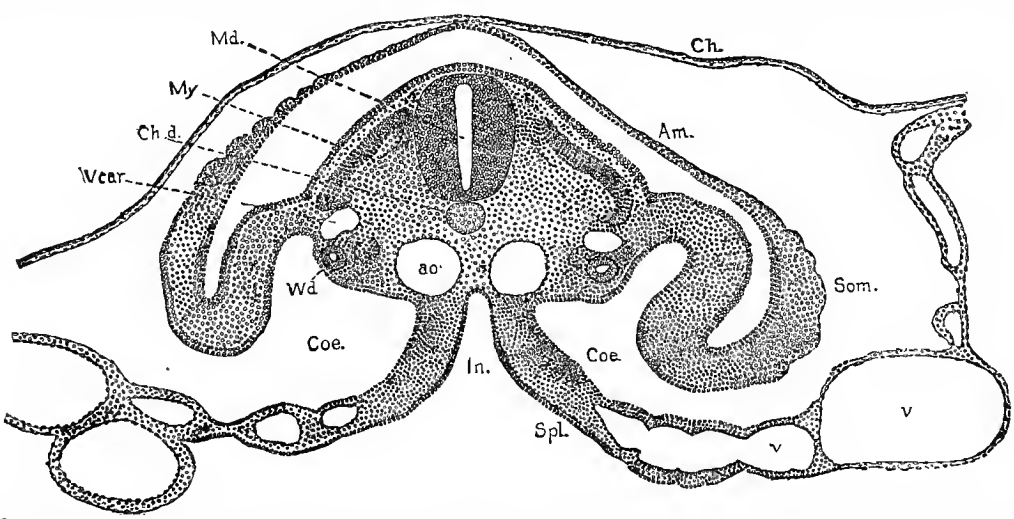


FIG. 102.—Section through the Body of a Chick of the Third Day. (After Minot.) *Ch.*, chorion; *Am.*, amnion; *Som.*, somatopleure; *v.*, blood-vessels; *Coe.*, cœlom; *Spl.*, splanchnopleure; *In.*, intestine; *ao.*, aorta; *Wd.*, Wolffian duct; *Vcar.*, vena cardinalis; *Ch.d.*, chorda dorsalis; *My.*, myotome; *Md.*, medullary canal.

on the oral side of the sinus venosus. In its further development the sinus venosus grows to the dorsal side of the cross-piece, thus reversing the relation of the vascular system to the lymphatic, or rather cœlomic system. The uprights of the H fall to the outside of the body and are swallowed up in the formation of the amnion. Fig. 102 is united directly, and these sections were no doubt made after the writing of the rough draft of his manuscript. Therefore, instead of stating that the two pleuro-peritoneal cavities arise as independent diverticula, we must say that they are pinched off from the cœlomic cavity after the amnion is formed.

The cœlomic cavities which are so intimately united with the lymphatic system, unite and again divide into sections, thus forming the various compartments of the visceral cavity of higher vertebrates. In all of the vertebrates the heart, as it is developing, hangs into the ventral transverse portion of the cavity, or the primitive pericardial cavity. This is shown diagrammatically in Figs. 104, 105, 106, and 107, *P.*

Figs. 104 to 107 show the very early condition of things; the cœlomic cavities are united by the cross-piece or the

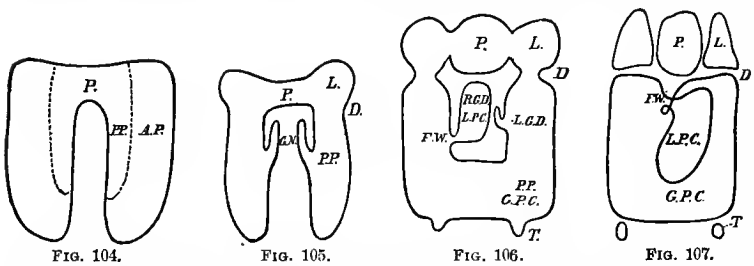


FIG. 104. FIG. 105. FIG. 106. FIG. 107.

FIGS. 104, 105, 106, and 107.—Diagrams to Show the Development of the Cœlomic Cavity. *P.P.*, pleuro-peritoneal cavity; *A.P.*, portion of the cœlomic cavity swallowed up in the amnion; *P.*, pericardial cavity; *L.*, pleural cavity; *G.M.*, gastric diverticula, right and left; *D.*, position of the diaphragm; *L.G.D.*, left gastric diverticulum; *R.G.D.*, right gastric diverticulum or lesser peritoneal cavity; *F.W.*, foramen of Winslow; *G.P.C.*, greater peritoneal cavity; *T.*, tunica vaginalis.

primitive pericardial cavity. The dotted lines (Fig. 104), mark what portion of the cavity is taken up in the amnion (*A.P.*), while the remaining middle portion (*P.P.*) becomes the pleuro-peritoneal. Figs. 105, 106 and 107 show in succession the more advanced stages. In higher vertebrates the pericardial cavity is completely closed off from the pleuro-peritoneal, but in elasmobranch fishes a communication between them exists in the adult. The separation of the pericardial cavity from the pleuro-peritoneal is aided materially by the heart going over to the ventral side of the body, as shown in Fig. 108. Sections through various parts of the same embryo, from which Fig. 108 is taken, are shown in Figs. 109 to 114. In none of these sections is the communication between the pericardial and pleural cavities shown, but sections nearer the head contain it.

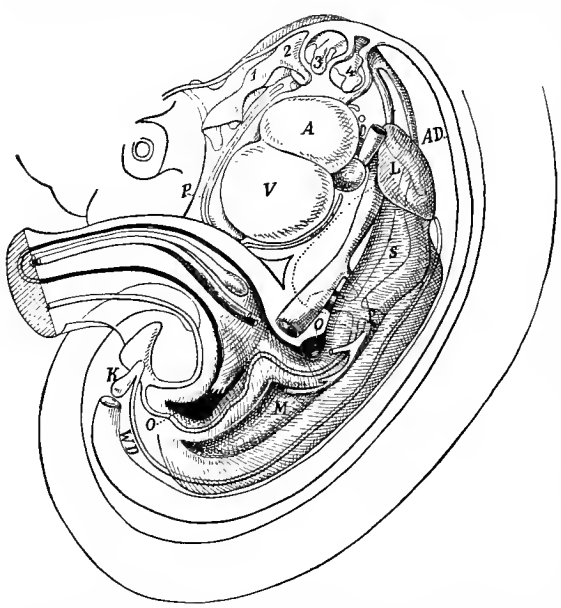


FIG. 108.—Reconstruction of a Human Embryo. (Enlarged 16 times, viewed from the left side.) *P.*, pericardial cavity; 1, 2, 3, and 4, branchial pockets; *A.D.*, descending aorta; *A.*, auricle; *V.*, ventricle; *L.*, lung; *S.*, stomach; *P.*, pancreas; *M.*, mesentery; *K.*, kidney; *W.D.*, Wolffian duct; *O.*, openings through which the right and left peritoneal cavities communicate.

A cast of the cœlomic cavity of this same embryo is given in Fig. 115. There is only a slight communication between the pericardial cavity and the pleuro-peritoneal. The groove in the cast marked *M* indicates the position of the simple mesentery. Its relation to these organs is better shown in the sections (Figs. 109 to 114). Fig. 116 represents a section through a chick at an earlier stage of development, in which the duct communicating between the pericardial and pleural cavities is cut longitudinally. Thus it is seen that the heart first grows into the primitive pericardial cavity, which is nothing else than the cross-piece of the H already spoken of. The heart grows larger and larger, at the same time hanging as it were over the ventral side of the body, and is soon connected with the pleuro-peritoneal cavity only by two ducts, which later on become closed in the higher vertebrates.

In early embryos the veins enter the heart behind, and not in front, as is the case in higher animals. The heart in its whole development undergoes a half revolution, and in this way the twists, etc., are formed.

Before the pericardial cavity is shut off from the pleuro-peritoneal the large vessels enter from behind. They are embedded in a mass of mesoblastic tissue which is encroaching upon the pleuro-peritoneal cavity, and has been termed by His the transverse septum. This, by its further growth, forms the diaphragm of higher animals (Figs. 105, 106, 107). In lower animals only a rudimentary diaphragm, or none at all, is present. By the formation of the diaphragm the pleuro-peritoneal cavity is divided into a smaller anterior portion, the pleural, and a larger posterior portion, the peritoneal. The lungs now grow into the pleural, as shown in an early stage in Fig. 116, and in a somewhat later stage in Fig. 109.

The peritoneal cavity is at first composed of two distinct portions, one on either side of the intestine, which in lower animals is quite a straight tube, lying in the middle line of the body. Soon, however, two communications are found between the two halves, one in front and one behind the omphalo-mesenteric vessels (Fig. 115, *O.*) These openings enlarge more and more as the intestine becomes more convoluted, and soon flow together, severing completely the omphalo-mesenteric vessels and duct. A portion of the duct may, however, remain in connection with the small intestine to form the diverticulum of Meckel.

As the organs grow the peritoneal cavity surrounds them more or less completely, until the condition of things as seen in the adult is produced.

In lower vertebrates the peritoneal cavity remains quite simple, but in reptiles, birds, and mammals it may become quite complex. Especially is this true regarding the birds, in which these divisions are greatly complicated by the growth of the air-sacs from the lungs.

The first trace of the lesser peritoneal cavity is seen in the reptiles. Ravn has shown that in the lizard there are two diverticula from the peritoneum, one on either side of the stomach. From the one on the right side the lesser peritoneal cavity of mammals arises. In general the relations of the lesser peritoneal cavity to the greater is much like what is shown in Fig. 105. In the true sense of the term there is no lesser cavity, but only the two pouches. These are already present in the embryo, and in the adult they retain their embryonic appearance.

In birds the conditions become more complex. They appear in the chick during the third day of incubation. A section of the chick at this stage is given in Fig. 116, *G.D.*, making the lesser cavities, or, as they may better be termed, the right and left gastric diverticula. At the beginning of the fourth day the gastric diverticula be-

come larger, and on tranverse section semicircular. Figs. 117 and 118 are from casts of the cavities about the stomach of a chick of eighty-eight hours. The right is larger than the left and is markedly cup-shaped, and connects by means of a narrowed opening with the right pleuro-peritoneal cavity (Fig. 117, *F. W.*). The two together enclose the proventriculus. On account of the relations of the opening of the right diverticulum with the blood-vessels, stomach, and liver, and also for reasons which find their basis in comparative anatomy and embryology, the opening can be nothing else than the foramen of Winslow.

On the left side the gastric diverticulum is much smaller, and in older embryos it disappears altogether.

In a chick of five days and sixteen hours (Fig. 119) the right gastric diverticulum has about doubled all its dimensions, while the embryonic foramen of Winslow has become much more sharply defined. At this time the liver has greatly increased in size, the right lobe being larger than the left, both lying anterior to the foramen of Winslow. The original position of the liver being behind the foramen, its rotation necessarily carries the hepatic artery and the portal vein around the foramen of Winslow —its adult position. With the growth of the gizzard a space extends from behind the right gastric diverticulum along the dorsal side of this organ, and marks the beginning of the cavity of the great omentum (*O.*). Nearly the whole of the right diverticulum now lies on the left side of the body ; the same position is held by the proventriculus and the gizzard.

The domestic fowl possesses three peritoneal cavities, completely separated from one another, and from one of them the lesser cavity arises. The communication is by means of the foramen of Winslow. After the anterior abdominal walls are removed, two ventral cavities are exposed, separated from each other by a vertical longitudinal septum. Into each of the cavities hangs a lobe of the liver, while into the left the ventral surface of the gizzard projects. On the dorsal side of the liver there are, on each side, three air-sacs—an anterior, a middle, and a posterior. The middle one is the smallest, and the posterior the largest, extending as it does throughout the posterior portion of the abdominal cavity. Each sac communicates by means of a special opening directly into the lungs. By allowing the sacs to collapse we find that a very distinct membrane projects backward from the gizzard and cuts off the portion of the abdominal cavity containing the intestines. This is the "pseudo-epi-

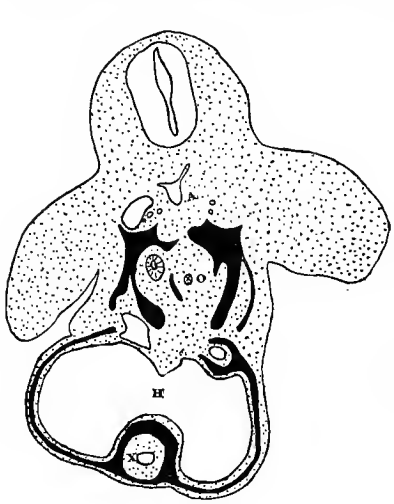


Fig. 109.

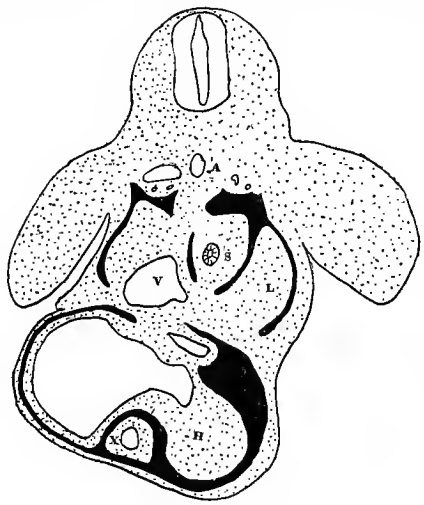


Fig. 110.

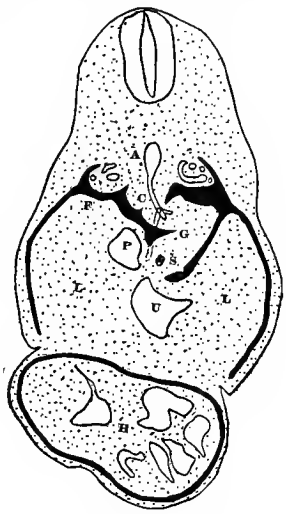


Fig. 111.

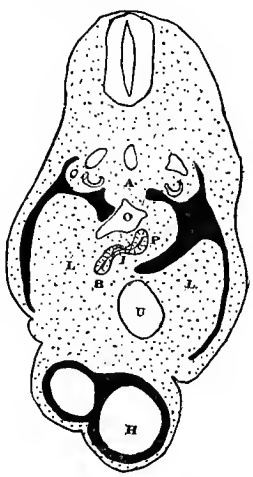


Fig. 112.

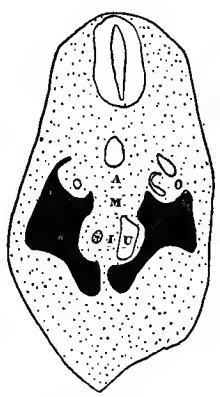


Fig. 113.

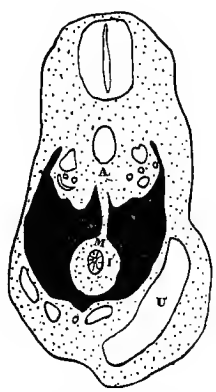


Fig. 114.

Figs. 109-114.—Sections through an Embryo Twenty-six Days Old. (× 25 times.) *O.*, œsophagus ; *S.*, stomach ; *I.*, intestine ; *P.*, pancreas ; *B.*, bile-duct ; *A.*, aorta ; *C.*, cœliac axis ; *G.*, right gastric diverticulum ; *F.*, foramen of Winslow ; *M.*, mesentery ; *L.*, liver ; *P.*, portal vein ; *U.*, umbilical vein ; *H.*, heart ; *X.*, bulb of the aorta. The pleuro-peritoneal cavity is colored black throughout.

ploön" described by Weldon and followed more extensively by Bedderd. A similar membrane is present in the crocodile. In all respects, this membrane is situated in the same position as is the epiploön in mammals, with

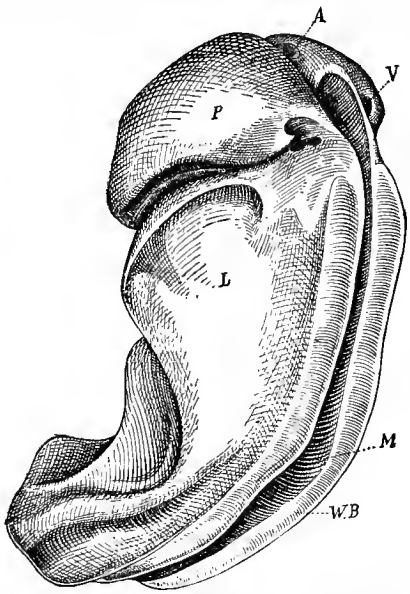


FIG. 115. — Corrosion Preparation of the Pleuro-peritoneal Cavity of an Embryo Twenty-six Days Old. (× 22 times.) *P*, pericardial cavity; *A*, opening for the aorta; *V*, opening for the vein; *L*, space over the liver; *M*, slit for mesentery; *W. B*, space for Wolffian body.

upright, only one gastric diverticulum is found. It is on the right side in Figs. 109 to 114, which are taken from a young human embryo. In each drawing the cœlomic cavity is colored black and the position of the section can be made out by the organs which are cut across in the section. A cast of the cavity is shown in Fig. 115. The portion of the cavity on the right side of the stomach and the liver is shown in Fig. 120, which is taken from a cast also. Figs. 109, 110, and 111 show sections through the gastric diverticulum of Fig. 120, Fig. 111 being through the foramen of Winslow.

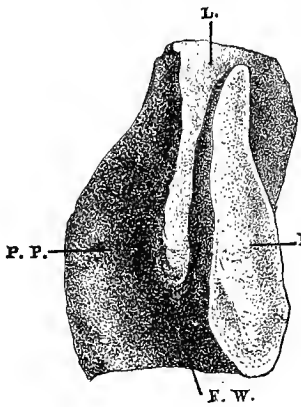


FIG. 117.

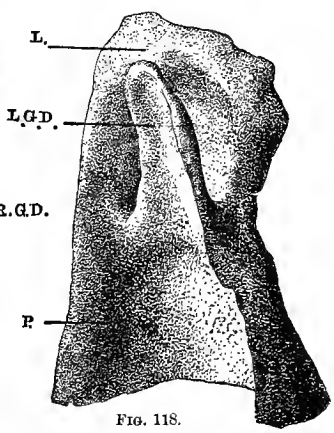


FIG. 118.

FIGS. 117 and 118.—Corrosion Preparations of the Right and Left Gastric Diverticula of a Chick Eighty-eight Hours Old. (× 33 times.) *P.P.*, pleuro-peritoneal cavity; *R.G.D.*, right gastric diverticulum; *L.G.D.*, left gastric diverticulum; *L.*, position of lung; *F. W.*, foramen of Winslow.

the difference that it is adherent to the abdominal walls along its free border. On the dorsal side of the gizzard the air-sacs fill all the space, thus closing off the communication between the cavity in which the intestines lie and the ventral cavities.

FIG. 116. — Section through the Region of the Heart of a Chick of Seventy Hours. (× 35 times.) The section strikes the oral end of the gastric diverticulum *G.D*, and the tips of the pulmonary buds, *L*. A few sections deeper the gastric diverticula communicate with the pleuro-peritoneal cavity. *H.*, heart; *D.C.*, ductus Cuvieri; *B.A.*, bulbus aortæ.

When the anterior and middle air-sacs on the right side are separated from the posterior sac on the same side, a slit is shown which extends anterior and dorsal to the hepatic veins. Here it communicates by means of a round opening, about one centimetre in diameter, with a large cavity lying on the median and dorsal side of the proventriculus and extending to the spleen. The cavity does not extend on the dorsal side of the gizzard. In all respects it corresponds with the right gastric diverticulum of embryos and with the lesser peritoneal cavity of mammals.

The relation of the embryonic omentum with the "pseudo-epiploön" is as yet unknown. However, I think it probable that the one is changed into the other, and that the "pseudo-epiploön" will prove to be the true epiploön homologous with the same in mammals. We must only imagine the embryonic omentum attaching itself on the sides of the abdomen followed by a loss of the epiploönic cavity. A subsequent growth of the air-sacs backward from the dorsal side of the stomach will produce the condition found in the adult.

In mammalian embryos, while the stomach is still

The general form of the cavities is shown in Fig. 120, which is taken from a reconstruction of a human embryo. The peritoneal cavity surrounds the Wolffian body, intestine, omphalo-mesenteric vessels, stomach, liver, and lungs, with the addition of the right gastric diverticulum.

In lower mammals, according to Ravn, there are two diverticula; so the symmetrical arrangement of these

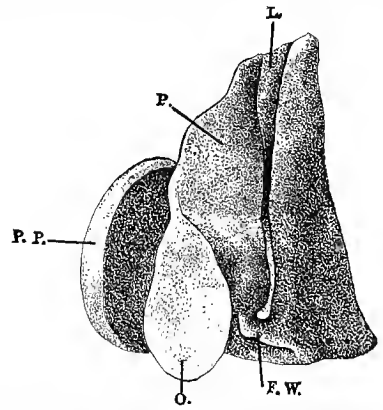


FIG. 119.—Corrosion Preparation of the Right Gastric Diverticulum from a Chick of One Hundred and Thirty-six Hours. (× 15 times). *P.P.*, pleuro-peritoneal cavity; *F. W.*, foramen of Winslow; *L.*, position of right lung; *P.*, position of proventriculus; *O.*, omental cavity (position of gizzard).

cavities in reptiles is still indicated in the mammals. It is so insignificant, however, that we need not take it into consideration.

The fate of the right gastric diverticulum of mammals has been studied in the dog, and it has been found that it is converted directly into the lesser peritoneal cavity, much as is shown in Figs. 106 and 107. In a dog's embryo, six millimetres long, the diverticulum is much like what it

is in the human embryo of about the same size (Fig. 120). A dog embryo, ten millimetres long, shows a picture more advanced, much like what is seen in the chick of five days (Fig. 119). In a later stage (Fig. 121) the stomach has been twisted about, holding in great part the adult position. The liver, which before lay on the ventral side of the stomach, now lies in front, and to a great extent on the dorsal side of it. A model of these parts from a ten-millimetre embryo, simply rotated to throw the stomach away from the mouth, gives the condition of things as they exist in the embryo thirteen millimetres long.

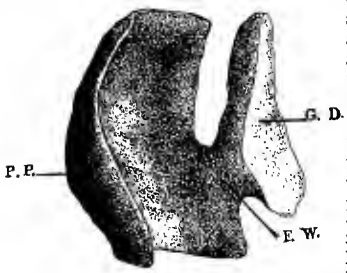


FIG. 120.—Corrosion Preparation of the Gastric Diverticulum of a Human Embryo, 7 mm. long. (× 35 times.) *P.P.*, pleuro-peritoneal cavity; *F.W.*, foramen of Winslow; *G.D.*, gastric diverticulum.

Fig. 121 shows the lesser peritoneal cavity as a cast stuck in behind the stomach. The intestine is composed of two loops, one from the stomach, extending into the pelvis, and the

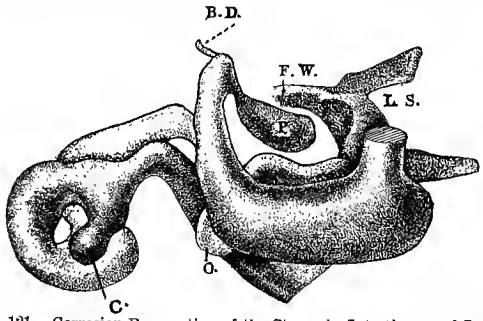


FIG. 121.—Corrosion Preparation of the Stomach, Intestines, and Lesser Peritoneal Cavity of a Dog, 13.5 mm. long, Viewed from the Left Side. (× 15 times.) The lesser peritoneal cavity has been filled with metal. *B.D.*, bile-duct; *P.*, *pancreas*; *C.*, cæcum; *O.*, omentum; *F.W.*, foramen of Winslow; *L.S.*, position of lobus Spigelii.

other from the cæcum into the umbilical cord. The rapid growth of the large intestine has thrown the cæcum as high as the stomach and to the right of it. The fold

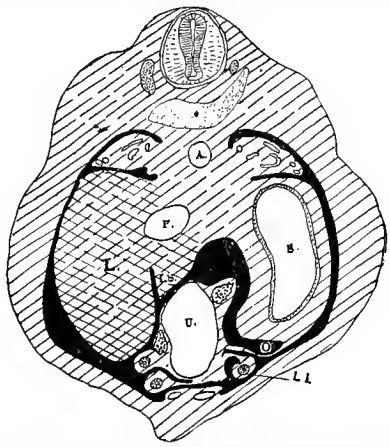


FIG. 122.—Section through the Foramen of Winslow and Lobus Spigelii of a Dog, 13.5 mm. long. (× 36 times.) *A.*, aorta; *S.*, stomach; *P.*, portal vein; *U.*, umbilical vein; *L.S.*, lobus Spigelii; *O.*, omental cavity; *L.I.*, large intestine.

of mesogastrium coming from the dorsal side of the stomach passes over the large intestine to form the omentum (Fig. 121, *O.*). The general shape of the lesser peritoneal cavity is shown in transverse section in Fig. 122, which can be compared with Fig. 111. The S-shaped loop of intestine is cut across three times, and the lesser peritoneal cavity with the foramen of Winslow is shown throughout its whole extent.

The omentum from now on rapidly grows over the whole ventral wall of the abdominal cavity, and in man adheres to the colon as first described by Meckel.

A *résumé* of the subject is given in Figs. 104 to 107.

Franklin P. Mall.

COLBERG. An important watering-place in Pomerania, Germany, near the Baltic Sea. It is also a seaside resort.

ACCESS.—Colberg is a railroad station, and can be readily reached from any European city.

ANALYSIS.—The waters of Colberg are saline, and are chiefly used for brine baths, although they are also administered internally after dilution with carbonated water. The principal springs are the Zillerbergsoole, Marktsoole, and Salinensoole. In 1,000 parts of Salinensoole there are contained:

Chloride of sodium	43.63 parts.
Chloride of calcium	4.37 "
Chloride of magnesium	2.13 "
Sodium bromide	0.04 part.
Carbonate of iron	0.08 "

INDICATIONS.—The place is much frequented owing to the advantages it possesses for sea-bathing, alternating or combined with a course of brine baths. It has been found beneficial in cases of scrofula, anæmia, tedious convalescence after acute diseases, and neurasthenia. Female complaints are successfully treated at Colberg.

ACCOMMODATION.—Good hotels and modern bathing establishments are found here.

Edmund C. Wendt.

CONTAGION. The progress of knowledge of the spreading diseases, in the past six or seven years, has enlarged the sphere of contagion as a factor, and in like degree has diminished that of heredity. (See article on Heredity, in this volume.) At the same time the agency of bacteria in their dissemination has gained greatly in importance with increased research.

Under the present title, in Vol. II. of the HANDBOOK, allusion was made to the ptomaïnes in connection with bacteria. The study of the animal alkaloids has been actively pursued by the German pathologists, with reference to their origin, development, and agency in disease. They are distinguished as *ptomaïnes* when they attend fermentation or putrefaction of a dead animal body, and leucomaïnes when found in living tissues. They result from retrograde metamorphosis, and resemble in composition and character the vegetable alkaloids. The alleged alkaloid of tetanus, for example, has the formula $C_{13}H_{30}N_2O_4$. They are highly unstable compounds in a chemical sense, and consequently difficult to manipulate. Some are toxic; others not so; most are acrid. They are to be regarded as the consequence, but never the cause, of bacteria; and there is good reason to suppose that pathogenic bacteria largely operate through these secondary products.

Brieger and Fränkel (1890) have obtained a ptomaïne from the bacillus of diphtheria, which produced in the animals experimented on precisely the same symptoms which follow inoculation with pure cultures of the same bacillus. Its activity was destroyed by a heat of 140° F. Brieger gives a list of the animal alkaloids isolated up to 1889, amounting to forty-one in all. Wurg has demonstrated (1889) the presence of leucomaïnes in normal blood, and further researches may prove them to be habitually present. Obviously they are not pathogenic, but experiment might show them to be transferable from one healthy individual to another by appropriate culture and inoculation.

S. S. Herrick.

CONTREXÉVILLE. This spa, being the most important one of the group in the Vosges district, and being now frequented by many English-speaking invalids, it may be well to give some additional information concerning it. (See also Vol. II. of the HANDBOOK.)

That the waters are the chief point of attraction is not doubted, although the pure invigorating air, the pleasing scenery, as well as the good walks and drives, all contribute to make the place popular and even fashionable. The new railroad has brought Contrexéville to within an eight hours' ride from Paris. Large sums of money have been recently spent upon the thermal establishments, which are now modern and complete in every detail.

Although the *Source du Pavillon* is the spring most generally employed, there are six other springs, all of tried efficacy in the particular line of maladies here treated. The *Source le Clerc*, *Source du Prince*, *Sources Mongeot*, and *Source du Quai*, deserve to be mentioned. All these waters are diuretic, aperient, and at the same time tonic. They disturb the stomach less than the more highly mineralized springs, and have been named "*amis de l'estomac*," in consequence. A statistical table published by Dr. Debout d'Estrées shows that of every hundred patients visiting Contrexéville, on an average thirty-seven suffer from gravel (uric acid, oxalic, or phosphatic), twenty-two from gout, nineteen from vesical catarrh, cystitis, etc., nineteen from gouty diabetes, seven from hepatic colic, and the remaining ten from other chronic diseases of the kidneys, the bladder, the liver, or the stomach (Wolff: "The Watering-places of the Vosges").

The waters of this spa are taken in larger quantities than at the resorts having stronger springs. Patients at Contrexéville are at times directed to take as much as twenty-five glasses a day, which produces a veritable internal flushing. Mr. Wolff summarizes the rules for drinking in this way: "You rise early, to dispose of the prescribed quantity of liquid in good time and with requisite ease. Five or six o'clock sees all the little bathing world assembled round the bubbling spring attractively housed in a neat and roomy pavilion. You drink your tumbler and then take a quarter of an hour's walk—that or thereabouts. Then comes another glass—another walk, and so on. For rainy weather the administration has provided convenient covered walks, sheltered by transparent walls and roofs of glass. In fine weather there is the well-kept little "park," with its gravel walks and its tastefully laid-out turf, and bosquets, and shrubs."

After lunch comes exercise, then perhaps a bath or a moderate potation. Another walk, or lounge, fills up the afternoon, and then comes the six o'clock dinner. In the evening the ordinary amusements are provided, and everybody retires at an early hour. It is in the strict enforcement of regular habits and a suitable régime that the European spas excel our own, and for this reason the therapeutic results seem so much better there. Mr. Wolff notes that the first effect of the water, which is readily assimilated, is to stimulate generally all animal functions. There is a notable acceleration of both pulse and respiration, and a marked diuretic action. All this is not unpleasant. But after a period, in most cases after about a fortnight, but sometimes much sooner, comes the "crisis," rather a trying ordeal. It does not as a rule last beyond from one to three days. Whatever its duration, it makes the patient most decidedly uncomfortable.

In regard to hotel accommodation and lodgings, Contrexéville is now on a level with the better class of French resorts. The season lasts from the middle of May to September. *Edmund C. Wendt.*

CONVALLAMARIN. This glucoside is recommended to replace the other preparations of convallaria majalis, as its dose is more definite and its action more certain and prompt. It possesses all the desired properties as a heart tonic, and is devoid of any irritant action on the bowels and stomach. Convallarin, the other principle of the plant, contains the irritant properties and has been employed for its purgative action. Convallamarin, the chemical composition of which is $C_{23}H_{44}O_{12}$, is a whitish, bitter, amorphous powder, soluble in water and alcohol. Its dose is from one-half to one grain, to be cautiously increased. When administered its action is directed to the muscular structure of the heart; it renders its action more slow by prolonging the period of diastole, which period of rest is followed by a forcible contraction and more thorough emptying of the cavities. When death is produced the heart is arrested in systole. As a cardiac tonic it proves of greatest service in cases where there is a failure of circulation due to organic heart disease; it is indicated where the arterial pressure is reduced, the veins full, and the right side of the heart and lungs are engorged. By the more forcible contractions which its use produces the arteries are filled and the equilibrium of the circulation regained. Where the heart trouble is far advanced, with extreme dilatation and loss of muscular power, the remedy must be given cautiously and its action carefully watched, as the exhausted heart may not be able to maintain the increased effort. The drug is excreted by the kidneys, and at the same time it exerts a direct diuretic action which is supplemented by the increased tension in the vessels, which must also be attributed to the action of the drug. Its advantage over digitalis as a diuretic is its promptness of action, in which it resembles caffeine, and probably it occupies a position intermediate between the two. Although very much praised, it does not prove as efficient in cardiac therapeutics as digitalis, and in no sense supersedes the more used drug; it, however, often proves of value to replace digitalis when it has been given for a prolonged period, and may always be given when digitalis has failed or for other reasons cannot be administered.

Beaumont Small.

CORFU. The most important of the Ionian Islands (Greece), and a popular winter health-resort. Corfu can be reached by way of Trieste in fifty-three hours, and from Brindisi, Italy, in twelve hours. The steamers are moderately comfortable. The climate of Corfu may be considered as typical of the whole group of Ionian Islands. It is a warm place, having a mean annual temperature of 65° F. But the winter months, which represent the invalids' season, average 53° F. Corfu has a moist, marine climate, although when the wind blows from the north extreme dryness may be the temporary result. Rain falls in almost every month, but during the seven cooler months only eighty rainy days occur on an average.

The capital (26,000 inhabitants) of the island is also called Corfu. It is well sheltered. According to Bradshaw: "The bay is open to the full south and southeast winds, and consequently well protected against all northerly winds. The Bora is not felt here. Northwest and northeast winds are tolerably frequent, though the latter are objectionable only as being cold. The atmosphere is never stagnant, owing to a sea-breeze which blows up to three o'clock, after which the land-breeze sets in. Rapid atmospheric disturbances, such as are met with on the Riviera, occur but seldom, and there is almost complete immunity from dust and high winds.

"The climate, though warm, is bracing. At the end of January and in February hyacinths, roses, and almond trees begin to blossom. By March, spring has set in, and in April cherries are ripening. The temperature rarely falls to freezing-point, and still more rarely below it. Fogs occasionally occur and last some time.

"The town itself offers many attractions. It is a link between the East and the West. Its streets are very lively. Close to the town on a small hill is a villa belonging to the King of Greece. The esplanade and the Strada Nuova are the centre of Corfu life. The environs are mostly covered with olive groves. The interior of the island offers a fine field for excursions and sports. Naples has been called the El Dorado of Hypochondriacs, and Corfu may claim the same honor. The drinking-water and the means of communication are excellent."

The class of cases sent to Corfu comprises many morbid states, and many tourists of the semi-invalid class spend more or less time there. Scrofula, chloro-anæmia, neurasthenia, protracted convalescence after severe ill-

ness, catarrhal affections of the upper air-passages, dyspepsia, gout, and incipient phthisis are all said to be benefited by a winter residence on this pretty island. There are fair hotel accommodations at moderate prices, postal and telegraph facilities, an English church, etc. The Hotel St. George is one of the principal establishments. *Edmund C. Wendt.*

CRANIAL AND SPINAL NERVES. The account of the development of the cranial and spinal nerves given in a previous volume of the HANDBOOK must now be considerably enlarged by reason of recent discoveries.

It is well known that the first trace of the nervous system is the formation, in the middle of the blastodermic area, of a longitudinal band of cells called the medullary plate; and that this plate, by the inversion of its edges caused by cell proliferation, is converted first into a groove, the medullary or neural groove, and afterward into a canal, the neural canal.

The epithelium forming the inner wall of the tube is, of course, derived from the ectoderm. Its cells show, even at an early stage when composed of but a single layer, a differentiation into two kinds that differ in shape, function, and subsequent history. One form, the spongioblast of His, is columnar, with oval nuclei, is passive in character, and constitutes the sustentacular portion of the tissue; the other, the germ-cell of His, is round, with a large nucleus which usually has karyokinetic figures indicating rapid proliferation, and is evidently more active in character. (See Fig. 123.)

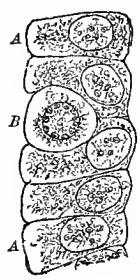


FIG. 123. — Ectoderm from the Medullary Plato of the Rabbit. *A, A*, supporting epithelial cells or spongioblasts; *B*, germ-cell. After His.

The cell-body of the spongioblast soon differentiates into two distinct substances, a clear, hyaloplasmic, non-stainable portion, probably of fluid consistency, and a dark, metaplasmic portion that is readily stained and becomes arranged in a reticular manner. This latter at first extends throughout the entire cell-body, but finally disappears at one end, and a columnar process is formed by the apposition of the walls of two contiguous cells, while at the other the basket-like reticulum remains. (See Fig. 124, *A*.)

At the ends of the columns the original boundaries of the cell remain defined by a ring of metaplasm, and a section parallel to the surface shows a flat sheet of lace-like net-work. (See Fig. 124, *B*.) Sooner or later the hyaloplasmic material disappears, leaving the nuclei with the columns stretching toward the free inner or ventricular surface of the medullary canal and the basket-work forming the external boundary of the original plate. (See Fig. 124, *C*.) This external boundary or reticulum becomes important, as it limits the migration of the active elements hereafter to be described. It is accordingly called by His the "border veil," for which Hill has proposed the equivalent term, *velum confine*.

By means of this arrangement of the spongioblasts there is laid down a trabecular framework with the trabeculæ disposed radially about the ventricular cavity of the neural tube. The system is termed the myelospongium, and is afterward developed into the neuroglia, which is, therefore, a purely ectodermic tissue correlative with the other nerve-elements, and not, as was formerly supposed, a mesodermic or true connective tissue. At an early stage the trabeculæ appear to anastomose. (See Fig. 125.) This is due to the adherence of the metaplasmic walls of contiguous cells.

Origin of Nerve-cells and Nerve-fibres.—Even when

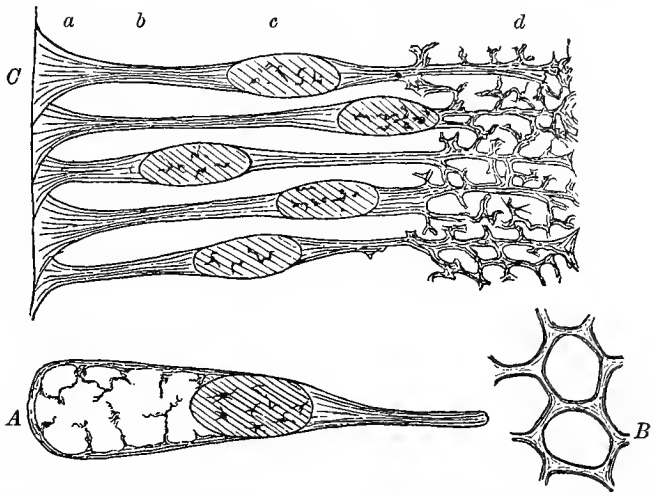


FIG. 124.—Details of the Spongioblasts. *A*, spongioblast in which the reticulum is forming at one end while the other has become columnar. *B*, arrangement of the inner ends of the spongioblasts to form the membrana limitans. Surface view. *C*, radial arrangement of the spongioblasts; *a*, membrana limitans; *b*, columnar layer; *c*, nuclear layer; *d*, velum confine. After His.

the epithelium of the medullary plate is constituted by only a single layer, there are found here and there among the columnar cells the round-celled elements which have already been referred to as germ-cells. They occur in varying numbers, sometimes diffused at considerable intervals, sometimes quite closely packed. In the region of the neck they develop earlier than elsewhere. It is not yet known whether they develop from the spongioblasts, or exactly by what steps both are derived from the common, embryonic, ectodermal cells. They are found at first

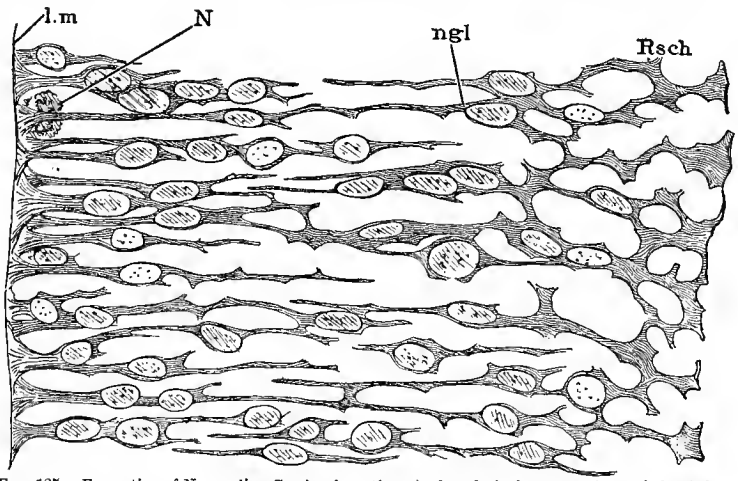


FIG. 125.—Formation of Neuroglia. Section from the spinal cord of a human embryo of about three and a half weeks. *l.m*, membrana limitans; *N*, germ-cell; *ngl*, neuroglia cells; *Rsch*, velum confine. After His.

in the so-called germinal area of the medullary tube, that is to say, quite near the ventricle or lumen of the tube, between the rod-like processes of the spongioblasts (see Fig. 126, *G*), or in rare cases extruding through the meshes of the membrana limitans and projecting into the ventricle.

Soon these cells begin to grow. At first spherical, they

become pointed and then pear-shaped, lengthening out into a conical process. They are then called *neuroblasts*, as they are the primitive nerve-cells, and the process is the beginning of a nerve-fibre. (See Fig. 126, *N*.) At this period they are evidently movable, as they migrate from the situation where first found, near the membrana limitans, and pass outward, following the radial interspaces of the spongioplasm, to become collected near the velum confine in a sheet, known as the mantle layer, which becomes the foundation of the gray matter of the cord. The

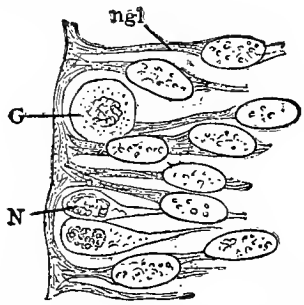


Fig. 126.—Development of Neuroblasts. From a section of the medulla oblongata of a human embryo. *G*, germ-cell; *N*, neuroblast; *ngl*, neuroglia cell. After His.

processes have now become striated and extend for a considerable distance peripherally. (See Fig. 127, *f*, *f'*.)

At the end of each growing process a slight enlargement occurs, and upon this there may be seen minute elevations or papillæ. The enlargement is called by Ramón y Cajal the cone of growth. The direction which these primitive fibres take differs somewhat in different regions of the cord. In the dorsal half the nerve processes turn so as to run vertically along the velum confine and parallel to the surface; in the ventral half they proceed directly outward, pierce the velum confine in compact bundles, and become the anterior or ventral roots of the spinal nerves. (See Fig. 128.)

The rounded head of the neuroblast usually undergoes

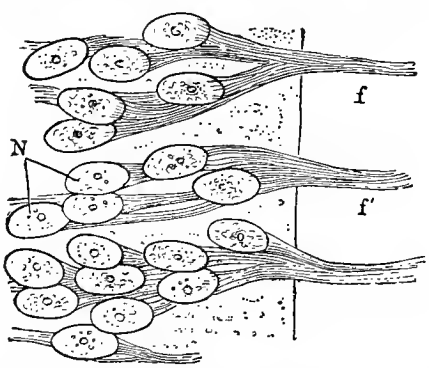


Fig. 127.—Neuroblasts forming Nerve-roots. Section from the spinal cord of an embryo cat. *N*, neuroblasts; *f*, *f'*, their processes combining in bundles to form the anterior roots of the spinal nerves. After His.

a further modification. Around its circumference small buds begin to appear which push outward in the same manner as the primitive process did, and develop into the so-called protoplasmic or dendritic processes of the nerve-cells. These are seen therefore to be of precisely the same character as the others, only differing in the time of their development. Lenhossék has shown, by observations upon the earthworm (Lumbricus), that there is originally no morphological difference between these processes. All the processes are dendritic in this animal, one set passing out to communicate with the periphery, another to convey impulses to other cells.

The primitive process which, because it assists in the formation of nerves, is now called the nerve process (axis cylinder process of Deiters), may, as already stated, pass out to become a constituent element of the anterior or

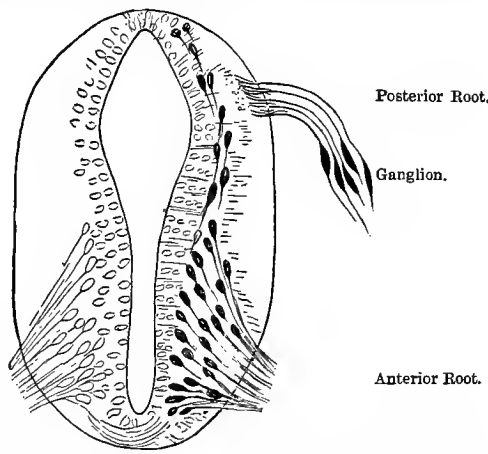


Fig. 128.—The Formation of the Nerve-roots. Section through the spinal cord of a human embryo. The condition of the anterior root corresponds to the development at the fourth week, that of the posterior to about four and a half weeks. Combined by Edinger from representations by His.

motor root of the spinal nerves. It passes to the periphery and there becomes associated with the muscular elements. Afterward the process becomes provided with a medullary sheath derived from the connective tissue of the mesoblast, the process itself being the axis cylinder of the nerve-fibre. Thus we see that we must no longer consider the fibres of the nervous system as elements distinct from the cells with which they are connected, but rather as integral parts of such cells. In the adult human body the cells of the anterior horn of the spinal cord send prolongations to the extremities of the

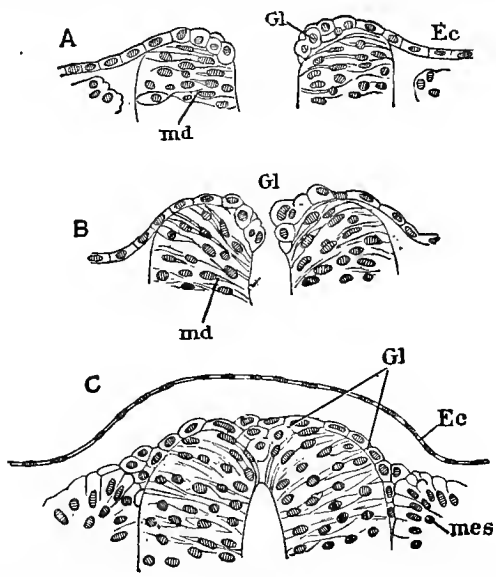


Fig. 129.—The Formation of the Neural Crest. Sections through the cervical region of a human embryo of 14 to 16 days. *Ec*, ectoderm; *mes*, mesoderm; *Gl*, beginning of the spinal ganglion, first known as the neural crest; *md*, medullary plate. After Lenhossék.

limbs. The growth of the nerve-process is at first quite rapid, but afterward decreases.

It seems at first difficult to understand how these processes can pass from the spinal cord and traverse so unerringly such a vast extent of the body (comparatively

speaking), and arrive at their destination in the group of muscle-cells to which they belong. Yet it should be remembered that the distance traversed is, at the stage of embryonic life at which this growth occurs, but a few centimetres at most; and further, it is noticed that the neuroblasts have a tendency to unite together in groups, sending out their processes together as a single bundle (see Fig. 127) which appears to be directed to a corresponding bundle of muscle-fibres, so that an exact adjustment of each neuroblast to a special myoblast does not appear to be necessary, the adjustment taking place rather between the grosser elements formed by the separate groups. It is not impossible that in this group-like arrangement of the primitive elements there may yet be found the key to a true morphological arrangement and classification of the muscles.

It will be noted that the foregoing account relates only to the origin of the anterior roots. The development of the posterior roots is no less instructive.

In Fig. 129 there are shown sections across the medul-

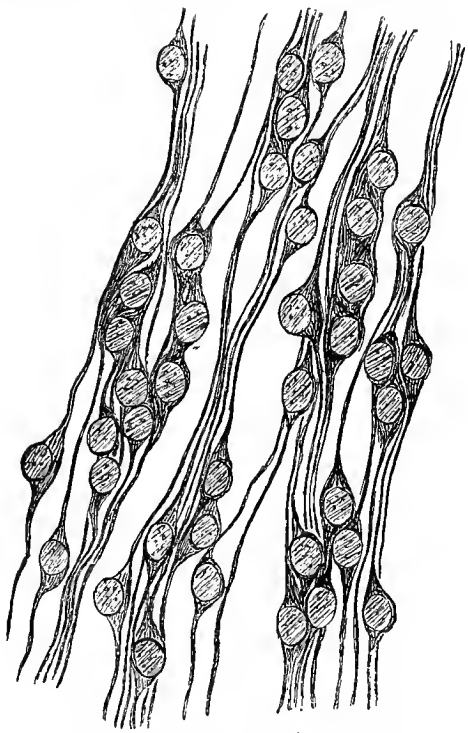


Fig. 130.—Gangliobiasts. Group of cells from the spinal ganglion of a human embryo. After His.

lary groove taken at different nerve-levels. At *A* the groove is widely open, the ectoderm exterior to it is seen as a thin layer which becomes thicker by the addition of some spherical cells, *Gl*, just at the edge of the groove. At *B* we see the groove nearly closed, and at *C* the closure completed. The spherical cells have united on the middle line to form a longitudinal band known as the neural crest. This at first occupies a median position and shares the segmentation which, though but slightly shown in the cord, is well marked in all accessories belonging to the nerves. It then becomes displaced on either side to form the ganglia situated on the posterior roots of the spinal nerves. It will thus be seen that the spinal ganglia are not, as they seem, integral parts of the nerves exterior to the cord, but detached portions of the original medullary plate, and should be regarded as displaced segments of the spinal cord. Therefore their cellular elements may well be of the same general nature.

This is found to be actually the case. The rounded cells of the neural crest assume a spindle shape before they become detached from the medullary canal. They are then termed gangliobiasts (Lenhossék). The ends of the spindle finally lengthen out into processes running in opposite directions, and a bipolar cell results. (See Fig. 130, also *A* of Fig. 132.)

In these cells the oval nucleus is placed to one side, so that the fibres run directly through opposite to each

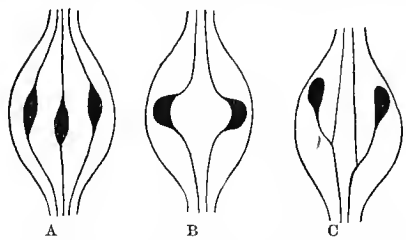


Fig. 131.—The Stages of Unipolarization of Ganglion Cells. (Lenhossék.) *A*, oppositipolar cells; *B*, geminipolar cells; *C*, unipolar cells.

other. The cells have accordingly been termed *oppositipolar* (Courvoisier). They resemble greatly at this stage the cells found in the ganglia of most adult fishes. The condition remains permanent in man only upon the ganglia connected with the auditory nerve, viz., the ganglion of Scarpa, found upon the vestibular nerve within the internal auditory meatus, near its origin from the auditory, and the ganglion spirale, found upon the cochlear nerve within the walls of the cochlea. In other situations the processes change their relations to the cell-body, for the axis of the ganglion being more and more invaded by nerve-fibres, the cells are pushed to the sides and the processes are so displaced as to be given off close together from one side of the cell, which is then called *geminipolar*. Finally the processes unite to form a single one, and the cell is then *unipolar*, the cell-body standing at some distance from an apparently continuous fibre attached as by a pedicle. The stages of the process are shown in the annexed diagram, Fig. 131.

It seems unlikely that this modification in the arrangement of the processes of the cell should make any material difference in its functions. The evidence that we have in regard to the functions of cells shows that the principal seat of activity is in the central protoplasmic mass, and especially in the nucleus of that mass. It seems, therefore, almost certain that the influences received from the periphery must travel up to the body of a unipolar cell, and thence out again toward the cord.

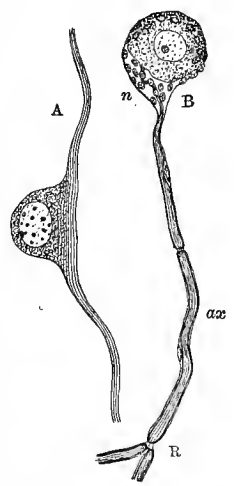


Fig. 132.—Cells from Spinal Ganglion. A. from human embryo of four and a half weeks; B, from an adult rabbit; *ax*, axis cylinder; *n*, nuclei of the medullary sheath; R, node of Ranvier. After His and Schiefferdecker.

The appearance of the adult ganglion-cell is shown in Fig. 132, B, where it is contrasted with the earlier form. The bifurcating fibres characteristic of these cells are known as the T fibres of Ranvier.

From a morphological point of view gangliobiasts may be regarded as cells of special sense, formerly situated at the periphery of the body, and now withdrawn to the edges of the medullary plate. In invertebrate animals, as, for example, in lumbricus (Lenhossék), such cells exist at the periphery and receive impulses like other sensory cells upon special collecting processes situated immediately under the epidermis. These impulses they transmit to the central nervous system by means of a

fibre. Such cells agree in general form with those of the anterior horn of the spinal cord, the collecting processes of the one corresponding to the dendritic processes of the other. When the cells are withdrawn to a more central situation, the connection with the collecting processes is made by a lengthened, secondary fibre, which becomes the peripheral pole of a bipolar cell. Other matters connected with the development of the ganglia of the cranial nerves tend to show that the ganglia may properly be considered as sense organs that have been withdrawn from the surface.

Thus it is found that both the anterior and posterior nerve-roots are formed of processes of cells situated, for the anterior roots, within the gray matter of the spinal cord, for the posterior roots, within the spinal ganglia.

This discovery is due almost entirely to the researches of His. It strikingly confirms the results obtained by section of the nerve-roots. It is well known that if the anterior root is cut the nerve-fibres degenerate from the section toward the periphery of the body, and that if the posterior root is cut between the ganglion and the cord the fibres do not degenerate, while if cut beyond the ganglion the fibres affected are speedily destroyed. (See Fig. 133.)

This was formerly ascribed to a supposed "trophic influence" which was thought to reside in the anterior horn of the spinal cord for the anterior roots, and in the spinal ganglion for the posterior roots. Since it is recognized that we are merely cutting off cell-processes, the results become intelligible.

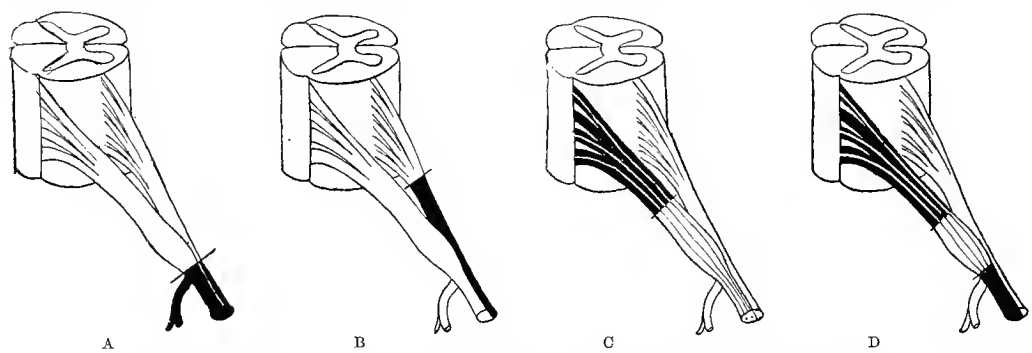


FIG. 133.—Degeneration of Nerve-fibres after Section. A, section of entire trunk beyond ganglion; B, section of anterior root; C, section of posterior root (a few fibres are shown as degenerating beyond the section); D, excision of ganglion.

Central Connections of Cells and Fibres.—The investigation of the central organs has long been singularly unsatisfactory from an anatomical point of view. The ganglion-cells in the spinal cord were first discovered by Ehrenberg in 1833, and described by Valentin in 1836. Those in the brain were discovered by Purkinje in 1838. In the same year Remak noticed that some processes of cells in the sympathetic nervous system appeared to be continuous with medullated nerve-fibres. Kölliker first noticed that such fibres arise from the unipolar cells of spinal ganglia. That these cells are usually bipolar in fishes was noticed in 1847 by several observers, independently, viz., Bidder and Reichert, Charles Robin, and R. Wagner. In 1851 Wagner, in examining the electrical organ of the torpedo, noticed that but one, or at most two, of the processes of the nerve-cells were connected with nerve-fibres. This was verified by Remak in the spinal cord of the ox in 1854. Special attention to these facts was, however, first drawn by Deiters in 1865, who noted that the greater number of the processes of the nerve-cells are short and break up immediately into fine arborescent forms that he called "protoplasmic" processes, but that among the others there was frequently found one that appeared to run without division. This he assumed to be continuous with the axis cylinder of a nerve-fibre, and therefore called it the axis-cylinder process. Recent discoveries have made it advisable to change these names. The first class are now known as dendritic processes, the second as nerve-processes.

Gerlach, in his excellent article on the spinal cord, published in Stricker's "Handbook of Histology" (1871–72), attempted to show that all cells are not provided with nerve-processes, that those so characterized are typically represented in the anterior horn of the spinal cord, and are probably motor, as they appear to be connected with the motor roots of the nerves, that the cells not so characterized are found in large numbers in the posterior horn of the spinal cord, and that their dendritic processes are united together to form a fine reticulum with which he believed the posterior roots to connect. This, therefore, was characteristic of the sensory nerves. Gerlach's views have prevailed until quite recent times, his "reticular formation" being mentioned as an anatomical fact in text-books now in general use, as for instance, Macalister's "Human Anatomy," 1889, and in Obersteiner's "Anatomy of the Central Nervous Organs," translated by Hill, 1890.

It is not at all surprising that those views should be held when the technical methods in use are considered. Every advance in histology has been heralded by some improvement in microscopic or in technical manipulation, and it is not always realized that our knowledge of minute anatomy is so recent. Schwann's researches on cells were not published until 1839, it was not until 1842 that Stilling invented the method of cutting thin sections in series, Gerlach first stained tissues in 1858. The wide extension of this method is now well known.

The preparations by which Gerlach sustained his views were prepared with the greatest care and are marvels of patient skill. He admitted, however, that he had never been able to trace a nerve-process into a nerve-fibre, nor had he actually demonstrated the connection of nerve-fibres with the plexus of dendritic processes. The connections of the fibres rested therefore upon hypothesis rather than upon any actual anatomical demonstration. The special obstacle in the way of progress was the great complexity of the interlacing fibres and processes that made it absolutely impossible to follow the connections of the cells for any distance. It seemed of no use to further pursue the subject by this method.

This being the case, attempts were made to obtain further knowledge of the connections of the cells by their behavior under pathological and embryological conditions. Waller, in 1852, discovered that when a nerve was cut its peripheral end degenerated. It was soon surmised that this same law governed certain degenerations found in lesions of the spinal cord and other portions of the central nervous system; and since the researches of His it is definitely known that degeneration occurs along the entire course of a nerve-fibre when it is severed from the cell from which it originally grew. Ample illustration of this is shown in Fig. 133. Since degenerated fibres can be readily distinguished in serial sections, it became possible to investigate the course of fibres or groups of

fibres by means of experimental lesions made in different portions of the spinal cord.

By observing degenerations, whether artificially produced or the result of pathological processes, it was soon found that the central connections of the cranial and spinal nerves were not arbitrarily arranged, but that they followed a certain definite plan. A knowledge of this was often assisted by the study of malformations in which special tracts of the central nervous system were found to be wanting.

Another discovery also greatly aided investigation. In the early embryo the only nerve-fibres found are those of the non-medullated variety, the myelin being afterward added. Flechsig (1872–76) found that this process of myelination does not occur at the same time in all parts of the nervous system, but seems to follow certain definite laws. Certain of the tracts already made out by the study of degenerations were found to myelinate at a different period from others, and thus their connections could be made out, confirming and amplifying the data already obtained.

It would be beyond the scope of this article to give a complete account of the researches made under these different heads. It will be necessary, however, to give a short summary of the principal results obtained with regard to the central connections of the cranial and spinal nerves at the date of the publication of the HANDBOOK in order to make intelligible the recent discoveries. (See Fig. 134.)

In the gray matter of the cord certain rather ill-defined clusters of cells were made out which were thought to have certain definite relations to the nerve-roots. The anterior or motor root was composed of fibres arising from cells in the anterior and lateral horns. Those in the anterior horns are in three groups, described by Waldeyer as the antero-medial, antero-lateral, and postero-medial. The large cells of the lateral horn are considered by themselves and termed by Waldeyer the postero-lateral group. The postero-medial group was believed not to send fibres to the root of the same side, but to communicate through the anterior gray commissure with the anterior root of the opposite side.

The fibres of the posterior root were not considered to be connected with cells, but rather with the plexus of Gerlach. An exception was made, however, with regard to certain cells found in the column of Clarke, each of which was believed to have two processes, by one of which it was connected with the fibres of the posterior column. It was, however, acknowledged that many of the fibres of the posterior root did not enter the plexus at all: some turned inward and upward passing toward the brain, first in the column of Burdach, then in the column of Goll; others passed into the lateral column where their subsequent course was unknown.

The idea generally prevailed that the transmission of nervous impulses could only be explained by assuming a continuity of structure. The fibres and the cells must be continuous with other fibres and cells in order to produce the so-called nerve-paths by which these impulses travelled. Thus the ordinary reflex acts which physiologists found to occur within the spinal cord were believed to be produced by the transmission of sensations through the posterior roots to the plexus of Gerlach, from which they were transferred either to a motor cell or to nerve-fibres formed by the union of the fibrillæ of the plexus. The act was thus made clear and intelligible. It did not, however, rest upon any actual demonstration.

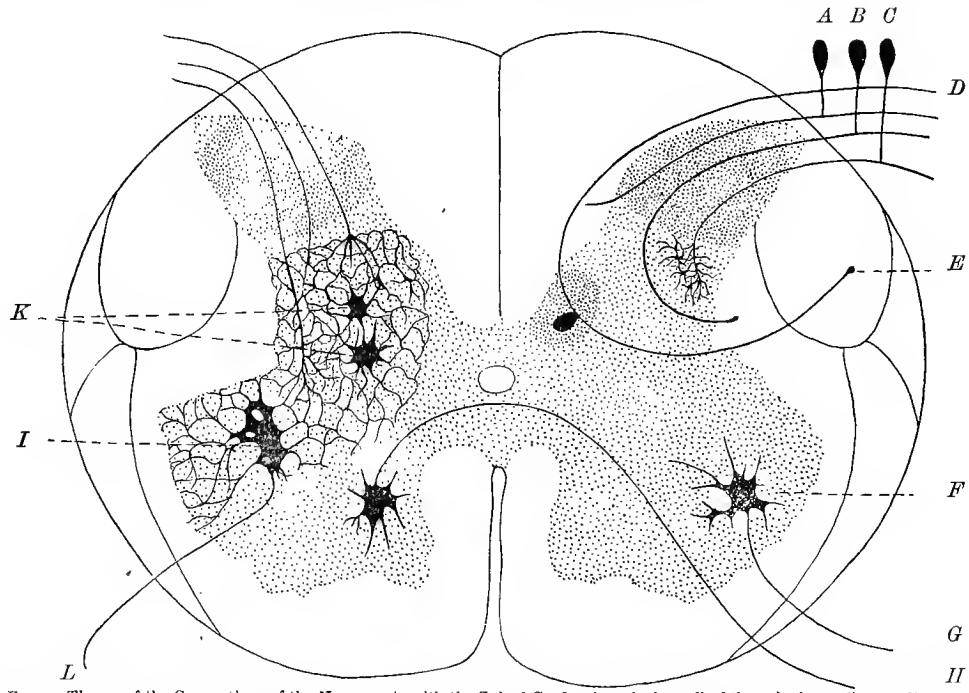


FIG. 134.—Former Theory of the Connections of the Nerve-roots with the Spinal Cord. A, unipolar cell of the spinal ganglion sending process to the column of Burdach; B, same sending process to lateral column; C, same ending in Gerlach's plexus of the posterior horn; D, fibre of posterior root passing to a bipolar cell in the column of Clarke; E, the other process of the same cell passing to the cerebellar lateral tract; F, large motor cell of the anterior horn ending in a nerve-process G, that passes into the anterior root; H, nerve-process from a cell of the anterior horn of the other side of the cord that passes through the anterior gray commissure; I, K, cells that form the plexus of Gerlach by anastomoses of their dendritic processes; L, nerve-process from one of these cells passing to the anterior root.

A short notice should be given to the views which have been advanced by Gaskell upon the nature of cranial and spinal nerves.

On section of a nerve stained with osmic acid, it is noticed that the fibres involved are by no means all of the same calibre, or provided with the same thickness of medullary sheath. Nerves that supply the voluntary muscles appear to have a large proportion of large, dark-bordered fibres, while those supplying involuntary muscles and viscera have a great majority of small, fine me-

dullated, or so-called "leucenteric" fibres. (See Fig. 135.)

Gaskell showed that these leucenteric fibres pass out of the spinal cord at certain definite levels, corresponding to

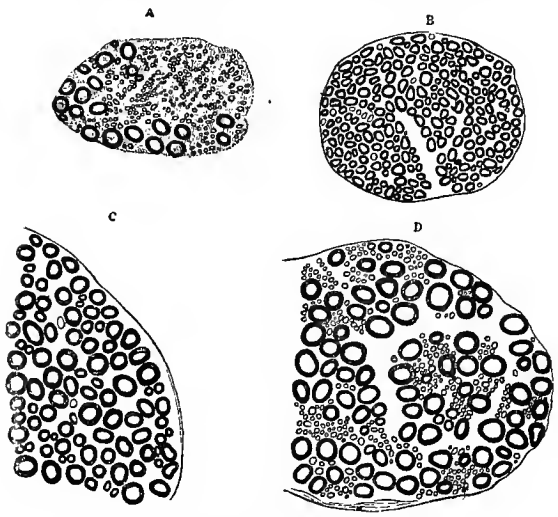


FIG. 135. — Sections across Parts of the Roots of Various Nerves of the Dog, to show the Variations in Size of their Constituent Fibres (Gaskell). The nerves were stained with osmic acid and the sections are all drawn to one scale. *A*, from one of the upper roots of the spinal accessory; *B*, a rootlet of the hypoglossal; *C*, from the first cervical anterior root; *D*, from the second thoracic anterior root.

the exit of the fibres going to the splanchnic nerves and other trunks of the sympathetic nervous system. He thus divided the nerve-fibres into two classes, the *somatic*, supplying the somatopleuric portion of the mesoderm, and the *splanchnic*, supplying the splanchnopleuric portion. These he again separates into efferent and afferent subdivisions.

He also assigned to certain definite cell-groups in the spinal cord the function of presiding over these separate nerve-fibres. The somatic efferent nerves he connected with the large cells of the anterior horn; the splanchnic efferent with those of Clarke's column; the cells of the lateral horn with the solitary cells at the base of the posterior horn.

No special groups for cells are assigned to the efferent nerves.

He considers that in the system of cranial nerves certain of these groups have a tendency to break up and form special nerve-strands. His application of the theory will be seen on examining Figs. 137 and 138.

To an Italian anatomist, Camillo Golgi, of Pavia, is due the discovery of methods of staining nerve-fibres which has led to most important practical advances in our knowledge. This is essentially an impregnation of the tissue with either a chromic salt or bichloride of mercury, and then placing it in a silver solution. After suitable maceration in this it is found that a fine deposit occurs along every nerve-fibril, distinctly marking it out. This deposit is probably a chromate or chloride of silver precipitated in exceedingly delicate crystals. The preparation of material by this method is by no means easy. It must be perfectly fresh; the solution must be of a certain definite strength; the exposure is long, weeks and even months being required for some results, and certain precautions in handling and keeping are absolutely necessary. The section must be mounted in Canada balsam without a cover glass.

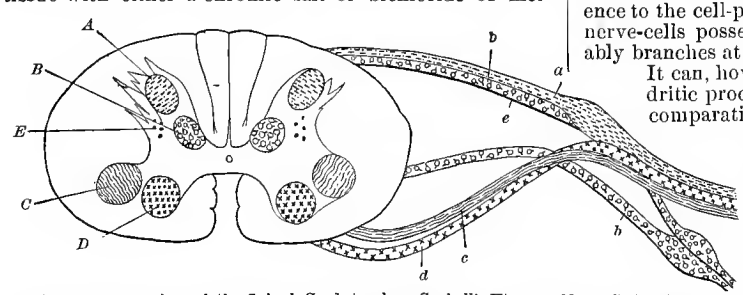


FIG. 136.—Cross-section of the Spinal Cord, to show Gaskell's Views. (Hans Gadow.) *A*, cells of posterior horn; *B*, cells of Clarke's column; *C*, cells of the lateral horn; *D*, cells of anterior horn; *E*, solitary cells at base of posterior horn; *a*, somatic afferent fibres; *b*, splanchnic ganglionated efferent fibres; c, splanchnic non-ganglionated efferent fibres for visceral and enteric muscles; *d*, somatic efferent fibres; *e*, splanchnic afferent fibres.

The results obtained are truly astonishing. For the first time every detail of the cell-processes is clearly made out, marked with the precision of a line of black upon a white page. It is no longer necessary to deal with nerve-cells that have been mutilated and displaced from their natural connections by teasing, their processes appearing

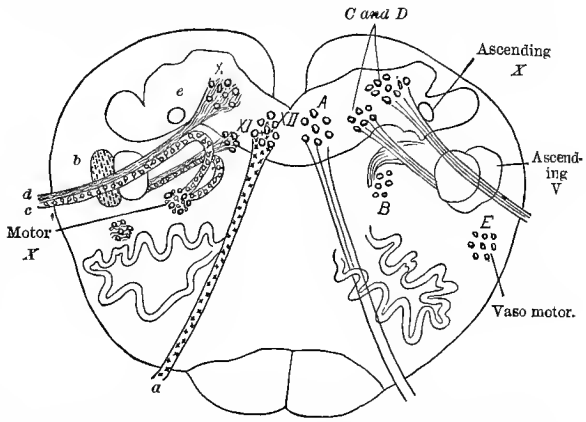


FIG. 137.—Schematic Cross-section of the Medulla Oblongata. (Gaskell.) *A*, cells corresponding to those of anterior horn; *B*, cells corresponding to those of lateral group of anterior horn; *C*, cells corresponding to Clarke's column; *D*, cells corresponding to the solitary cells at base of posterior horn; *E*, cells corresponding to those of lateral horn; *a*, somatic efferent fibres; *b*, somatic afferent fibres; *c*, splanchnic non-ganglionic efferent fibres; *d*, splanchnic ganglionated efferent fibres; *e*, splanchnic afferent fibres.

as bare stumps, and all fine details of structure swept away. Another advantage is that, for some reason not yet clearly understood, certain cells of the section stain sooner than others, so that by adjusting the time of maceration it is possible to obtain only a few cells stained at a time, and thus to follow out the complicated ramifications of a single cell without having it confused by the details of the other cells in its immediate neighborhood. By varying the procedure slightly it is possible to stain the neuroglia without affecting the other elements.

Golgi was at once able to settle definitely certain important matters. The connections of the nerve-roots became no longer matters of surmise and hypothesis, but reached the realm of actual ocular demonstration. He was able to show that the prevalent theory with reference to the cell-processes was incorrect. Not only do all nerve-cells possess a nerve-process—that process invariably branches at a greater or less distance from the cell. It can, however, be distinguished from the dendritic processes by its manner of branching and its comparatively simple course.

There exist two types of cells, distinguished by the behavior of their nerve-processes: First, those in which the nerve-processes preserve their integrity for a considerable distance, always giving off, however, some collaterals, passing finally into a nerve-fibre and breaking up at its termination; 2d, those in which the nerve-process after a short course divides and subdivides within the gray substance of the nervous centres, form-

ing thus the plexiform arrangement described by Gerlach. The nerve-processes of these cells never contribute to the formation of nerve-fibres. (See Fig. 139.)

Golgi was not able to fully disembarrass himself of the old ideas with regard to the anatomy of the nerve-centres. As the cells with long nerve-processes are found mostly within the anterior horn of the cord, he concluded that they must necessarily be motor cells. He also assumed that the great part of the cells of the second type, that is to say, those with short nerve-processes, were to be found in the posterior horn, and must therefore be considered as sensory cells. In fact, his view differed but very slightly from that of Gerlach, as will be seen by contrasting the two diagrams in Fig. 140. The difference was merely one which affected the processes by whose ramification the plexus was made up. While Gerlach assigned this *rôle* to the dendritic processes, Golgi considered that it was effected by the collateral branches of the nerve-processes, and that reflex phenomena take place through this plexus in essentially the same way as imagined by Gerlach, and that by its connections with other nerve-roots different levels of the cord are excited and associated for co-ordinate movements.

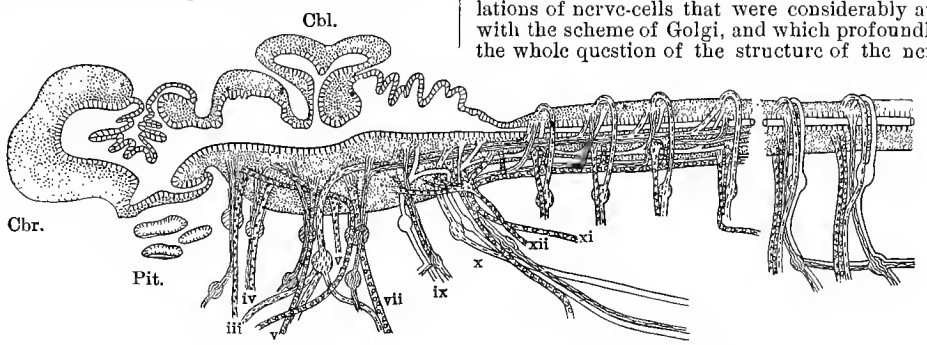


FIG. 138.—Diagram of the Arrangement of the Cranial Nerves. (Gaskell.)

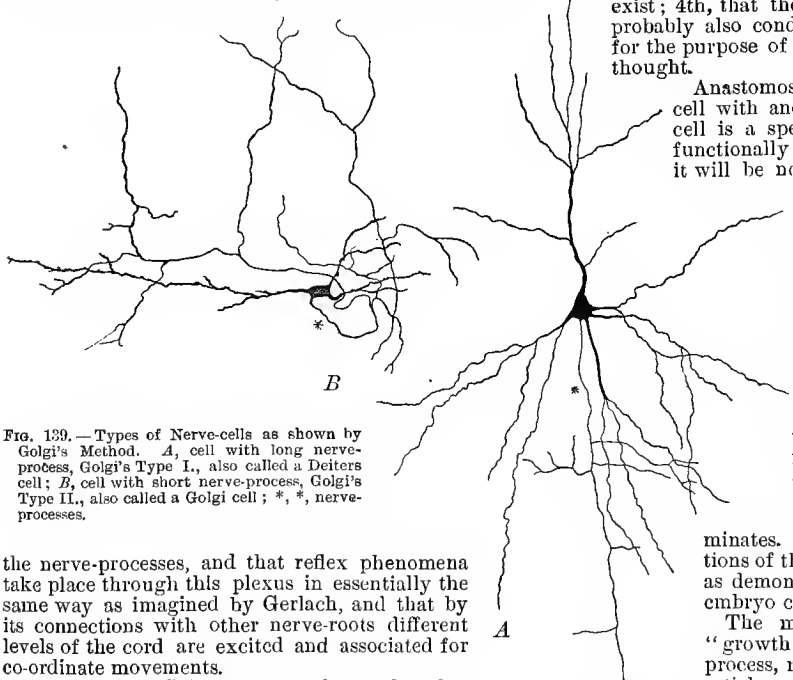


FIG. 139.—Types of Nerve-cells as shown by Golgi's Method. *A*, cell with long nerve-process, Golgi's Type I., also called a Deiters cell; *B*, cell with short nerve-process, Golgi's Type II., also called a Golgi cell; *, *, nerve-processes.

The method of Golgi was soon taken up by other histologists and applied to a wide range of research. It has been especially fruitful in the hands of the well-known Spanish investigator, Dr. Santiago Ramón y Cajal, Professor in the University of Barcelona. Great advantage is obtained by applying it to embryonic tissues, as the field is much smaller and the elements fewer, so that it is possible to bring an area corresponding to a considerable extent of the adult tissues within the limits of a single specimen. Then, too, it is found that the embryonic tissues are particularly susceptible to this method of investigation.

In studying by the new method the cerebellum of the embryo of birds and mammals, Ramón y Cajal arrived at certain conclusions with reference to the nature and relations of nerve-cells that were considerably at variance with the scheme of Golgi, and which profoundly affected the whole question of the structure of the nervous system. Continuing his observations to the investigation of the spinal cord, he was able to show, first, that the nerve-cells are entirely independent, and never anastomose either by their dendritic or by their nerve-processes; 2d, that every nerve-process, whether long or short, ends either simply or by ramifications which may either be within the motorial end-plate of a muscle-fibre, as in the cells of Golgi's type I., or in protoplasmic expansions in contact with the body or processes of other cells; 3d, that these latter establish by contact alone communications as effectual for the transmission of impulses as the continuity of structure formerly supposed to exist; 4th, that the dendritic processes of cells are probably also conducting elements, and not merely for the purpose of imbibing nutriment, as heretofore thought.

Anastomosis of the processes of one nerve-cell with another is absolutely denied. Each cell is a special structural unit that remains functionally and anatomically distinct. This, it will be noted, agrees entirely with the embryological evidence produced by His; for each cell, with its dendritic and nerve-processes extending perhaps a distance of several feet, is the result of the growth of a single neuroblast. Waldeyer has given to each of the units so formed the name of *neuron*. The entire nervous system is a combination of neurons, independent in structure, and combined for functional purposes by the juxtaposition of their processes. Each neuron may be considered as composed of three portions: the cell-body, the nerve-fibre, and the fibrillary arborescence in which the fibre terminates. The appearance of the connections of the nerve-roots with the spinal cord, as demonstrated by Golgi's method in the embryo chick, is shown in Fig. 141.

The minute elevations noted on the "growth cone" at the end of each growing process, referred to in the first part of this article, are apparently the budding terminal fibrillæ of the fully developed neuron. The power of peripheral extension appears by no means to be confined to fœtal life. It is probably by such extension, from already existing cells and fibres, that nerves are renewed after section. There appears indeed to be a general tendency for fibres to extend until arrested at the periphery. When cut, as in amputations, they still continue to grow, causing the well-known convoluted growths (traumatic

neuromata) found in stumps after healing, His suggests that it is by a similar extension of growth of fibres within the central organs that one portion of the brain is enabled to assume vicariously the functions ordinarily belonging to another part, after such part has been destroyed or become disabled. The growth of fibres is by no means

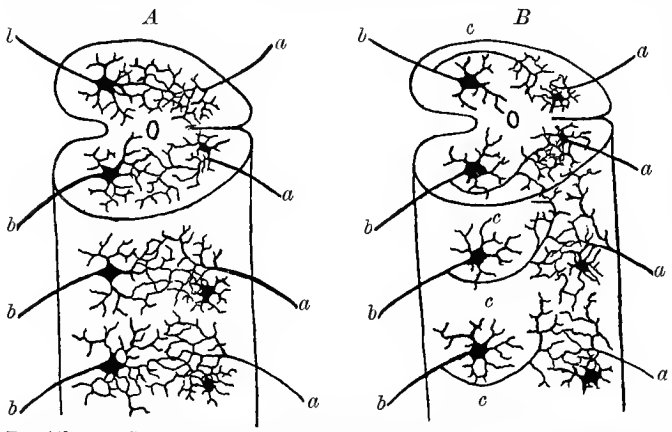


FIG. 140.—The Connection of the Nerve-roots in the Spinal Cord. (Van Gehuchten.) *A*, Gerlach's view; *B*, Golgi's view: *aa*, posterior roots; *bb*, anterior roots; *cc*, collaterals of the nerve-processes of the anterior roots.

rapid—weeks and even months being required for them to reach their ultimate destination.

The cells belonging to the spinal ganglia, in some cases, end peripherally without bifurcation, and become enveloped by special sheaths of connective tissue, as in the corpuscles of Pacini or of Krause; in others they divide into fibrillæ that end freely in the intercellular spaces.

What, now, are the central connections of the fibres derived from the posterior roots? Already, in 1885, Nansen had demonstrated that in *Myxine glutinosa*, one of the lowest fishes, those fibres bifurcate upon reaching the white substance of the cord. Golgi also had seen such

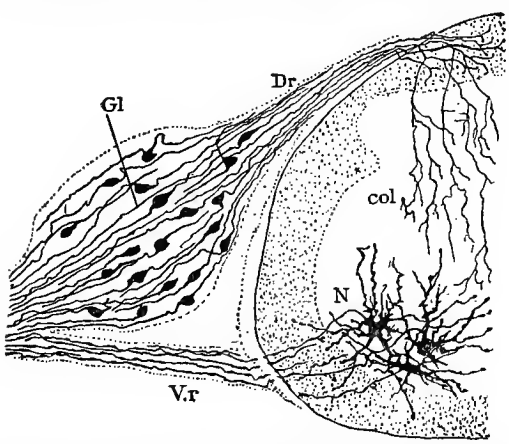


FIG. 141.—Transverse Section of the Spinal Cord of a Chick at the Ninth Day of Incubation. (Ramón y Cajal.) *V.r*, axis cylinders of anterior root-fibres issuing from the large cells of the anterior horn, *N*; *Dr*, posterior root-fibres passing from the bipolar ganglioblasts of the spinal ganglion, *Gl*, into the posterior column of the spinal cord, where they bifurcate and send collaterals that penetrate the gray matter.

bifurcations, as appears from publications made by him in 1881. These observations were, however, fragmentary and without special result. It was reserved for Ramón y Cajal to clearly unravel the central connections. His first publications were received with the same incredulity as those of his predecessors, and the text-books of Obersteiner, Edinger, and others, on the anatomy of the nervous centres, although published some time after his discoveries had been made, yet give no account of them. But in 1889, at the meeting of the Anatomical Society at Berlin, he exhibited specimens which convinced the most sceptical. The discoveries were immediately taken up and fully confirmed by von Kölliker, of Würzburg; Waldeyer, of Berlin; Lenhossék, of Basel; and van Gehuchten, of Louvain; all of whom have published important papers on the subject.

The fibres of the posterior root, according to these observers, are of two varieties, centripetal and centrifugal. The former, by far in the majority, do not enter the gray substance as undivided fibres, according to the prevalent view, but immediately bifurcate, Y-like, one limb ascending, another descending. These limbs run longitudinally in the posterior columns of the cord, which are almost wholly made up of these continuations of the posterior roots. (See Fig. 142.)

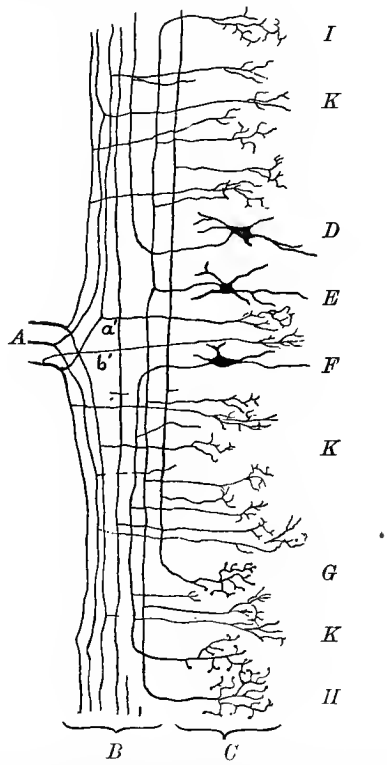


FIG. 142.—Entrance of the Posterior Roots of the Spinal Nerves. (Ramón y Cajal.) A semi-diagrammatic, longitudinal section of the posterior column of the cord, taken parallel to the entrance of the posterior nerve-roots. *A*, posterior root; *B*, white substance; *C*, gray substance; *D*, cell of the posterior horn whose nerve-process bends upward; *E*, cell with bifurcating nerve-process; *F*, cell whose nerve-process bends downward; *G*, *H*, and *I*, final ramifications of nerve-processes; *K*, *K*, *K*, final ramifications of collaterals; *a'*, collateral from the ascending branch of a nerve-fibre of the posterior root; *b'*, collateral from the main trunk of a fibre of the posterior root.

These latter fibres give off, at right angles to their course, delicate collateral branches (*a'*, Fig. 142) which penetrate the gray substance and terminate by free ramifications (*K*) that surround the nerve-cells. Collaterals may also be given off from the trunk-fibre before its division (*b'*). A slight thickening is observed at the point where these collaterals arise, and their origin is always, as in the division of the single pole of an adult ganglioblast (Fig. 132, *B*), at a node of Ranvier.

The ascending and descending limbs of the bifurcating fibre probably end by bending sharply at a right angle, taking a course like the collaterals, and breaking up in a similar manner. Their full extent has not been completely demonstrated. In the embryo the course of the fibres has been followed for a distance of several milli-

metres, and it has been estimated by Kölliker that this corresponds to a distance of from six to seven centimetres in the adult. From clinical and experimental evidence it is believed that they extend much further. It is known that after section of the posterior roots an ascending degeneration occurs, reaching as far as the medulla oblongata to the nuclei found in the columns of Goll and Burdach, or perhaps even higher. Also, that a certain amount of descending degeneration occurs, not extending, it would appear, for any very great distance.

As the fibres of each successive nerve-root divide, the ascending and descending limbs push those coming up from a lower level toward the middle line, so that their ascending course is slightly oblique rather than vertical, and at last they are displaced from the column of Burdach to the column of Goll. This accounts for the fact already noted by physiologists, that lesions of the latter column are usually found to be associated with the leg rather than the arm; and also explains the reason why that column is usually composed of finer fibres. Containing the terminals of the fibres that enter on much lower levels than those in the column of Burdach, they would naturally be smaller. The fibres of the column of Goll also acquire their myelin sheaths at a later date. (Flechsig.)

The course and ultimate distribution of the collaterals within the gray matter of the cord is, it will be seen, of considerable interest, as it may be expected

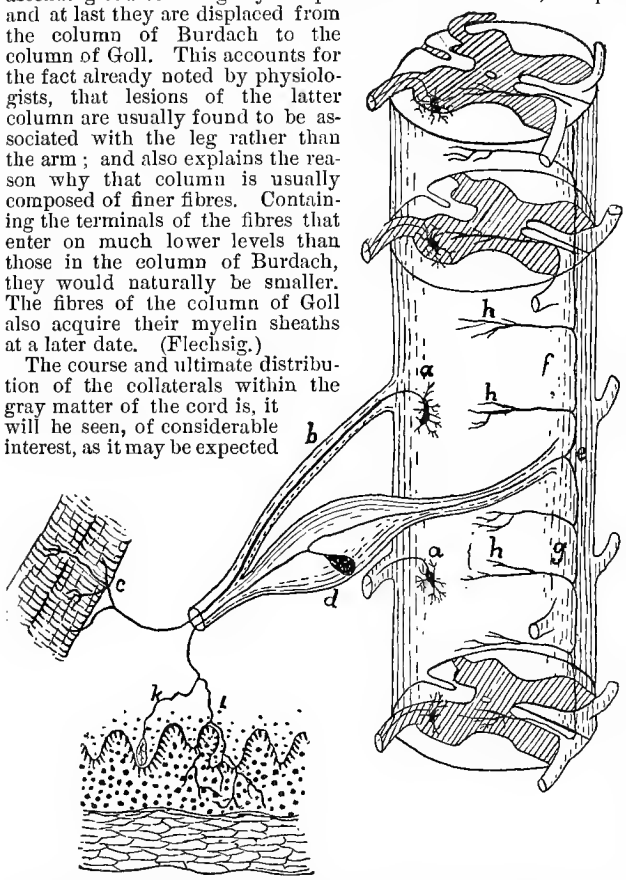


FIG. 143.—Scheme of Simple Reflex Action. (Lenhossék.) *A*, motor cell of anterior horn; *b*, its nerve-process extending through the anterior root; *c*, its termination by ramifications upon striped muscular fibres; *d*, a single ganglioblast situated in the ganglion of a posterior root and sending into the cord a centripetal fibre that bifurcates at *e* into an ascending limb, *f*, and a descending limb, *g*; *h*, *h*, collaterals that reach by their ramifications the motor cells of the anterior horn; *i*, the peripheral origin of the other process of the ganglioblast from ramifications ending free in the epidermis; *k*, from a Pacinian corpuscle.

to throw light upon the physiological processes in which the cord takes part. We may divide them into several categories, as follows:

I. A large number of the collaterals belonging to the posterior roots unite in a bundle which crosses the posterior horn and breaks up into terminals that ramify about the cells of the anterior horn. (Fig. 144, 1.) There is thus established the reflex-path imagined by Gerlach and Golgi (see Fig. 140), there being, however, this difference in the new conception, 1st, that the path is not made directly by the fibres of the posterior roots, but by their collaterals; 2d, that the terminals do not anastomose with the cell-processes of the anterior horn.

On consulting Fig. 143, it will be seen that sensations taken up from the skin by the nerve-filaments *i* and *k*, are conveyed to the ganglioblast at *d*, and thence to the cord, where by the bifurcation at *e* they may extend either upward or downward, and affect different levels supplied by the collaterals *h*, *h*, *h*, which in their turn communicate by contact with the motor cells *a*, *a*, that convey impulses through the anterior root, and by terminal ramifications to the muscle-fibre *c*. It will be noticed that but two neurons are involved in this act.

II. Another bundle of collaterals passes to the column of Clarke from the middle region of Burdach's column. The fact that such a path existed was already demonstrated by Flechsig ("Leitungsbahnen," Plate xviii., Fig. 123), as shown on Fig. 134, D. The fibres break up within the column, surrounding the cells with a rich net-work. The fibres are provided with a medullary sheath much farther than usual, and this is thought to be the reason why Clarke's column has such a markedly fibrous appearance when colored by hæmatoxylin (Lenhossék), and why it is one of the first areas to show degeneration in tabes.

III. A few collaterals pass from the fibres of the posterior root through the gray posterior commissure, to break up into tufts in the posterior horn of the opposite side, in front of the substantia gelatinosa of Rolando. (Fig. 144, 3.) Unilateral section of the cord, as is well known, abolishes tactile sensation on the opposite side below the lesion. The decussating fibres here described are, however, evidently insufficient to fully account for this phenomenon. These decussating fibres are much more marked in the dog, rabbit, and guinea-pig than in man.

IV. A great number of the collaterals from the fibres of the posterior root penetrate the posterior horn, passing through the substantia gelatinosa and breaking up in the gray matter immediately beyond. These are the fibres that have been hitherto noticed by anatomists streaming through the gelatinous substance in arcades like meridians of longitude on the surface of the globe. The terminal filaments are unusually fine and numerous, and being readily stained, produce the appearance which Waldeyer has called the nucleus of the posterior horn.

As to the elements of the posterior nerve-roots which have been spoken of as centrifugal, it is noticed that when the roots are cut a small number of fibres degenerate peripherally. (See Fig. 133.) These have no connection with the cells of the spinal ganglia. Lenhossék thinks that in the spinal cord of the chick, on the fifth day of incubation, he has been able to demonstrate that these fibres arise from cells in the anterior horn. Their function is unknown. If their existence in all vertebrates is ascertained, it will be a very interesting exception to the well-known law of Bell, by which the posterior roots are held to be exclusively centripetal.

It will be evident from this sketch of the behavior of the posterior roots, that an account of them will be incomplete without some notions of the cells of the cord with which they are anatomically related, and to which they probably transmit their impulses. Upon the right-hand side of Fig. 144, the principal groups of such cells are diagrammatically indicated.

Radicular Cells.—Those are the cells already referred to that send processes to the nerve-roots. (Fig. 144, *a*, *a*.) They are confined to the anterior and lateral portions of the anterior horn, and send their processes to the anterior root already adverted to. The passage of fibres from cells of one anterior horn to the anterior root of the opposite horn (Fig. 133, *h*) is positively denied by all recent observers.

Commissural Cells.—These are cells that send a nerve-process to the opposite side of the cord by the way of the anterior commissure. (Fig. 144, *c*, *d*.) Ramón y Cajal finds them distributed throughout the gray matter in all parts of the cord. Lenhossék describes a special group

of these cells on the medial side of the anterior horn, and these are the ones which were formerly supposed to send fibres to the anterior root of the opposite side. Commissural cells are usually smaller than the radicular cells, and their nerve-processes may spring either from the cell-body or from one of the dendritic trunks. The axis cylinder may (1) break up at its termination into the usual arborization; or (2) divide into two branches, one of which breaks up, the other proceeding to the adjacent white matter; or, (3) after bifurcating, both branches may pass to separate portions of the white matter. The branches proceeding to the white columns may either bend simply upward, or divide T-like, sending branches upward and downward. This affords an interesting anatomical explanation of the simultaneous ascending and descending degenerations sometimes found after lesions of the opposite side of the cord. Occasionally lateral branches may be seen given off from the nerve-process in its course.

It will be remembered that, in considering the distribution of the collaterals of the posterior nerve-roots, it was found that but a very small number penetrate to the opposite side of the cord, and that these were insufficient to explain the phenomena of crossed, tactile sensations. The discovery of the commissural cells makes the matter clear. They appear to constitute neurons of the second order, that serve to transmit to the opposite side of the cord impulses received from the periphery. It should also be noted in this connection that those fibres that ascend from the posterior roots in the columns of Goll and Burdach are interrupted, when they reach the medulla oblongata, by the nuclei found in those columns, and there transfer their impulses to neurons which decussate like the commissural cells of other levels of the cord. These nuclei then are in fact local collections of such commissural cells.

In a former volume of the HANDBOOK (VIII., p. 186) it was noted by Spitzka that it is probable that the lemniscus tract of the brain is composed of fibres that take up impulses from the nuclei of the posterior columns, and also communicate through the tegmental region with the cortex of the brain. After removing the parietal lobe of the cat, Monakow found that the lemniscus tract degenerated, and could be traced to the nucleus of Goll's column of the opposite side.

Column Cells (células de los cordones, Ramón y Cajal). —These pass from the gray substance into the surrounding columns of gray matter of the same side. (Fig. 144, *c*.) They are scattered without order in nearly all parts of the cord, but are especially abundant in the middle zone of the gray substance, that is to say, the region between the anterior and the posterior horns. They are usually of median or small size. They may either divide into ascending and descending branches, or simply turn up without division. Sometimes their nerve-processes divide within the gray matter and send two or even more divisions into the columns at a distance from each other, which divisions comport themselves like a single fibre (células multicordonales, Ramón y Cajal). Most of these cells send their processes to the anterior and lateral columns. These processes quite frequently show an increase of calibre during their course. Among the interesting cells of this class are those of the column of Clarke, whose processes pass outward and turn toward the brain in the cerebellar lateral tract. The existence of a path of this kind has been known since Gerlach and Flechsig, and it is sometimes called Flechsig's bundle. (See Fig. 134, *E*.) It has been hitherto supposed that the cells of the column of Clarke were many of them bipolar. (See Mott, Obersteiner, p. 182, and Fig. 107.) This is now shown to be an error. They are all multipolar cells with extremely rich dendritic processes. These are sometimes given off from two stems arising at opposite ends of the cell, and as the processes are for the most part torn away in the preparations ordinarily made, the cells then appear as bipolar.

The collaterals that were mentioned above as passing to the column of Clarke, surround these cells with an interlacing basket-work of processes. From clinical evidence it is believed that the impulses here conveyed are

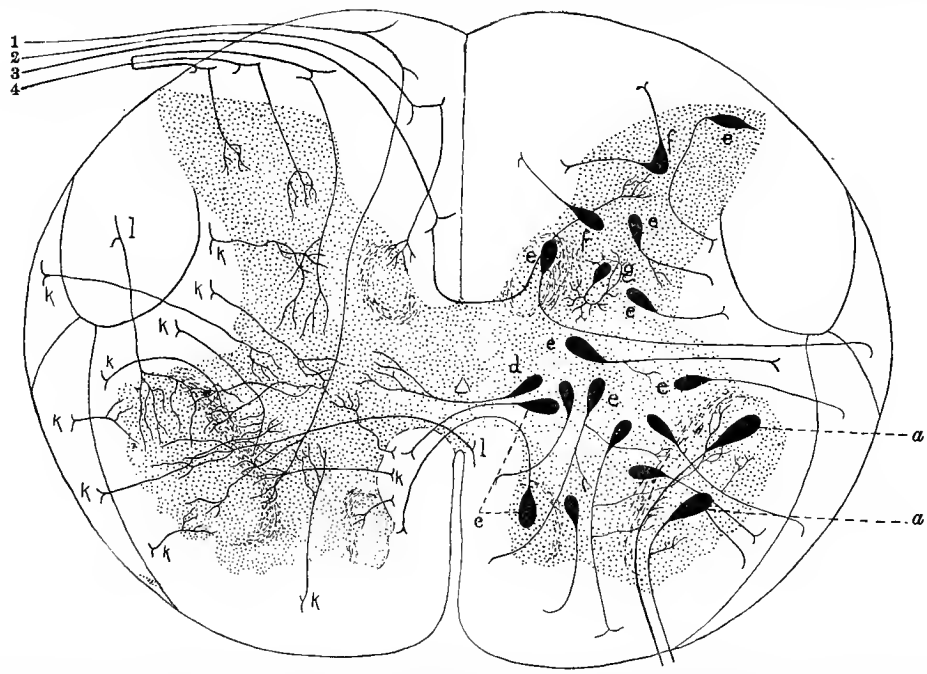


FIG. 144—Scheme of our Present Knowledge of the Relations of the Cells and Fibres of the Spinal Cord. (Lenhosšék.) The right side of the figure shows the cells of different classes found in the cord with their processes. The left side shows the processes of cells whose bodies are either beyond the cord or at other levels, with the distribution of their collaterals. *a, a*, Motor cells of anterior horn; *c*, commissural cells; *d*, Golgi commissural cell; *e, e*, columnar cells of antero-lateral column; *f, f*, columnar cells of posterior column; *g*, Golgi cell of posterior horn; 1, fibres of posterior root forming the antero-posterior reflex tract; 2, fibres passing to column of Clarke; 3, commissural fibres of posterior root; 4, fibres that enter the posterior horn; *k, k*, collaterals of antero-posterior column; *l, l*, collaterals from the pyramidal tracts.

not those that relate to tactile sensation, but rather those which concern co-ordination of movements. The cells constitute neurons of the second order, communicating with the cerebellum. It is well known that disorders of the cerebellum produce inco-ordination of movements, and also that when a sclerosis is set up about the cells of Clarke's column and the elements atrophy, as in tabes dorsalis, that inco-ordination is one of the prominent symptoms. There is no ground for the hypothesis advanced by Bechterew, that these cells communicate with the column of Goll.

But few cells are found that send nerve-processes into the posterior columns. Lenhossék has found some such in the posterior horn behind the column of Clarke.

Cells occupying the area of the posterior horn known as the substantia gelatinosa of Rolando, send their processes for the greater part to the area at the tip of the posterior horn, which, since Lissauer's description, has been known as the zona terminalis. The cells of the substantia are large and spindle-shaped, and were formerly

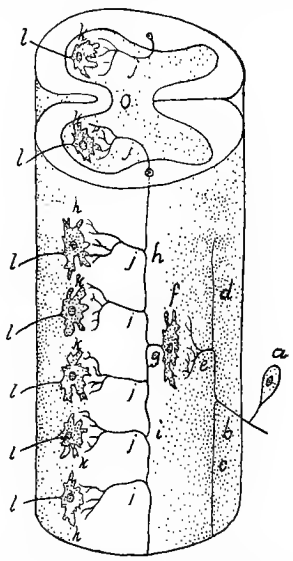


Fig. 145.—The Indirect Reflex Path. (A. v. Kölliker.) *a*, Gangloblast sending into the cord a fibre, *b*, which divides into ascending and descending limbs, *c*, *d*, and gives off collaterals, *e*, which embrace the cell *f* with their terminal filaments. This in turn sends off a nerve-process, *g*, which divides into ascending and descending limbs, *h*, *i*, provided with collaterals, *j*, *j*, that embrace with their filaments the motor cells *k*, *k*, from whose nerve-processes, *l*, *l*, the anterior roots are formed.

supposed to be connected either immediately with the posterior roots, or with Gerlach's plexus. (See Fig. 134, *K*.)

Cells with Short Nerve-processes (Golgi cells).—It was held by Golgi that these cells were confined to the posterior horn. This is found not to be the case. Still there is one locality in that horn, near Clarke's column, in which they are especially numerous. (Fig. 144, *g*.) They are also found near the anterior commissure, sending their processes across to the opposite side of the cord. (Fig. 144, *d*.)

Collaterals of the Columns.—We have hitherto considered only the collaterals given off by the ascending and descending limbs of the vertically-branching fibres of the posterior roots. These are by no means the only ones. A longitudinal section of the white columns in any portion of the cord shows that all the vertical fibres have the same disposition to give off to the gray substance collaterals that end by arborescent divisions. Kölliker could find no exception to this rule.

It is evident that these collaterals may arise from two sources: First, they may belong to column cells that have divided at higher or lower levels into their ascending and descending branches, and are sending back into the gray matter their terminals. These would produce what Kölliker has designated as the "indirect reflex path" by which the motor cells of different levels of the cord can be correlated in special groups (see Fig. 145); 2d, the collaterals may belong to nerve-processes of cells situated at levels entirely above the cord, in the cortex of the brain, in the cerebellum, or in the medulla oblongata. There seems to be some reason to think that this is the case. The so-called pyramidal tracts connect, as is well known, the motor area of the cerebral cortex with the cord. The result of degenerations shows that they are divided into two portions, the direct pyramidal tract, situated in the anterior columns, and the crossed pyramidal tract situated in the lateral column near the tip of the posterior horn. From each of these columnar areas collaterals pass in considerable numbers to ramify about the large cells of the anterior horn. It is interesting to note that, by the group of commissural cells situated on the medial side of the anterior horn, connection may be made with

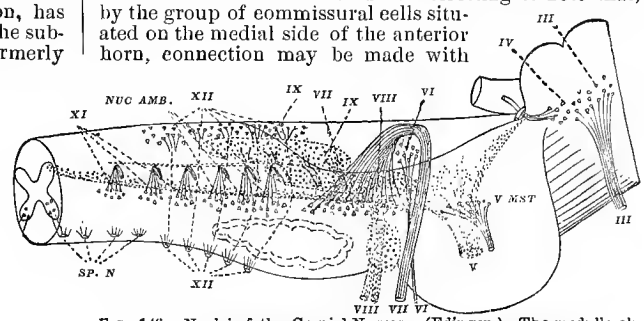


Fig. 146.—Nuclei of the Cranial Nerves. (Edinger.) The medulla oblongata and the pons are represented as if transparent.

the direct pyramidal tract of the opposite side, and that thus may be explained the fact, already demonstrated clinically, that lesions of this tract affect movements of the opposite side of the body.

Upon examining by the same method the nerves at a higher level than the spinal cord, we find that the same general structure is found. Some of the results obtained are most striking, and throw a flood of light on the general constitution of the nervous system.

The existing knowledge of the situation of the nuclei of origin of the cranial nerves is shown in the following diagram. (See Fig. 146.)

Olfactory Nerve.—In Fig. 147 there is diagrammatically shown an antero-posterior section of the olfactory bulb.

In the olfactory mucous membrane are found two kinds of cells, the epithelial, *ec*, and the nervous, *bc*, the latter being bipolar, presenting one process to the surface for the reception of impressions, while the other passes centrally and breaks up into the usual ramifications, forming the well-known glomeruli of the olfactory bulb, which have caused so much speculation. In these glomeruli they come in contact with the peripheral processes of another set of cells, called mitral cells from their shape, they having a large body and two processes given off nearly together. The peripheral process receives the stimulus from the olfactory glomeruli, and it is transmitted to the brain by the other process, which is directed horizontally. This shows in a striking manner that the hypothesis of Golgi, that the dendritic processes are for the purpose of absorbing nutriment, is incorrect. Each of the nervous elements or neurons is in fact independent, and each probably serves as a transmitter of stimuli.

Optic Nerve.—Here the sensory cells appear to be the large ganglion-cells of the retina. By their short processes they communicate with the special receptive elements, the rods and cones and the spongioblasts. Their long processes go to make up the principal mass of the optic nerve-fibres (see Fig. 148), and break up into the usual arborescent filaments that become associated with filaments of short-process cells situated within the central ganglia (corpus geniculatum, optic thalamus). The white radiations observed in the corpora geniculata are composed of such fibres. His has shown that in the embryonic retina there exist neuroblasts whose processes

grow centrally into the optic nerve. There are also in the optic nerve certain fibres that belong to cells situated in the corpora quadrigemina anteriora, and also probably some from cells in the occipital lobe of the cortex.

The question has been often discussed whether the fibres of this nerve between their real and apparent origin

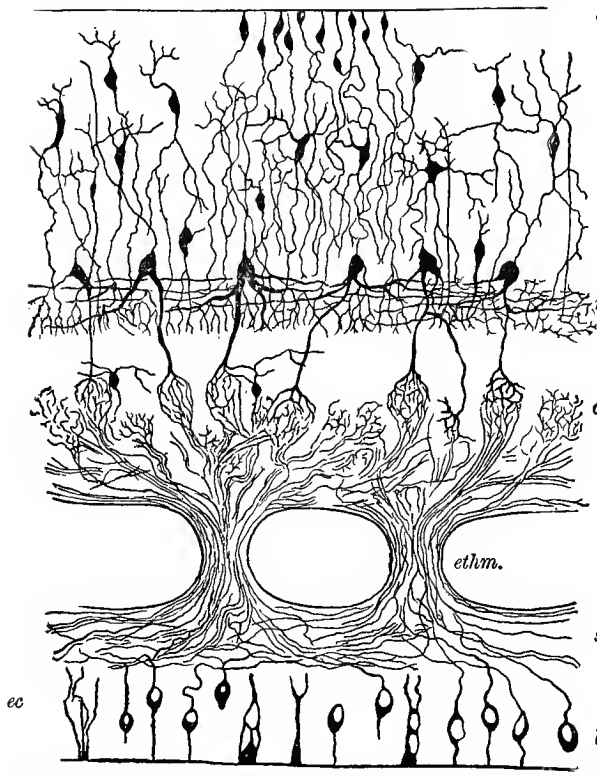


FIG. 147.—Structure of the Olfactory Filaments and Bulb. (Ramón y Cajal.) *bc*, Bipolar cells of the olfactory mucous membrane; *sm*, submucosa; *ethm*, cribriform plate of the ethmoid; *og*, olfactory glomeruli; *mc*, mitral cells; *ep*, epithelium of the olfactory ventricle; *ec*, epithelial cells of the olfactory membrane.

undergo a decussation either total or partial. Duval held that the fibres of the nerve proper do not decussate, but that there are mingled with them certain fibres from the posterior longitudinal bundle, probably derived from the nucleus of the abducens, that undergo decussation. This view was adopted and figured by Testut in his "Anatomie Humain," 1891.

Gudden showed, however that in the rabbit, and prob-

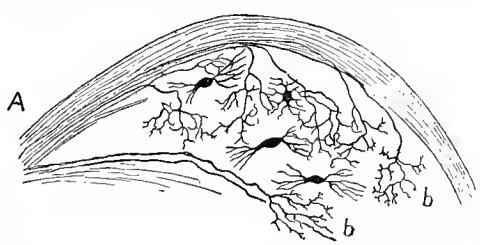


FIG. 148.—Connections of Fibres of the Optic Nerve. (Ramón y Cajal.) Section through the corpus geniculatum laterale of the cat. *A*, fibres of the optic nerve; *b*, *b*, their ultimate filaments eotwining with Golgi cells.

ably in man, the nucleus of the oculo-motor nerve is composed of two parts, one ventral, sending fibres to the nerve of the same side, one dorsal, sending fibres to the nerve of the opposite side.

Kölliker and van Gehuchten have recently studied the question anew, the former observer using the methods of Weigert and Pal, the latter that of Golgi. They find that in the duck, at least, there is a partial decussation of fibres derived from both the dorsal and ventral portions of the nuclei. The crossed fibres pass principally into the internal or median part of the peripheral nerve. The fibres of the posterior longitudinal bundle give off numerous collaterals that come in contact with the protoplasmic processes of the cells of the nuclei.

Starr divides the cells of the nucleus into groups which innervate special muscles, as follows:

Sphincter iridis.	Ciliary muscle.	Median Line.
Levator palpebræ.	Rectus internus.	
Rectus superior.	Rectus inferior.	
Obliquus inferior.		

Gaskell has put forward a theory that a ganglion formerly existed upon the third and fourth cranial nerves, and as evidence therefor shows a considerable mass of connective tissue, apparently the re-

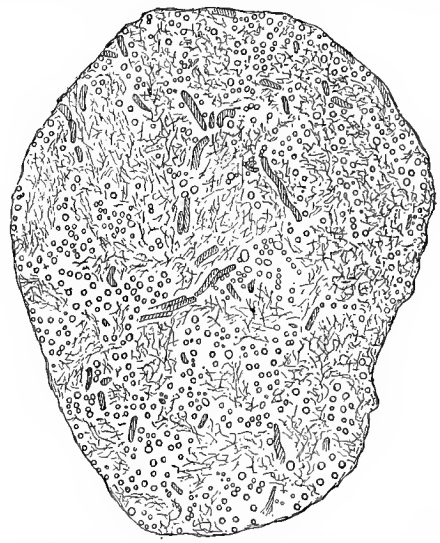


FIG. 149.—Transverse Section through a Rootlet of the Third Cranial Nerve of Man, to Show Degenerated Ganglion.

sult of degeneration, through which some of the rootlets of the nerve pass. He holds that the arrangement and appearance of these roots, as shown on section through this mass, is precisely that which would appear in a section through a ganglion. (See Fig. 149.)

He considers that this degenerated ganglion belonged to the sensory root of the nerve, and that this sensory root has disappeared because of the great changes that have taken place in the vertebrate head and brain. He also thinks that the substantia nigra of the crura cerebri is a degenerated nucleus from which arose certain lost fibres belonging to the third and fourth nerves.

He thinks the ciliary ganglion is a vagrant ganglion belonging to the small-fibred portions of the oculo-motor nerve.

Patheticus Nerve.—The evidence that the fibres of the fourth cranial nerve decussate completely has not in any way been shaken. Gaskell thinks that a small vagrant ganglion will be discovered in connection with it, as he believes it to belong to his efferent ganglionated splanchnic class.

Trigeminus Nerve.—Gaskell considers the motor-root of the trigeminus as a complete segmental nerve, that has its small-fibred ganglionated portion in the fibres that go to the spheno-palatine ganglion and whose sensory fibres have degenerated. The sensory root of the trigeminus he considers to belong to several of the segmental cranial nerves.

Abducens Nerve.—A novelty with reference to the origin of the sixth nerve is the discovery of a small and

easily overlooked bundle of fibres that turns toward the middle line ventrally from the nucleus and enters the abducens nerve of the opposite side. A connection has been described between the abducens nucleus and the superior olive. Edinger suggests that this connects the abducens with the auditory nerve and correlates the movement of the eyes with orientation in space. The connection of the fibres of the facial nerve with the nucleus of the sixth is definitely disproved by the researches of Gudden.

Facial Nerve.—Fibres from the facial nucleus are now known to decussate. The "superior facial nucleus" described by some authors as supplying fibres for the orbicularis oculi and frontalis muscles is now discredited. It is believed that these fibres, which do not degenerate in central disease of the facial nerve, are probably derived from the posterior longitudinal bundle.

Auditory Nerve.—A considerable addition has been made to our knowledge of the origin of the auditory nerve. It seems clear that we have here to deal with two nerves, one for the supply of the cochlea and one for the semicircular canals. Many physiologists hold that this latter nerve has nothing to do with hearing. The roots of these nerves lie on opposite sides of the restiform body and are therefore distinguished as lateral (superficial, inferior, posterior) and medial (deep, superior, anterior). The lateral is connected with the cochlear nerve, the medial with the vestibular.

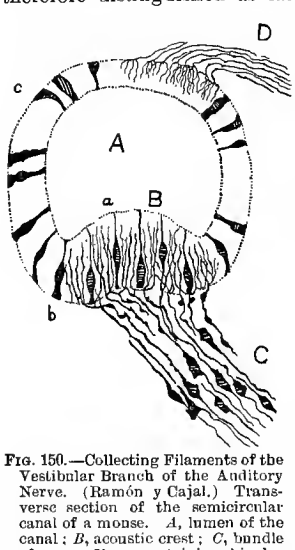


FIG. 150.—Collecting Filaments of the Vestibular Branch of the Auditory Nerve. (Ramón y Cajal.) Transverse section of the semicircular canal of a mouse. *A*, lumen of the canal; *B*, acoustic crest; *C*, bundle of nerve-fibres containing bipolar cells; *D*, a similar bundle supplying the top of the canal; *a*, *b*, and *c*, varieties of bipolar epithelial cells.

The lateral root springs from a collection of cells lying partly outside the brain substance, like a ganglion on a nerve-trunk. In some vertebrates and in the embryo it is wholly detached. It is sometimes termed therefore the auditory ganglion. It produces the eminence in the medulla oblongata known as the acoustic tubercle.

The medial root arises chiefly from a large nucleus lying near the median line known as the chief auditory nucleus, also from a collection of large cells lying more externally, termed Deiters's nucleus.

By the method of Golgi, Retzius has shown that the endings of the auditory nerve are essentially the same as those described for other sensory nerves. Both in the organ of Corti and in the acoustic crest of the semicircular canals exist the terminals of bipolar cells situated in the ganglion spirale (cochlear nerve) and ganglion of Scarpa (vestibular nerve), which terminals break up into numerous branches situated between the epithelial cells. The epithelial hair-cells represent, then, the same elements as the rods and cones of the retina, and are agents for carrying to the nerve-cells the sonorous vibrations. This arrangement will be seen in Fig. 150. The epithelial expansion of this bipolar cell corresponds apparently to a dendritic process, while the central communication is an axis cylinder. *Frank Baker.*

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CREASOTE. Discovered in 1830 by Reichenbach it early acquired a reputation for being of service in pulmonary troubles, and has always been used to a greater or less extent in such diseases. Its recent revival, however, dates from the communications of Professor Julius Sommerbrodt, of Breslau, Fraentzel, Guttman, and others in 1887 and 1888. Ten years previously Drs. Bouchard and Gimbert had given the results of their experience with the drug, and had recommended that it should be more extensively used in pulmonary phthisis, as it had proved of decided valne in their hands. During the intervening years many physicians tried the remedy, but it was not until Professor Sommerbrodt corroborated the statements of Bouchard and Gimbert, and claimed for it even greater curative properties, that it received the attention which it appeared to deserve. Sommerbrodt's experience appears to have embraced many thousand cases and to have extended over a number of years ; as a result he is very decided in his views, and claims that it is not only a very useful drug for the relief of the numerous troublesome symptoms, but that, by its power of checking the progress of the disease, it appears to possess almost specific properties. In a later paper, in reviewing some five thousand cases of tubercular disease, he states that definite recovery has been attained in a much greater proportion than by any other method of treatment, and in the great majority of cases decided benefit could be traced to its use. The fever, night-sweats, cough, and expectoration were lessened, the general health of the patient improved, and in the cases where no curative effect followed or was to be expected, the lives of the patients were prolonged and rendered more comfortable. He dwells particularly upon the importance of an early diagnosis where curative results are to be expected, and insists upon the drug being administered in full doses and for a prolonged period. In his early cases he considered five to eight minims a day to be sufficient, but he now advises that as much should be given as the patient can bear, his rule being that the more creasote can be introduced into the system the greater will be its beneficial action. He now advises that twenty to twenty-five or thirty minims a day should be given, and this dose continued for many months or even years. His mode of administering it is to commence with one minim three times a day and increase the dose by one minim each day for eighteen days, until such an amount is reached as the patient can bear, and then continue that quantity for an indefinite period. He gives the drug with a few drops of cod-liver oil or oil of sweet almonds in capsules,—never on an empty stomach, but after the three principal meals. The purity of the drug he considers of the greatest importance, and advises that only the best beech-tar creasote be used. If these points are observed no difficulty should be experienced by the patient, as any ill effects—such as eructations and belching of wind—never continue for any length of time. The antiseptic action improves the condition of the digestive tract and a decided improvement soon follows its use, not only relieving the digestive disturbances but increasing the appetite and promoting assimilation and the general well-being of the system. Another advantage that he claims for this treatment is, that it is simple and devoid of danger and does not prevent the adoption of further methods of combating the disease.

Sommerbrodt's purpose in administering the drug so freely is based upon the researches of Guttman, who found that the bacillus of tuberculosis would not live in a solution of greater strength than one part in four thousand. He points out that if about twenty grains could be introduced into the blood of an ordinary man it would represent a solution of such a strength. He considers it possible to produce such a condition by giving it in large quantities, as it is not likely to be changed or excreted as rapidly as it is introduced. He has given as much as sixty minims a day, and Freudenthal has pushed it to one hundred and fifty minims in the twenty-four hours.

How creasote acts or in what way it produces its beneficial action has not been determined. It is admitted that the improvement in digestion and nutrition that follows its use places the system in a better state to resist the disease, but beyond this nothing is known. Creasote does not exist in the blood in a free state, and this would seem a serious objection to Sommerbrodt's theory, but it is supposed to enter into combination with certain albuminoids in the blood, and this combination he considers still possesses the properties of the crude drug. Very recently Seifert and Hoelscher have formulated a theory which favors this view : they conclude that the products of creasote circulating in the blood render innocuous the ptomaïnes which have been formed by the bacilli and afterward absorbed. In this way it eliminates from the system these toxic compounds before they produce any of their deleterious effects.

Such experiments as have been made on animals to test the efficacy of creasote upon tuberculosis have not supported the views of those who consider it of so much value. The disease always progressed steadily, and no effect was apparently produced by the drug. Sommerbrodt, however, points out that artificial tuberculosis in animals is very different from the disease in man, and that many animals are particularly susceptible to the influence of the poison.

In using creasote much difficulty has been found in administering the large doses that are advised without producing gastric disturbance and causing the patient to rebel. How far this may be due to the quality of the drug is hard to estimate, but it may also be, to a certain extent, due to the preparation or the manner in which it is given. Mixed with the oil and enclosed in capsules is probably one of the simplest, as well as easiest ways of taking the drug. When the cod-liver oil is not well borne, the more bland oil of sweet almonds or olive-oil may be employed. In addition to the nutritive properties of the oil, it is supposed, to a certain extent, to convey the drug into the intestines before being acted upon. Freshly prepared capsules are always to be preferred, as it has been found that a chemical reaction occurs when the oil and creasote remain in contact for any length of time. Dissolved in spirits is a common way of prescribing the drug, and tincture of gentian has been favored as a means of disguising the taste. A combination of Bouchard, which has given rise to many modifications, was as follows : Creasote, 15 minims ; tincture of gentian, 40 minims ; rectified spirits, 6 drachms ; white wine, to make 3 ounces. Milk is recommended as a good vehicle for the drug, either in its purity or when in solution. Malt extract, or malt extract and emulsion of cod-liver oil, are very highly praised as a means by which it may be administered. The following emulsion is said to disguise the taste and supply the beneficial properties of the constituents : Malt extract and emulsion of cod-liver oil, 8 ounces ; creasote, 80 minims ; oil of bitter almonds, 4 minims ; oil of lemon, 6 minims.

Many pills containing creasote are prepared and form a convenient vehicle, but the insolubility of many of these pills must not be forgotten. A coating of keratin, resin, salol, collodion, and substances not acted on in the stomach, is now prepared, and the creasote is only liberated when the pill reaches the alkaline fluids of the intestine.

The hypodermic injection of creasote has been advocated as an excellent means of introducing it into the circulation, the great advantage being that it does not cause any derangement of the digestive organs. A ten per cent. solution in oil of sweet almonds is used, and the treatment begun by injecting small amounts, which are gradually increased. Local irritation, however, has frequently followed, and the internal administration is generally preferred when possible. Deep pulmonary injections have been used. Specially prepared long needles are employed, and the creasote carried through the chest-wall directly to the diseased tissue. Eight minims of a

three per cent. solution in oil is the quantity used. A modification of this is the intra-tracheal injection of the drug. A five per cent. solution in oil of almonds is used, and thirty-one minims (two grammes) injected into the trachea twice a day. The oil descends into the lungs and gradually enters the alveoli. It is said that no bad effects follow this use of the drug, and on the affected part a beneficial local action is exerted.

Inhalation is, of course, a valuable way of acting directly on the diseased organ, and forms an important adjunct to the internal use. The following combination is most efficient: Creasote, eucalyptus, and turpentine, each 5 drachms; iodoform, 7½ grains; dissolved in sulphuric ether, 1¼ drachm.

In a paper published by Professor Sommerbrodt within the past year the application of creasote is specially advocated in the glandular enlargement and other diseases arising from a tuberculous condition in children. With him the results of such treatment have been most favorable, and he urges others to adopt it in their practice. The dose for children above six years of age is from 7 to 12 minims per day, beginning with one minim and increasing it daily, as in his former directions for pulmonary disease. He also takes advantage of the occasion to insist upon the importance of a full dosage, and reiterates his faith in its value.

In this paper he records the first instance of profound intoxication by the drug that has been brought to his notice. A patient of Dr. Freudenthal, of New York, who was taking, with benefit, from 30 to 45 grains a day, took about 150 grains (9 or 10 grammes) within two hours. She became unconscious, and gave the impression of one narcotized; pulse, 128; respiration, 30; intense trismus, lips cyanotic, pupils contracted, sensory and reflex action annulled. After nine hours the patient recovered without any ill effects following, and continued the regular use of the drug.

Although it is now very evident that no toxic effects are to be dreaded during proper medication, there are some symptoms that must not be disregarded. The discoloration of the urine, when it occurs during large doses, calls for a diminution of the quantity, or its stoppage for a short period; but if it follows small doses, or occurs frequently, the drug must be given very cautiously. Vertigo, intoxication, and signs of stupor must not be disregarded, and malaise, prostration, sweating, cephalalgia are also signs of intolerance of the drug.

Beaumont Small.

CREOLIN is a proprietary article, the name being registered by the manufacturers in Hamburg. Commercial creolin, however, varies much in appearance and properties, and many preparations are sold under that title. It is obtained from the product that remains after carbolic acid has been removed during the fractional distillation of coal-tar. The cresols form the active ingredients. The following analysis of the German compound is furnished by Dr. Bernard Fischer: Cresols, 20 parts; naphthalene, 18 parts; other hydrocarbons. 20 parts; and non-volatile matter, 42 parts. It is quite free from carbolic acid and other poisonous ingredients, and should not possess any toxic properties. Creolin is prepared by treating these insoluble hydrocarbons with resin and caustic potash, which form a resinous, soapy emulsion. When added to water and agitated the ingredients remain suspended as an emulsion. In appearance it is a dark, resinous liquid, neutral to test-paper, not caustic. Its odor resembles creasote. It mixes with oils.

It possesses powerful antiseptic and disinfectant properties, and is recommended as a substitute for carbolic acid, to which it is said to be superior, as it does not contain any poisonous ingredients. It is very extensively employed, and numerous reports speak in its favor in all conditions where carbolic acid is indicated.

For surgical purposes two solutions are employed, one containing two per cent. of the drug, the other one-half per cent. The stronger is used for disinfecting the hands, the instruments, and surfaces of the body; the weaker solution is used for irrigation, moistening dressings, saturating tampons, etc.

For suppurating and sloughing wounds, and where discharges are offensive the parts may be cleansed and disinfected by the pure drug, and the effect maintained by a weaker solution. To irrigate the bladder, urethra, nose, pharynx, and other mucous surfaces, a solution of one part in a thousand is sufficiently strong.

The objections to its use are, the uncertainty of its action on account of the numerous preparations, and being unctuous it renders the hands and instruments slippery and difficult to handle. *Beaumont Small.*

CRESALOL. This is the cresylic ether of salicylic acid, and bears the same relation to cresylic acid that salol does to carbolic acid. It is analogous to betol and salol, and has been introduced by Nencki, the originator of the other two compounds. It is prepared by treating cresylate of sodium and salicylate of sodium with perchloride of phosphorus. Three salts are formed, according as the ortho-, meta-, or para-cresylic acid is used. All three possess the same properties, but the para-cresalol is the one usually prepared. The chemical formula is $C_6H_4OHCOC_6H_4CH_3$.

Cresalol is a white, crystalline powder, without taste; odor somewhat resembles salol. It is insoluble in water, slightly soluble in alcohol. The dose is given as from three to thirty grains daily. It possesses antiseptic properties similar to salol, and, like that salt, is not acted upon by the secretions of the stomach. It is used for intestinal antisepsis, and is said to be more efficient than its analogues. In the system it is decomposed into cresol or cresylic acid and salicylic acid, and its advantage is the freedom of these acids from any toxic properties.

Beaumont Small.

CRESOL, CRESYOL, CRESYLIC ACID. This consists of ortho-, meta-, and para-cresylic acid in variable proportions, having a general formula of C_6H_4, CH_3, OH. It is a higher homologue of carbolic acid or phenol, and differs from it by the replacing of one atom of hydrogen by the methyl group CH_3. It is present in coal-tar, with carbolic acid, and is obtained during the process of fractional distillation. The fractional distillation of coal-tar consists in the separation of groups of products according to their volatile properties. Up to 80° C. about four per cent. is separated, consisting of carbon bisulphide, ammonia, amylene, benzene, and other very volatile compounds. From 80° to 210° C. what is termed the light oil is removed; this is made up of benzene and its homologues. Between 210° and 400° C. the heavy oil is formed, consisting of phenol, naphthalene, cresols, and other hydrocarbons. The residue is pitch, about fifty per cent. The phenol, cresol, and naphthalene, and other constituents of the heavy oil, are separated by further distillation. It forms the greater part of the crude carbolic acids of commerce, which might more properly be called crude cresols.

It is a colorless, strongly refractive liquid, boils at 397° F., is strongly caustic; its odor resembles creasote. It is insoluble in water, soluble in alcohol, glycerine, and ether. The cresols are powerful antiseptics and produce some of the most active preparations of the aromatic series. According to the investigations of Jaeger and Ohlmüller, of the Board of Health, and Fraenkel, of the Berlin Hygienic Institute, it has been shown that when dissolved in sulphuric acid the most active of such antiseptics is formed. Being insoluble in water it is difficult to obtain a solution that is stable and applicable to surgical purposes.

Many methods have been devised and numerous preparations have been introduced into commerce under a variety of names: creolin, lysol, solveol, solutol, and others, are all preparations of this kind. Some contain other hydrocarbons in addition to the cresols. Resin and alkali soaps form a favorite means of retaining the active ingredients in solution, but when added to water they produce milky and greasy fluids, very objectionable for surgical uses; the antiseptic properties are, however,

effective as deodorizers and disinfectants. Cresotate of soda has been found to retain cresol in solution. For therapeutic purposes a one and one-half per cent. solution is sufficiently strong, free from irritant or caustic properties, and equal to a five per cent. solution of carbolic acid. Cresol is also dissolved in a concentrated solution of salicylate of sodium, which allows of free dilution; no decomposition occurs, a neutral solution of cresol being formed. Lime is recommended as a means of rendering a solution which forms a cheap and active disinfectant; one part of lime is treated with four parts of water, and five parts of cresol are added; the resulting liquid contains fifty per cent. of cresol and is miscible in water in all proportions.

For internal administration the preparation cresalol has been introduced and is highly recommended.

Beaumont Small.

CRESOTIC ACID (*Cresotinic Acid, Homosalicylic Acid*). This is a higher homologue of salicylic acid, to which it is allied both in chemical and in physiological properties. Its formula is $C_6H_3OHCH_3COOH$, which is that of salicylic acid, $C_6H_4OHCOOH$, with one atom of H replaced by the methyl group CH_3. It is obtained by the action of carbon dioxide on sodium and cresol; the product, when treated with hydrochloric acid, yields a solution of cresotic acid, from which it is separated by evaporation. It crystallizes in long, white, prismatic needles, which dissolve with difficulty in cold water, more readily in hot water, and are very soluble in alcohol, ether, and chloroform. Three isomeric acids are formed—the ortho-, meta-, and para-cresotic acids,—corresponding to the ortho-, meta-, and para-cresols. They differ in their melting-points, by which they may be distinguished, that of the ortho being 160° C.; the meta, 177° C.; and the para, 151° C. Their aqueous solutions are colored violet by ferric chloride, and in many other reactions they correspond to salicylic acid. They are now most readily separated from this acid by the fractional crystallization of their lead salts from alcoholic solutions. The three acids are generally present in the salicylic acid of commerce, which is prepared artificially, as much as 8.10 per cent. of the para-cresotic acid having been detected in some specimens. They are never present in the natural acid prepared from the oil of wintergreen.

These acids were brought to the notice of the profession in 1890, as dangerous ingredients of the salicylic acid of commerce, by the researches of Professors Charteris and Dunstan, of Glasgow, which were published in the *Pharmaceutical Journal and Transactions* of November 22d. It had long been known that very alarming symptoms often followed the use of the artificial salicylic acid, and in 1878 two bodies had been separated which had been shown to account for the toxic symptoms, but which at the time were not identified. These were now demonstrated to be ortho- and meta-cresotic acids, and the third acid was also found to be present in large quantities. The meta-cresotic acid was known to be inert, but it was now claimed that both of the other two possessed a powerful depressant action on the heart, and in comparatively small doses would produce fatal effects when given to animals. These statements, particularly in regard to para-cresotic acid, were important, as this acid was supposed to be less toxic than salicylic acid, and had been recommended to be used in medicine as a substitute. To verify those statements further experiments were made by Professor Charteris, and the results were published in the *British Medical Journal* for March 28, 1891.

His experiments proved that both acids were active poisons, and rapidly caused death when administered to animals by means of an hypodermic injection. His conclusions are that the lethal dose of the para-cresotic acid is about three grains per pound-weight of the animal, and that one grain of the ortho-cresotic acid would have the same effect. These doses were fatal within three hours, the toxic symptoms following immediately upon the use of the drug, and he considers that much smaller doses would also prove fatal, but after a more prolonged interval. Further experiments were made by combining the two acids, and it was found that the fatal quantity was less than when they were administered separately. The acids were also used when added to pure salicylic acid, and this combination added to the toxic power of the cresotic acids. One grain of para-cresotic acid and one grain of the ortho-cresotic acid were dissolved with twenty grains of salicylic acid, and experiments showed that one-quarter of a grain of each cresotic acid, with four and one-half grains of salicylic acid, proved fatal to an animal weighing two pounds.

Chemical experiments were also made which led to important results, and proved how essential the degree of crystallization and the melting-point are as means of indicating the purity of salicylic acid. He found that when either of the cresotic acids was added to pure salicylic acid, dissolved and recrystallized, the departure from the large and beautiful crystals of the latter was in direct ratio to the degree of contamination, and when the amount of impurity was great, an amorphous powder was the result, and the acids had to be redissolved several times before crystals could be obtained.

The practical conclusion to be drawn from this is, that the difference in degree of crystallization allowed by the Pharmacopœia between the natural and artificial salicylic acid allows a certain percentage of the cresotic acid to be present. With regard to the melting-point, it was also shown that 156.8° C., allowed by the British Pharmacopœia, was too low, and permitted the same impurities to be retained. The experiment showed that an artificial acid could be prepared as pure as that obtained from the natural sources, and it was urged that in the revised Pharmacopœia these tests should be insisted upon and the standard of purity raised. The following is a tabular statement of the results of experiments made to determine the melting-point of the various mixtures:

Natural salicylic acid of commerce	157.0° C.
Artificial salicylic acid of commerce	156.0° C.
Equal parts of salicylic acid and other cresotic acid, dissolved and crystallized	136.0° C.
Equal parts of salicylic acid and para-cresotic acid, dissolved and crystallized	128.5° C.
Twenty grains salicylic acid and one grain ortho-cresotic acid, dissolved and crystallized	152.5° C.
Twenty grains salicylic acid and one grain para-cresotic acid, dissolved and crystallized	152.0° C.
Sixty grains salicylic acid and one grain ortho-cresotic acid, dissolved and crystallized five times	156.0° C.
Sixty grains salicylic acid and one grain para-cresotic acid, dissolved and crystallized six times	154.5° C.
Ninety-seven grains salicylic acid, two grains para-, and one grain ortho-cresotic acid, dissolved and crystallized	155.0° C.

The only preparation of these acids that has been prepared for therapeutic purposes is the para-cresotate of sodium. It is a white, fine, crystalline powder, with a slightly bitter taste, soluble in twenty-four parts of warm water. It is said to possess antipyretic and antirheumatic properties similar to those of salicylate of soda, but in a lesser degree. It, however, has the advantage of not disturbing the digestive organs. Although it has been shown that the acid base has such decided toxic properties, this salt is said to be quite harmless, and may be given in doses of forty-five grains a day, for several days in succession, without any ill effects. The dose recommended is, according to the patient's age, from one and one-half grain to twenty-three grains, repeated three or four times a day. It is also reported to be of use as an antipyretic in pneumonia and typhus fever. In children it has been used in gastro-intestinal catarrh as an intestinal antiseptic.

Beaumont Small.

DAWLISH. A popular and pleasant seaside resort in Devonshire, England. It is about equidistant from Exmouth and Teignmouth. The English patronize the place at all seasons, but its chief attraction is a fine beach which is used in summer. The climate is not as equable and mild as that of Torquay, nor is the place as fashionable and expensive. Dawlish rests on gravelly soil, which, in view of the large amount of rainfall, is obviously a great advantage. It is cooler in summer than the resorts nearer London. The climate is humid, and,

while sedative, is rather relaxing. The indications are the usual ones for healthy seaside resorts; and the place is especially to be recommended for those conditions which a too bracing climate might injuriously affect. It is not an international resort, being visited by the British only. *Edmund C. Wendt.*

DEATH, ORIGIN OF. PHYSIOLOGICAL THEORIES.—Living things, in the forms most familiar to us, at least, all grow old and die. We infer that this fate is universal with something of the same certainty with which we prophesy that a stone thrown into the air at any spot whatsoever will fall back again to the earth's surface. On the other hand, it is equally a commonplace of observation that the death of the individual does not mean the death of the race, and, inasmuch as every living thing is directly sprung from a preceding form,—*omne vivum e vivo*,—we may assume that the continuity of life has never been interrupted, and never will be. If the environment remains as favorable in the future as it has been in the past, living things will continue in unbroken succession for all time. From this stand-point we may speak justly of living matter as possessing immortality, or, at least, potential immortality, since it has unlimited powers of propagation. It is one of the final aims of biological speculation to reconcile these two apparently paradoxical properties of living matter; to furnish a satisfactory hypothesis which shall explain the occurrence of old age and death in the individual, and at the same time account for the possibility of unending existence for the race, which is implied in the fact of reproduction.

In speculations of this character we must, moreover, keep clearly in mind that forms of living matter are not stable, in the same sense that forms of dead matter are. A given animal exists for a period of five years; but we are all perfectly well aware that no portion of the living substance of this animal has remained actually the same throughout this time; *i.e.*, the atoms of C, H, O, N, S, P, which constituted the living matter in the beginning, were replaced very early by others brought in with the food. What has remained unchanged through the individual's life has been, on the physiological side, a form of activity, and, on the morphological and chemical side, a material substratum of a practically definite composition. However familiar this fact may be, it is, after all, the great distinctive feature of life—or rather, of living matter. We express in the single word assimilation, or nutrition, that property which separates living matter from dead. As long as any particle of matter is in the living form, just so long has it the creative power of converting dead food into living substance like itself. Throughout its period of existence there is a steady stream of dead matter coming to it to be rearranged into the living form, and an equally continuous outflow of dead material from it which had once been in the living form. Nothing can make this conception clearer than Huxley's simile of the whirlpool at Niagara,—which fits so well as an illustration of the ever-changing particles which make up the unchanging form of life. From this point of view we may say that living matter is never actually the same, yet it must be evident that, in respect of any given mass of that body which we call protoplasm, it can only reproduce itself in its offspring by transmitting a portion of its actual substance. The formation of a new organism from this transmitted germ is therefore, from a chemical stand-point, no more a creation of a new being or of new living material, than is the continued existence of the parent form throughout its period of natural life.

As far as the mere external phenomena of senility are concerned they may be observed and recorded. In the human being this has been done with more or less care. The coming on of the signs of old age in the different tissues, the rate of its normal development, and the conditions which hasten or retard its development, are known to a certain extent, though they have not been investigated with the carefulness of detail which scientific exactness requires. We cannot expect any solid advance in our knowledge of the development of old age until the statistics, which may be determined by experiment and observation, have been recorded. The superficial signs of old age are spoken of usually in the text-books of physiology. In the old, the bones become more brittle because of a continually increasing excess of deposits of inorganic salts; the cartilages become more rigid and calcareous for the same reason; the elasticity of the lens of the eye decreases, bringing on imperfect accommodation; the muscles atrophy and lose their physiological mobility, as shown by the lessened vigor of their contractions and their diminished elasticity; the hairs lose their pigment, etc. It is important to notice that these signs of deterioration in the machinery of life do not make their appearance first during or after the period of maturity, but begin to develop from the time of birth, or possibly before. At ten years of age the near point of distinct vision is 7 ctm. from the eye, at twenty it has lengthened to 10 ctm., at forty years of age it is 22 ctm., at sixty years it is 100 ctm., and so on. The long-sightedness of old age begins to develop in early childhood, and results physiologically from a continual diminution in the elasticity of the lens. We obtain similar facts if we measure the rate of growth of the body throughout life. According to the somewhat unreliable statistics of Quetelet, the average male child weighs at birth 6½ pounds. At the end of the first year it will weigh 18½ pounds, a gain of 12 pounds. At the end of the second year it will weigh 23 pounds, a gain of only 4½ pounds. And so on to full maturity the rate of increase each year falls rapidly. If we measure the rate of growth by the increase in height instead of by the increase in weight, we find that in the first year the gain is 148 mm., in the second year it has fallen to 93 mm., in the third to 72 mm., from the twentieth to the twenty-fifth year it averages 12 mm., and from the twenty-fifth to the thirtieth year only 0.8 mm., while in extreme old age it becomes a negative quantity. In a recent paper Minot has given the results of a laborious research upon the growth of guinea-pigs, which show much more clearly and accurately the same general fact of a decrease in the rate of growth beginning shortly after birth. Minot bases his figures upon observations taken daily. He defines the term "rate of growth" with an exactness not hitherto employed, in that he calls attention to the fact that usually, in considering the rate of increase, the actual increment at different periods is given instead of the proportionate increment. In other words, if an animal in successive periods gains in absolute quantities only the same amount in weight or height, its rate of growth is in reality decreasing, since proportionately to the weight of the whole animal the increase has been less and less. Making use of his short periods of twenty-four hours, and expressing the rate of growth as the fraction of weight added during that period, he finds that, after the animal recovers from a short postnatal retardation of growth, the rate of growth diminishes during life, at first rapidly, and afterward more slowly. It follows from these facts, that what we may call the creative power of growth, or better, the creative power of assimilation, which measures the capacity of living matter to form matter like itself, decreases steadily from birth. Like a stone projected upward, the initial velocity begins to fall from the outstart. As the height to which the stone travels may be taken as a measure of the force with which it was thrown, so the length of life in any individual may be taken as a measure of the power or capacity of assimilation with which the germ of that individual started its career. When the power of assimilation is insufficient to replace the wastes of nutrition then death for that tissue is at hand. Whatever may be the internal causes which lead to this diminution, and thus serve to bring on old age, we are safe in saying that they begin to make themselves felt in the very first years of postnatal life. The curve of vitality—to use a much-abused but convenient word—does not rise from birth, reach its maximum in the vigor of maturity, and fall in old age, but begins to fall steadily, though not uniformly, from the beginning of life.

To mankind as individual organisms old age and death are inevitable, but it is interesting to inquire what may

be considered as the longest possible life under the most favorable conditions this world is likely to afford. We can answer this only by searching the records. If we put aside the oldest accounts on the ground of uncertainty as to the unit of time, and make our estimates on the basis of comparatively modern statistics, we may put the maximum age as lying somewhere between one hundred and twenty and one hundred and eighty years. Perhaps the most celebrated case of longevity is that of Thomas Parr, an account of whose life, together with the results of a post-mortem examination made by Harvey, may be found in the third volume of the "Philosophical Transactions," p. 886. The account relates "that he was a poor countryman of Shropshire, whence he was brought up by the Right Honorable Thomas, Earl of Arundel and Surrey, and that he died after he had outlived nine princes, in the tenth year of the tenth of them, at the age of one hundred and fifty-two years and nine months." Other interesting extracts from the letter of Harvey are as follows: "The cartilages of the sternum were not more bony than the others, but flexile and soft." "The cause of his death was imputed chiefly to the change of food and air; forasmuch as coming out of a clear, thin, and free air, he came into the thick air of London, and after a constant, plain, and homely country diet, he was taken into a splendid family where he fed high and drunk plentifully of the best wines." "He was able, even to the hundred and thirtieth year of his age, to do any husbandman's work, even threshing of corn." It is also stated that he married a widow when one hundred and twenty years of age, and from her own statement had frequent sexual intercourse with her. In an essay by Pflüger on macrobiotics, he refers to other recorded cases of unusual longevity. H. Jenkins, a native of Yorkshire, died, in 1670, at the age of one hundred and sixty-nine. It is related that on one occasion, when brought before a justice to testify with reference to an event which had occurred one hundred and forty years before, he appeared accompanied by his two sons, aged one hundred and two and one hundred years, respectively. A more remarkable case still is that of Kentigern, or Saint Mungo, founder of the Cathedral of Glasgow, who reached an age of one hundred and eighty-five, if we may trust the accounts of his life on record. Among the exceptional cases recorded some are stated to have been unusually temperate in their habits of life, while others paid no regard to such precautions. In this last category Pflüger mentions one Brawn, who reached an age of one hundred and twenty, although his tombstone records the fact that he was a confirmed drunkard. Outside of such evidence as this, it is evident that exceptional longevity cannot be referred solely to careful observance of hygienic conditions. We must explain it, in general terms, as due to an unusual power of assimilation in the living substance composing the tissues, and that this tendency to long life is inherited may be accepted as demonstrated by the statistics of life insurance. At the present day we have numerous cases of persons passing the hundred-year mark by a few years, so that this age cannot be regarded as very unusual.

However, leaving aside the reproductive cells, death sooner or later comes to the rest of the cells of the body, no matter how favorable the environments of life may be. It is not altogether hopeless to inquire into the causes which bring this about, though naturally any such investigation is largely made up of speculation of a very general character. We may define death as a cessation of life. In order, therefore, to arrive at even a general conception of its cause one must first define as clearly as possible what is meant by life. Spencer's definition is perhaps the one most familiar to educated persons. According to him life is the continual adjustment of internal to external relations. When properly analyzed the definition includes a great deal, and it is difficult to criticise it justly. But the physiologist will certainly object to it, because it attempts to present, in the most general terms, only the *ensemble* of properties manifested by living matter without pretending to trace these properties in any causative way to the physical substance which manifests them. It is as though one defined light by enumerating its chemical and physiological effects instead of referring it to vibrations of the ether. For the physiologist an adequate definition of life must be one which connects its phenomena with the chemical structure of living matter. As the chemist may deduce the chief properties of a salt from a knowledge of the structure of its molecule, so the physiologist believes that a scientific explanation of life—that is, of the phenomena of assimilation and reproduction—can only be obtained by discovering the essential chemical structure of the living molecule. To this end all biological work tends. The adjustment of internal to external relations, and the interaction of the different organs which brings about this adjustment, should be deducible from the chemical structure of living matter in somewhat the same way that the adjustments or reactions of benzine to different external conditions may be foretold from a knowledge of its molecular structure. That this kind of explanation of life is not inconceivably remote is demonstrated by the fact that several chemical theories have been seriously proposed and applied in some detail. Pflüger, for example, suggests that the essential difference between dead and living albumin lies in the grouping of the nitrogen in the molecule. In dead albumin it may exist in the form of an ammonia compound, while in albumin which is living it occurs in part, at least, in the cyanogen grouping. As something approaching scientific evidence for this view he asserts that the oxidation products of dead albuminous bodies—that is, as far as the nitrogen is concerned—are always ammonia compounds, amines, or amido-acids, while the end products of the oxidations of living substances may be classed among the cyanogen bodies. Moreover, the cyanogen compounds are characterized by their instability, and this is likewise one of the most prominent phenomena exhibited by living substances; it is doubtless the chemical cause of what is known as the irritability of living things. Cyanogen compounds also exhibit, in a striking way, a tendency to polymerize, and Pflüger suggests that this property of polymerization may be the essence of what we speak of in general as assimilation or nutrition, by which the living molecule takes into itself the molecule of dead albumin. Indeed, says Pflüger, we may may look upon the molecule of cyanic acid as showing properties intermediate between those of living and dead matter, as a half-living substance. In a similar way Loew and Bokorney attempt to explain the peculiar properties of living matter on the supposition that its molecule contains an aldehyde group. They find that living protoplasm, in certain plant-cells at least, has the property of reducing silver nitrate from alkaline solutions, while dead proteid has no such action. They infer that this reducing power is caused by the presence of an aldehyde group, and they give a scheme showing that formic aldehyde, by union with ammonia, may produce aspartic aldehyde, and this, by condensation and reduction, with the addition of S, will give, or might give, a compound of the molecular formula of proteid, which as long as it retained the aldehyde grouping would be living proteid, and would form the basis of living protoplasm. Latham attempts to combine the theories of Loew and Pflüger by supposing that living proteid is composed of a chain of cyan alcohols, united to a benzine nucleus, thus explaining the irritability or instability of living proteid, as well as its reducing action. However inadequate and premature such hypotheses may seem at present, they at least serve to demonstrate the fact that the physiologists and chemists are looking forward to a definition of life based upon a knowledge of the chemical structure of the substance through which it is made manifest.

Proceeding from his conception of what constitutes life, Spencer defines natural death as a want of correspondence between the internal and external relations. Perfect correspondence would mean eternal existence.

If the organism could adapt itself to every change in its environment, old age and death would be impossible. It is difficult to understand the full significance of Spencer's language. Taken literally it seems to assert noth-

ing more than that death is a cessation of life. It adds nothing at all to our knowledge of the causes leading to this cessation, nor does it indicate any fruitful line of investigation. If, however, Spencer means that the fatal want of correspondence may come from without; that is, from changes in environment to which no adequate adaptation can be made by the organism, and in many passages this seems to be implied, then his view is opposed to that accepted by most physiologists. They, the physiologists, believe in general that although the environment were perfect and unchangeable, yet by virtue of inherent changes in the organism itself the assimilative powers would inevitably grow weaker and finally cease with death. In want of a more exact knowledge of the structure of the living molecule and the changes in structure which come on in old age, the physiologist expresses his ideas of the general nature of these changes by similes and metaphors more or less apt. We may compare the living organism to a clock, the mainspring of which is so constructed that in consequence of slowly developing molecular changes it suffers a gradual loss of elasticity. In such a mechanism there will come a time when "winding the clock up" will no longer make it run, since energy can no longer be stored in the spring. We may imagine this loss of elasticity to develop gradually, giving stages that may be roughly compared to the periods of life. To carry out the simile, it is the food we eat and the oxygen we breathe which take the place of the winding force. In consequence of a slowly developing molecular change in the organism, this energy is less efficiently utilized as the individual grows older. The clock runs more feebly and needs relatively more frequent winding, until at last the elasticity is gone, the power of assimilation is insufficient, and we have what we call natural death. In complex organisms like ourselves this failure of assimilation may come first to some one organ, such as the heart or the nervous system, and through its collapse the organism as a whole ceases to exist. In the nature of the case natural death cannot come to every organ of the body at the same time, so that the death of a portion, perhaps from the stand-point of weight, the larger portion of the body, must always be accidental, as, for example, from a shutting off of the blood-supply due to natural death of the heart. But this consideration does not affect the general conception of the liability of all the organs to a similar fate. Rightly or wrongly, it is, or has been, a well-nigh universal belief that every organism and every bit of living matter in an organism has only a limited duration of life, no matter how favorable the external conditions may be.

In striking opposition to this view, Weissmann, in a recent series of essays upon the duration of life, has attempted to demonstrate the essential immortality of living matter, or, in other words, to show that death is not an inherent necessity of life, but an acquisition or adaptation on the part of living things. These essays have aroused a wide-spread interest and discussion among biologists, and are probably the most important speculations of recent times upon the origin and meaning of death. Weissmann carries the problem back to the lowest forms of life, the unicellular organisms or protozoa. Whatever in this regard is true of them must be looked upon as being or as having been true for living things in general, since modern biological doctrines trace the evolution of life from these forms, and modern morphology has demonstrated that all complex forms of life are in fact mere colonies or collections of unicellular organisms. If we study one of the protozoa, the amœba for instance, which has always been taken as the archetype of life, we find that it is a complete cell; that it feeds, and assimilates, and excretes; that it increases in size, and finally reprodnces by simple fission, forming two new individuals, or daughter-cells. In this last process we have the disappearance of one old individual and the formation of two new ones, nevertheless there is no death. To speak of the disappearance of the parent cell as an example of death, as some have done, is a mere figurative use of language. There is no death in such a change, because, as Weissmann puts it, there is no corpse. If we consider the two daughter-cells produced by the fusion, we find not only that they are similar morphologically, but that each of them has possibilities of growth and reproduction equal to those shown by the parent form;—there is apparently no reason why such a process should not go on indefinitely. Amœbæ, as we find them under the microscope, show no signs of old age; the daughter-cells are not less capable of reproduction than the parent cell. It is permissible to suppose that if a single amœba were given a favorable environment it would in time produce an infinite number of descendants, each of them possessing in turn the same unlimited possibilities of multiplication. This is precisely the hypothesis which Weissmann makes when he says that living matter is potentially immortal. It is an alternative hypothesis to the one usually adopted, and Weissmann's contribution to the subject comes not so much from his adoption of this view as from the application he makes of it in considering the higher forms of life in which death is an indisputable reality. Weissmann's theory of the origin of death among the metazoa is developed directly from his hypothesis that living matter was originally incapable of natural death. His direct statement that the simplest unicellular forms of life to-day probably retain this primitive constitution of protoplasm has not, however, passed unchallenged. Maupas has made an experimental test of the statement in some very interesting observations. He set himself to observe certain unicellular animals throughout an extended period, when placed under the most favorable conditions for growth and multiplication. The infusoria were chosen for experiment. After making careful observations upon the best conditions of temperature and food, an individual was selected, placed upon a microscopic slide in a suitable moist chamber, and kept under the most favorable conditions possible for propagation. A faithful record was kept each day of the increase in number through multiplication by division of the specimen chosen for study. After the increase had reached some hundreds of individuals, one of them was again isolated and allowed to multiply, and so on until unmistakable signs of what he calls a senile degeneration became apparent in the offspring. His experiments lasted for a variable time. In no case were the observations carried over less than fourteen days, and in the case of stylonichia pustulata, upon which the most careful experiments were made, the successive progeny were cultivated for nearly five months.

The rate of growth in some of the species was incredibly fast. He estimates that in six and one-half days a single stylonichia, at a temperature of 25° to 26° C., might produce by repeated fissions a body of protoplasm weighing one kilogramme, and in thirty days a mass of protoplasm a million times larger than the sun. He was able to observe that after a certain number of generations the progeny began to show signs of a physiological decline. The new animals formed were smaller than normal, seemed weaker, were not so well provided with cilia, and the nuclei contained within them gave microscopical evidence of pathological changes. Maupas looks upon this result as proof of a genuine senility which would have resulted—had the process of isolation been continued sufficiently long—in the natural death of all the descendants, despite the most favorable conditions for living. After a colony began to show signs of old age he found that if one of the animals was taken out and mixed with another lot having a different ancestry, conjugation took place. The weakened infusorian united sexually with one of the more youthful forms, and rejuvenescence was thereby secured. The descendants of this pair multiplied again with the original vigor and gave rise to normal healthy offspring. Weissmann takes exception to these experiments. The infusoria are the most highly developed of the unicellular animals, showing a marked degree of specialization of structure. Furthermore they are known to conjugate at certain periods in their life history. A pair will come together and exchange a portion of their nuclear material, after which

each begins to multiply by simple fission with renewed vigor for a certain undetermined period. It may be that in so highly a differentiated form the primitive reproductive power of protoplasm has been specialized in a particular structure of the cell, as in the higher animals it has been reserved only to the germ-cells; so that in this regard the infusoria might be classed with the metazoa rather than with the protozoa. Moreover, it may be doubted whether Maupas really kept his captive infusoria under perfectly normal conditions. Possibly the experiment could be made with greater certainty of success in this particular by using bacteria. Granting, however, that no exception can be taken to the experiments as made by Maupas, and that his results are correct, Weissmann contends that in the more primitive forms, in which reproduction is always by simple fission and anything approximating sexual conjugation is unknown, his fundamental hypothesis must still be true—death can occur only by accident, and not by natural decay. In the amœbæ, bacteria, and similar forms of life no conjugation has been discovered. While the conditions of life are favorable, growth and multiplication go steadily on. When the conditions of life are unfavorable—*e.g.*, when moisture is withdrawn—forms like the amœba may become encysted and cease to show the properties of living matter until more favorable conditions prevail. Götte has seized upon this process of encystment as the equivalent of death, but we will speak of the theory of this author after Weissmann's theory has been stated.

Let us assume that Weissmann is right in his fundamental hypothesis, and that the first forms of life were potentially immortal, as the simplest forms of life are to-day. What, then, has become of that immortality in organisms like ourselves? What was the origin of death? Weissmann makes the supposition that in the higher animals we have two kinds of living matter, one composing the mass of the body, which unquestionably is subject to a natural death, and one composing the reproductive cells, which is evidently possessed of potential immortality, since if fertilized and kept under proper conditions it will give rise to an infinite number of descendants. The former, the mortal, he speaks of as somatoplasm, the latter, the immortal, as germ-plasm. Furthermore, he supposes that the germ-plasm, constituting the reproductive cells in any individual, is directly derived from the fertilized ovum from which that individual developed. The fertilized ovum is a single cell; by cell division it multiplies a billion-fold and more to make the body. Of this infinite number of cells those which make up the muscles, skin, etc., although directly derived from the ovum, have become specialized physiologically as well as morphologically to fit them for the performance of their special functions, and at the same time they have lost the potential power of immortality which characterized the germ-plasm of the ovum. But among this infinite number of cells there are always certain ones which do not undergo specialization; they remain like the ovum from which they were formed; they retain a portion of the germ-plasm with its powers of immortality, and these cells become the ova and spermatozoa from which new organisms may be developed in turn. If we carry back this conception through the line of ancestral forms from which man has been developed, it involves the idea that the germ-plasm has been actually continuous throughout the history of living things, and that it represents the immortal protoplasm of the unicellular forms from which the metazoa were evolved. This is the doctrine which goes by the name of the "continuity of the germ-plasm," and in the form in which it is presented makes one of the most original contributions given to biology within recent years. The question as we have it before us now may be stated in this way: The unicellular forms are potentially immortal; the many-celled animals contain an immortal germ-plasm and a mortal somatoplasm, and yet the many-celled animals have been directly derived from the unicellular forms. In the first many-celled animals produced, the different cells must have had similar properties; they must all have been equivalent to reproductive cells. But subsequently, after specialization of structure and physiological division of labor had become established, it happened that the vast majority of the cells of the body, all those in fact that had undergone differentiation in structure and function, lost the power of perfect nutrition, and became subject to old age and death. Upon what biological grounds can we explain this variation? Weissmann refers it to the operation of the law of natural selection and states his theory briefly in saying that death is an adaptation, acquired because of its utility to the race on the one hand, and, on the other hand, because, after the beginning of a differentiation in function among the cells, the possession of immortality by all the cells was no longer of any value to the race, and therefore was not brought under the preserving influence of natural selection.

With reference to the first of these reasons, the utility of death to the race, it must be borne in mind that the operation of the law of natural selection is directed entirely toward the perpetuation of the species. Anything that endangers this perpetuity will be discarded, and the duration of life of the individual is a point worth fighting for, or against, only in so far as it influences the struggle for existence of the species. If natural death had not appeared, and creatures could have been destroyed only by fatally adverse changes in their environment, then we may imagine that every species would have been burdened in its fight for existence by individuals whose physical value had been impaired by previous minor accidents, such as loss of limbs, etc. There would have been, from the pitiless stand-point of natural selection, many useless mouths to feed. Weissmann was inclined in his first essays to lay great stress upon this point, but in later years he has emphasized chiefly the second of the reasons given above, namely, that immortality was lost to the non-reproductive cells because, being of no direct value in the perpetuation of the species, they were not acted upon and preserved by natural selection. This tendency of structures to retrograde and disappear when their value to the species becomes *nil*, even though they may not be actively injurious or burdensome, because natural selection no longer acts to preserve them, is something of a new idea in biology. Weissmann attaches great importance to it, and has coined for it the term panmixia. A simple example of its action is seen in the absence of eyes in the cave-inhabiting animals. Many of the crustacea living in the dark caves have lost their eyes—by panmixia, Weissmann would say; that is, in their peculiar environment their eyes are no longer of use, and they have therefore degenerated and disappeared, in the course of generations, by the lack of the direct preservative influence of natural selection. So Weissmann thinks that the original immortality of living matter became lost to the non-reproductive cells in the many-celled animals because, being of no value to the species, indeed, on the contrary, threatening the species with an unnecessary burden, natural selection let it alone.

Many eminent biologists have found a logical difficulty in understanding how from cells originally immortal cells that were mortal could have been derived by differentiation of any kind. They hold that natural selection can only operate upon a structure which exists, it cannot create a thing outright. If living matter was all originally immortal how could natural selection, by negative or positive action, produce mortality, if in some degree this latter property was not already inherent in living matter. As one of the objectors (St. George Mivart) puts it, the difficulty is to understand the first step, the beginning of something from nothing. Objections of this kind are of course fallacious; it is curious that they should have been seriously made by eminent men. The words mortality and immortality do not stand for definite things; they are not substances or entities, or whatever term of this kind one may choose to use. On the contrary, they are in this case merely convenient phrases to express the kind of nutrition going on in living things, whether it is self-perpetuating or self-limiting. They are properties which are connected with the physical or chemical structure of the living molecule, and this latter is a thing

which does exist and may be acted upon and modified by natural selection in many ways.

In accepting or refusing Weissmann's theory of the origin of death, everything seems to depend upon the validity of his fundamental hypothesis with regard to the absence of natural death among the primitive forms of life. If we admit that there are simple organisms, such as the bacteria or amœba, which do not propagate by conjugation or by any method of multiplication other than simple fission, it would seem logically impossible for such a species to be perpetuated unless its protoplasm is exempt from senility. If we do not accept this solution, then we must suppose either that there is some kind of sexual rejuvenation which has not yet been discovered in these particular forms, or that there is some process of molecular rejuvenation occurring at periods in the life-history of such forms which brings the living substance back to its primitive constitution and nutritive vigor. Götte has clearly recognized this necessity, and has proposed a theory which is logically acceptable. According to Götte, death is a necessity immanent in life. As regards the unicellular forms of life, he avoids the difficulty which has just been described by assuming that the process of encystment is the death of the old individual and the beginning of a new one. Encystment, of course, is known to occur among the unicellular forms. During the process the visible evidences of life, such as movement, come to an end, to be renewed again after a certain period, or under more favorable conditions. Götte believes that during the encystment a change of molecular structure takes place. There is first a dissociation or dissolution, which is an actual death, inasmuch as the properties of living matter are lost. This, however, is succeeded by a stage of reconstruction with the formation of new protoplasm possessed of the primitive powers of assimilation, and capable of developing and multiplying for a certain period. This is obviously an hypothesis which it is practically impossible to test by chemical investigations. To the physiologist it will probably not be acceptable on theoretical grounds because of the difficulty of conceiving how matter once in the dead form can again pass into the living form, as the result of spontaneous molecular activities, and without the aid of an exciting or liberating force. Dead matter, as we know it, is converted into the living form only by the process of assimilation on the part of matter already living, whereas the hypothesis of Götte calls upon us to believe that the transition may take place by virtue of the inter-molecular movements in the dead matter itself. Encystment, then, according to the theory of Götte, represents at the same time the primitive form of natural death and the primitive method of reproduction. As the metazoa have been derived from the unicellular forms, he further assumes that among the former both natural death and reproduction have been acquired by direct inheritance. As in the protozoa reproduction and death stand in a causal relationship, so in the simpler forms of metazoa, *e.g.*, in the orthonectidæ, this connection is still maintained, inasmuch as the liberation of the ova results in the death of the individual. Among the higher forms the relationship between reproduction and death is not so evident, though the theory demands always a causal connection between the two processes.

It will be evident from this brief statement of Götte's views that he differs from Weissmann, not only in his belief of the necessity and universality of death, but also in respect of the discontinuity of life. Among the protozoa, which propagate by encystment, his theory denies that the new individual is directly sprung from the living substance of the parent cell. On the other hand, the general belief has been that in some way the continuity of life is maintained. Darwin's theory of pangenesis, which was formulated to explain the phenomena of heredity, implies a continuity of living matter between parent and child. It will be remembered that in this theory the ova and spermatozoa are supposed to contain minute germs, gemmules, thrown off from the different cells of the body and collected in the germ-cells. Under the proper physiological stimulation, the gemmules develop into organs like those from which they were derived. The gemmules must be considered as living matter; hence the theory implies a direct carrying over of living substance from parent to child, a continuity of living matter at least. In contrast with this the theory of Weissmann supposes a direct continuity of germ-plasm, the essential part of the germ-cells of the child being an actual portion of the germ-protoplasm of the reproductive cells of the parents. The immortality of the germ-plasm and the direct continuity of the germ-plasm, are, then, the fundamental parts of Weissmann's theory, and his hypothesis of the origin of death as regards the somatoplasm follows naturally if we accept these premises. It will be observed, however, that Darwin's pangenesis theory may also be considered as implying the essential immortality of the material composing the germ-cells, although neither Darwin himself nor those who have made use of his theory have ever made a specific statement of this kind.

In the older treatises upon the nature of death a distinction was often made between molecular death and somatic death. The former term was meant to include those changes of disassimilation or katabolism, to use a more modern word, which are supposed to be in play in every bit of living matter, and to lead to the formation of dead waste material, such as urea, carbon dioxide, and water. Somatic death was used, as it is at the present time, to describe the final cessation of all vital activities in the body at large. It was supposed that we had here the production of dead from living matter by two entirely different methods. The term molecular death is obviously an unhappy one, and has fallen into disuse, although it is possible that it is an accurate statement of what takes place. The essential nature of the physiological oxidations which lead to the formation of the products of disassimilation is at present a subject of discussion, and will probably remain so for a long time. Treating the subject in the most general way, it seems evident that in disassimilation one of two things may take place. If, for the sake of simplicity, we confine our attention to a single cell, then it is possible, on the one hand, that the formation of the wastes of nutrition is brought about by the actual death and disintegration of portions of the cytoplasm, their places being supplied by new living material formed in other parts of the cytoplasm or in the nucleoplasm. Or, on the other hand, it is equally possible that in normal disassimilation no single living molecule undergoes total destruction. The process of dissociation may be such that only a portion of the molecule is split off, and lost from the cell as dead material, while the remainder of the molecule reconstructs itself from the food material of the cell-juices into the originally complex molecule of living matter. This, in fact, is the hypothesis of physiological oxidation which has been proposed by Pflüger with special reference to the metabolisms of muscle during functional activity. His theoretical views have much to recommend them, and some account of them is usually given in the text-books of physiology.

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W. H. Howell.

DERMATOL, the trade name for the subgallate of bismuth, $BiC_7H_7O_7$, containing fifty-five per cent. of the oxide of bismuth. It is a fine, yellow powder, devoid of odor, quite insoluble in water or any of the ordinary solvents, free from irritating action, and non-poisonous.

It has been introduced to replace iodoform, on account of its freedom from many of the disagreeable qualities of that drug.

It is not a bactericide, but prevents their growth or formation, and in this way compares favorably with iodoform and aristol. Its beneficial action is due to its neutralizing the ptomaïnes produced. It is not only insoluble but also repels water, thus rendering the part unfavorable to the growth of bacteria.

It is not so suited to the treatment of sloughing or septic wounds as iodoform, nor is it sufficiently stimulating in chronic indolent ulcers. It is most serviceable to promote cicatrization in healing surfaces, and in affections of the skin; in burns, scalds, chancres, eczema, particularly when characterized by much discharge, it has been used with marked success. In these cases the parts become dry on the second or third day of its use, and the relief is very marked. If the part is previously washed with an antiseptic lotion its action is greatly assisted. It may be applied by dusting on the part, or in the form of an ointment of one part in ten. It may with advantage replace oxide of zinc, starch, etc., as a dusting powder in scalded and denuded surfaces.

In doses of thirty to ninety grains it has been given internally, as a substitute for the subnitrate, for diarrhœa in children, in phthisis, typhoid, etc., with good results. It may be given in wafers or as an emulsion.

Beaumont Small.

DIARRHŒA. If we are to credit the results of recent investigations, the symptoms and pathological conditions of diarrhœa, to a larger degree than we have supposed heretofore, are due to the products of bacterial action in the alimentary canal. It has been shown, almost conclusively, that ptomaïnes develop in the intestines during the decomposition of food in diarrhœa, as well as sometimes in the opposite condition of constipation, and the results of treatment show that in diarrhœal states those medicaments are most useful which exercise a repressive, if not a destructive action upon bacterial growth.

Numerous cases of obstinate constipation with anæmia and slight toxic symptoms have been promptly relieved by a free evacuation of the alimentary canal, and by the exhibition of antiseptic remedies like preparations of mercury, bismuth, and naphthol, strongly suggesting that some leucomaïne poison must have been produced in the intestine, or cast into it, which, being absorbed, caused the mischief, and of which the constipation prevented the regular discharge. Cases of diarrhœa are not only benefited by germicide medicines taken by the mouth, but also by similar remedies introduced in the form of large enemas.

In the treatment of diarrhœa the necessity of insuring perfect digestion of such food as is taken, and of keeping the intestinal canal free from abnormal decompositions, has been of late very much emphasized, and what we ought always to have understood is being recognized more than ever, that every particle of food taken that is not digested is a menace to the intestinal mucous membrane by the irritation its decomposition may light up.

It should be a positive condition in the treatment of all cases, especially of the more chronic forms, of diarrhœa, to obviate that sort of indigestion or disorder; and it is coming also to be recognized that such cases cannot be treated by an occasional dose of medicine, regardless of conditions and circumstances, but that the patient must be put upon a strict regimen, and that he cannot vary from it in any particular, or lose his courage or watchfulness of himself for a day, without danger of a relapse.

In the chronic cases the digestion may be conserved by various gastric and other tonics in small doses, and by peptogenic preparations, and by a most careful selection and preparation of food.

The normal condition of freedom from vicious decompositions in the intestinal canal may be conserved by moderate doses of salicylate of bismuth (2 to 5 grs.), subnitrate of bismuth (5 to 10 grs.), hydronaphthol or betanaphthol, which may be taken in doses of 5 to 20 grains, or even more, without harm, calomel ($\frac{1}{20}$ to $\frac{1}{30}$ gr.), biniodide of mercury ($\frac{1}{30}$ to $\frac{1}{60}$ gr.), or bichloride of mercury ($\frac{1}{60}$ gr.), and by salol (1 to 3 grs.), but the possible unpleasant effect of the last upon the kidneys when given in large amount should lead to caution in its use. Arsenite of copper has been highly praised of late for diarrhœa, mostly for the acute forms, in very minute doses ($\frac{1}{200}$ to $\frac{1}{100}$ gr.), frequently repeated. It is a drug of superior value, both in the acute and chronic forms, and may be taken in somewhat larger doses than those mentioned above. There would seem to be no objection to using it in small doses regularly for a long time in those cases of debility which show a tendency to diarrhœa from even the smallest variation from the usual dietary or hygienic conditions; for then its wholesome effect on the intestinal canal would be a sustained one, and the general tonic effect of the arsenic would be experienced.

It has been discovered recently that a form of amœba (amœba coli) swarms in the intestinal canal at times and causes dysentery of such a character that it is liable to be mistaken for one of the forms of diarrhœa described in the original article on this subject in Vol. II. The dejections are liable to much variety in their character, and the diarrhœa to alternate with constipation. The sanguineous and mucoid qualities of the discharges are less marked than in ordinary dysentery, although blood and thick mucus may freely appear at times. The disease lasts long and is very intractable to treatment, and the mortality is high. It is remarkably prone to produce complications, especially perforation, peritonitis, abscess of the liver, and, consecutive to it, of the lung. Fever is not a marked symptom in the disease when uncomplicated. Ulceration of the intestinal wall occurs in all bad cases, —deep excavations and underminings, but with little true suppuration. The amœbæ can easily be found in the discharges, and, of course, are the sole diagnostic sign. Their discovery in small numbers in the stools in any case would not absolutely prove that they were the cause of a diarrhœa, since they are sometimes discovered in the dejections of health. As a matter of fact, in these cases, the amœbæ swarm in the stools, as well as in the products of the abscesses of the liver and of the lung.

Injections of substances destructive to the parasites seem the most useful treatment. Their complete destruction in the walls of the intestines is evidently difficult, owing to the unavoidable obstacles to carrying effective quantities of the medicament to every nidus of their multiplication in the irregularities of the intestinal lining, as well as in the ulcers and excavations.

The treatment of many of the more chronic forms of diarrhœa by enteroclysis, or injections of sterilized water containing various medicaments, is very properly coming more into vogue. A salt solution, of 6 or 7 parts of chloride of sodium to the 1,000 of water, is best for irrigation, and weak solutions of tannic acid (1 to 3 drachms to the quart) or boric acid, for destruction or repression of micro-organisms, work best. For any ordinary case of diarrhœa it is unsafe to use corrosive sublimate or carbolic acid solutions; they are too poisonous, whereas the tannic and boric acids, in proper quantities, are quite harmless, as is also hydronaphthol, which may be used in a saturated solution. Occasionally a slight admixture of some opiate is required, but ought never to be used unless demanded by pain or irritation of some sort.

This method of medication is not by any means as difficult to use as it would seem, since almost an unlimited amount of water can easily be introduced into the bowel, provided the patient is horizontal, and the movement of the water into the body is extremely slow, and the stream perfectly continuous from a fountain syringe, the reservoir of which is elevated but a few inches. No pulsating stream will do; the water must be, when it reaches the intestine, as warm as the body, and may be two degrees above the normal heat; it must be at least four degrees above normal body heat as it leaves the bag. If

too much is introduced for the large intestine to contain, it readily passes the ileocæcal valve into the small intestine, and, if further relief is required, into the stomach and out through the mouth. With the precautions named, all the tenesmus disappears, and even little children receive the treatment without complaint. But slowness of introduction of the water is a precaution never to be forgotten.

The method has several distinct advantages: it washes the intestines free of mucus and decomposing and decomposed substances of numerous kinds; it washes away vast myriads of microbes, which may be wholly or in part responsible for keeping up the diarrhœa, if not of causing it originally; and it kills or lessens the growth and virulence of swarms of them that remain. In dysentery, especially, a treatment of this sort is in the highest degree useful when practised once or twice each day, particularly when the tannic acid is used; only, to be most effective, it should be often repeated, or, better still, employed as an irrigation with a long double tube, having a large and free outflow. This procedure should be carried out once or twice each day.

The treatment, moreover, is a rational application of the principles so effective on other parts of the body, namely, a thorough cleansing of inflamed surfaces, the removal from them of substances, however produced, which are capable of causing irritation, and the soothing of them by appropriate medicines.

There is perhaps no form of diarrhœa where the carrying out of these principles is more demanded than in the summer diarrhœas of children, often improperly called cholera infantum, and in these this treatment deserves a freer trial. But in this class of patients it is specially important that the treatment be carried out with care, caution, and faithfulness. It unavoidably requires the hand of the physician or of a most carefully instructed nurse.

The frequency of the injections should depend on the effect. The effect of each one should be to quiet the irritation for a number of hours, and during this time the bowel should remain unmolested, the treatment being repeated on a recurrence of the symptoms.

No attempt should ever be made to pass a tube through the sigmoid flexure. The effort is rarely successful, and the danger from the use of a hard tube is great.

Norman Bridge.

DIEPPE. A fashionable watering-place, and one of the favorite sea-side resorts of the Parisian "monde." It is prettily situated on the coast of Normandy, at the mouth of the river d'Orques, and between high calcareous cliffs. The bathing season lasts from June to September. To quote from Baughan ("The Northern Watering-Places of France"): "The life of the place seems concentrated on the beach, and at the *Établissement des Bains de Mer*. The beach is quite a mile long, and extends from the timber-yards near the jetty to the foot of the high cliff on which stands the Château, a picturesque old building with a square tower, now used as a barrack. The beach at Dieppe was once but a stretch of meadow-land, but now it is a fine promenade, laid out as an English garden, and bordered by stately hotels. Trees would be an improvement, but of these there are none, which is a pity, for the heat at noontide along the unshaded promenade is something not to be endured. There is a wide and beautiful expanse of sea at Dieppe, and though the beach at high tide is of bowlders, when the sea goes out there are sands, but the bathing at high tide is, of course, on the bowlders, and this is one of the greatest disadvantages of Dieppe.

"The Casino and the Établissement des Bains de Mer are the property of the town, and they are charmingly managed. They are to the southwest of the beach—just beneath the cliff on which stands the Château. The Établissement is built in imitation of the Crystal Palace, London, and contains a theatre and ball-room, several charming salons, a billiard-room, and a reading-room. It is surrounded by a well-laid-out garden, where there is a place set apart for children's sports, a gymnasium, and several pavilions where different games are played."

Accommodation.—The principal hotels are the Royal, l'Hôtel de Bristol, le Grand Hôtel des Bains, l'Hôtel de la Plage, and le Grand Hôtel de Dieppe. All these hotels are situated along the beach, and are expensive. L'Hôtel du Nord, Quai Henri IV.; l'Hôtel de la Paix, Grande Rue; and l'Hôtel du Géant, Rue de Chêne-Percé, are more moderate.

Numerous interesting excursions can be made into the surrounding country. Of late years many English and American visitors are seen at Dieppe.

Edmund C. Wendt.

DIGESTION. The changes and additions now contributed to the articles furnished by the writer to the subject of "Digestion," the "Digestive Secretions," etc., are rendered necessary, in part, by the increase in our knowledge from new observations and experiments, but still more owing to an alteration in the point of view that must, sooner or later, work great, if not radical, changes in the whole of physiology.

It is now being perceived that it is impossible to explain vital processes entirely by the laws of physics and chemistry. The attempt to do so has led physiologists aside from the true path, and we are now obliged to confess failure and seek other ways.

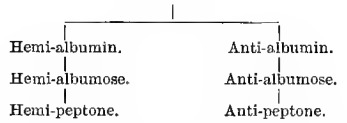
There is also a hopeful broadening taking place; and it is not so common as it was to assume that, what holds for one animal applies to others, even though alike in many respects. Greater caution and breadth, and a truer insight, with less hasty generalization, will probably mark the physiology of the future.

This has been very clearly illustrated by the views recently published on the subject of digestion, as the writer will endeavor to show.

It would seem that we have been too ready to accept simple explanations, and to consider life processes as much less complicated than more recent investigations show them to be.

Proteid Digestion.—It is still held that in peptic digestion, peptone, or more properly peptones, are the final products of the action of gastric juice on proteids; and that the process of digestion is one of hydration; but between albumin on the one hand and peptones on the other, there are now recognized several bodies of distinct properties.

The following tabular statement embodies the most recent views, and indicates the antecedents of the final peptones:



Hemi-peptone may, by the pancreatic secretion, be split up into leucine, tyrosin, etc., but this is not true of anti-peptone.

Albumoses may be classified chemically, according to the action on them of different reagents, thus:

1. *Proto-albumose.*—Soluble in cold and hot water, and in dilute saline solutions; precipitated by saturation with magnesium sulphate or sodium chloride.

2. *Hetero-albumose.*—Insoluble in water; soluble in cold solutions of sodium chloride of a strength of from one-half to fifteen per cent.; precipitated by heating to 65° C., the coagulum being soluble in dilute acids and alkalies. It is precipitated by alcohol, but, unlike other albumoses, is thus altered to an insoluble body, dysalbumose. Like the preceding, it is precipitated by saturation with neutral salts.

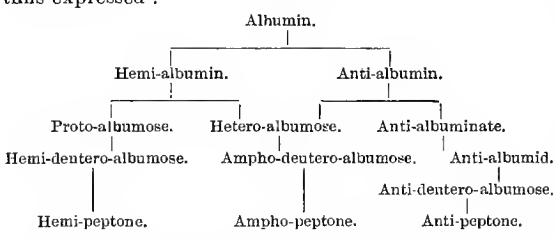
3. *Deutero-albumose.*—Soluble in cold and hot water; not precipitated by saturation with sodium chloride or magnesium sulphate, but thrown down by saturation with ammonium sulphate.

It is in its reactions allied to the peptones, for it is not precipitated by copper sulphate, and only gives the nitric acid reaction in the presence of excess of salts.

Variety of proteid.	Hot and cold water.	Hot and cold saline solution, *e.g.*, 10 per cent. Na Cl.	Saturation with Na Cl or Mg SO_4.	Saturation with Am_2 SO_4.	Nitric acid.	Copper sulphate.	Copper sulphate and ammonia.	Copper sulphate and caustic soda or potash.
Albumins.	Soluble in cold, coagulated in hot, water.	Soluble in cold, coagulated in hot, solutions.	Not precipitated.	Precipitated.	Precipitated in cold, not soluble on heating or only slightly.	Precipitated.	Blue solution.	Violet solution.
Globulins.	Not soluble in either.	The same as albumins.	Precipitated.	Precipitated.	The same as albumins.	The same as albumins.	The same as albumins.	The same as albumins.
Proto-albumose.	Soluble in both.	Soluble in both.	Precipitated.	Precipitated.	Precipitated in cold; precipitate dissolves with heat and reappears on cooling.	Precipitated.	Violet solution.	Rose-red solution.
Hetero-albumose.	Insoluble, *i.e.*, like globulins, precipitable by dialysis from saline solutions.	Soluble in both; partly precipitated, but not coagulated on heating to 65° C.	Precipitated.	Precipitated.	Precipitated in cold; precipitate dissolved with heat and reappears on cooling.	Precipitated.	Violet solution.	Rose-red solution.
Deutero-albumose.	Soluble.	Soluble.	Not precipitated.	Precipitated.	This reaction only occurs in presence of excess of salt.	Not precipitated.	Violet solution.	Rose-red solution.
Peptone.	Soluble.	Soluble.	Not precipitated.	Not precipitated.	Not precipitated.	Not precipitated.	Violet solution.	Rose-red solution.

The above table, from Halliburtin's "Chemical Physiology and Pathology," puts the most recent information in a compact form.

According to Neumeister, the relations of the various proteid bodies formed in the digestive process may be thus expressed :



From the above table it appears that albumin is made up of hemi-albumin and anti-albumin, and the subsequent changes of each are indicated down to the final products in peptones, and all are to be regarded as stages in a hydration process.

Primary albumoses are those formed directly from albumin, *i.e.*, proto-albumose and hetero-albumose. Although this table shows that digestion is now regarded as a much more complex process than formerly, it seems to the writer that what we have ascertained is rather an indication of possibilities than actualities, and that our views may be expected to undergo great changes, if they are not shown to be wholly inadequate. It is also likely that the process of digestion of proteids may vary much for individuals, or even in the same individual at different times, not to mention differences for unlike groups of animals. But certain it is, that a modest and expectant attitude, in view of the radical modifications that have recently taken place in our ideas with regard to this subject, is the only correct one.

Besides, it is more and more apparent that conclusions founded on artificial or laboratory digestion are to be drawn with the greatest care.

Digestion of Fat.—Owing to the more rational view now taken with regard to digestion generally, and with regard to the true nature of absorption, the digestion of fat is more readily comprehensible, though no very new light has been thrown on the action of those digestive juices that are concerned in altering the ingested fat.

Though the pancreatic juice, especially when mixed with bile, has the power of splitting up neutral fats into fatty acids and glycerine, from which result a certain proportion of soaps, yet there is reason to believe that the greater part of the fat finds its way into the blood as a very fine emulsion, or even as "molecular fat."

The fact that, even in the absence of bile or pancreatic juice, some fat digestion may, if not at first, eventually take place in an animal, shows that we have been regarding digestion too much in a purely chemical light.

Bile.—The tendency, in view of recent researches, is rather to confirm the opinions of those that held that the bile itself takes no essential part in digestion, though helpful to the pancreatic juice; at the same time it must be said that a conservative attitude is the most justifiable one at present.

Fæces.—Though actual experiment has not recently brought to light much that is new in regard to the composition of fæces, it is still clear to the writer's mind that the facts of clinical medicine indicate that many harmful products are in all probability discharged from the body by means of the intestines. In other words, we must regard the intestine as a great excreting as well as secreting surface, and must believe that the fæces contain not only some of the altered digestive secretions and the indigestible remnants of the food, but possibly numerous products of tissue-waste, either as they were formed in the cells of the various tissues, or as they were modified by the glandular and possibly other cells of the gut.

A subject of which some notice may be taken is self-digestion of the stomach, etc. This is all the more necessary as the views that formerly prevailed indicate how much was overlooked. In this connection the writer begs leave to introduce an extract from his "Animal Physiology" (D. Appleton & Co., New York, 1889).

"*Self-Digestion of the Digestive Organs.*—It has been found, both in man and other mammals, that when death follows in a healthy subject while gastric digestion is in active progress and the body is kept warm, a part of the stomach itself, and often adjacent organs, are digested, and the question is constantly being raised, Why does not the stomach digest itself during life? To this it has been answered that the gastric juice is constantly being neutralized by the alkaline blood; and, again, that the very vitality of a tissue gives it the necessary resisting powers, a view contradicted by an experiment which is conclusive. If the legs of a living frog be allowed to hang against the inner walls of the stomach of a mammal, when gastric digestion is going on, they will be digested.

"The first view (the alkalinity of the blood) would

not suffice to explain why the pancreas, the secretion of which acts best in an alkaline medium, should not be digested.

"It seems to us there is a good deal of misconception about the facts of the case. Observation on St. Martin shows that the secretion of gastric juice runs parallel with the need of it, as dependent on the introduction of food, its quantity, quality, etc. Now, there can be little doubt that, if the stomach were abundantly bathed, when empty, with a large quantity of its own acid secretion, it would suffer to some extent at least. But this is never the case; the juice is carried off and mixed with the food. This food is in constant motion, and doubtless the inner portions of the cells—which may be regarded as the discharging region, the outer, next the blood-capillaries, being the chief manufacturing region of the digestive ferment—are frequently renewed.

"Such considerations, though they seem to have been somewhat left out of the case, do not go to the bottom of the matter. Amœba and kindred organisms do not digest themselves. Some believe that the little pulsatile vacuoles of the infusorians are a sort of temporary digestive cavities.

"But, to one who sees in the light of evolution, it must be clear that a structure could not have been evolved that would be self-destructive.

"The difficulty here is that which lies at the very basis of all life. We might ask, Why do living things live, since they are constantly threatened with destruction from within as from without? Why do not the liver, kidney, and other glands that secrete noxious substances, poison themselves? We cannot in detail explain these things; but we wish to make it clear that the difficulty as regards the stomach is not peculiar to that gland, and that even from the ordinary point of view it has been exaggerated."

The Movements of the Alimentary Tract and the Nervous Mechanisms Concerned.—So far as the movements of the tract are concerned, we find a localization of function with an interdependence corresponding to anatomical differentiations. The movements of the œsophagus and stomach, for example, are more independent than those of the rest of the digestive canal. Peristalsis naturally takes place in the region lying between the stomach and the cæcum, while the large gut, and especially the sigmoid flexure of the colon and the rectum, have a subordinate degree of independence in this respect.

The nervous supply is more or less distinct in those regions of greatest localization of movement. Nevertheless we recognize both in health and in disease, even in such parts as the small intestine, that there is a tendency for the peristalsis to be confined to one region, temporarily in health, but for a protracted period of time in disease, as in colic.

There is little new to add to what appeared in the original article on the movements of the œsophagus or the nerves concerned, and we have still a great deal to learn about the innervation of the stomach.

Gaskell, acting on the suggestion furnished by the double nerve-supply of the heart, has projected a scheme for the sympathetic system which, as applied to the alimentary canal, has already yielded some definite results, and it seems probable that it will be shown that there is to this long muscular tube, as to the less obviously similarly formed organ the heart (tubular in embryonic life and also derived from the mesoblast), a double nervous supply of motor or augmenter and inhibitory fibres.

The more we learn of the vagus, the more wonderful a nervous path does it appear to be. It contains both afferent and efferent fibres for the alimentary canal, fibres which seem to be continued through nerves bearing other names, as the splanchnic, to a very wide distribution.

Fig. 151 gives in a highly diagrammatic form the most recently known facts regarding the innervation of the alimentary tract. Physiologists are not yet thoroughly agreed as to the true nature of the intestinal movements. The fact that they will take place in an isolated loop of intestine, that they are augmented by conditions producing an increase in waste products, notably carbon dioxide, as in asphyxia, suggest that they may be independent of the central nervous system, yet usually more or less under its control.

The functions of the ganglia in the intestinal walls are no more known than are those in the heart. Nevertheless, the writer is inclined to believe that it will ultimately be considered that nearly all functions are in a sense reflex, *i.e.*, dependent on stimuli reaching a centre and determining the nature of the outgoing impulses. But in this there are all degrees. The cardiac and intestinal movements are so readily induced in any case that their essentially reflex character may not be so obvious; and it is not surprising that some have been

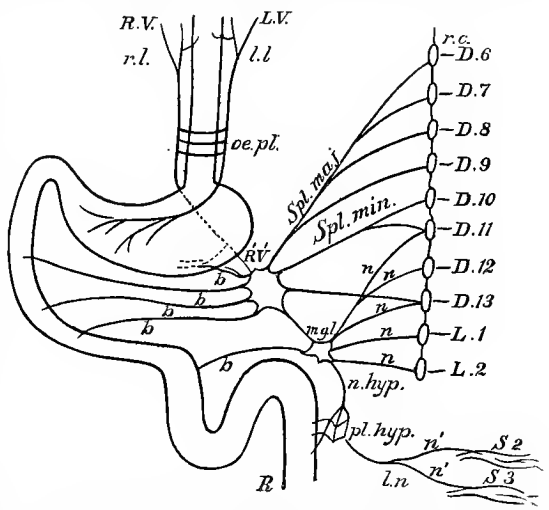


Fig. 151.—The whole is purely diagrammatic, which renders the comprehension of the general plan simpler. *L. V.*, left vagus, passing to the anterior aspect of the stomach; *R. V.*, right vagus, communicating with left vagus in œsophageal plexus, *œ. pl.*, and supplying the posterior part of stomach, then continued (*R' V'*) to solar plexus, represented by a single ganglion, and connected with the inferior mesenteric ganglion (plexus), *m. gl.*; branches from solar plexus to stomach and small intestine, and from mesenteric ganglion to large intestine, represented by *b*; *Spl. maj.*, large splanchnic nerve from thoracic ganglia, and *r. c.*, rami communicantes from sixth to tenth dorsal; *Spl. min.*, small splanchnic nerve arising in like manner from tenth and eleventh dorsal nerves (these both join the solar plexus and thence make their way to the digestive tract); *n*, nerves from the ganglia, etc., belonging to tenth, twelfth, and thirteenth dorsal and first and second lumbar nerves, reaching the inferior mesenteric ganglia (plexus) and thence proceeding by the hypogastric nerves, *n. hyp.*, and hypogastric plexus, *pl. hyp.*, to the circular muscles of the rectum; *n'*, nerves from the second and third dorsal nerves (*S2*, *S3*, *nervi erigentes*), reaching the longitudinal muscles of the rectum by the hypogastric plexus. (Modified from Foster.)

inclined to hold to an independence of rhythm that is not natural but peculiar to the laboratory. At the same time they are not reflex in the same sense or degree as the movements of striped muscle may be. Experiments seem to show that in the vagus are found augmenter (motor) fibres for the intestine, and in the splanchnic both major and minor inhibitory fibres, since stimulation of the former causes movements of the gut, and of the latter, arrest of the same.

It is certain that the splanchnic nerves are the paths of vaso-constrictor (augmenter) impulses to the blood-vessels of the gut, and probable that dilator (inhibitory) fibres are found in the vagus, which would correspond somewhat to the cardiac innervation.

As regards the rectum, we are in possession of more definite knowledge. So far as the dog is concerned, and it is not likely that there is any essential difference for man, the longitudinal fibres of the rectum are under the control of fibres which are found in the anterior roots of the second and third sacral nerves (Fig. 151, *S2*, *S3*) and pass along the *nervi erigentes* to the hypogastric plexus (*pl. hyp.*), and so reach the lower gut. Stimulation of

these nerves leads to contraction that pulls down the rectum, owing to the action of the longitudinal muscular fibres.

The supply to the circular fibres is derived from nerves which leave the spinal cord by the lower dorsal and upper lumbar (Fig. 151) nerves, and pass to the rectum by the inferior mesenteric ganglia, the hypogastric nerves, and hypogastric plexus (*m. gl., n. hyp., pl. hyp.*). The fibres lose their medullary sheath before reaching the gut. Stimulation of this set leads to contraction of the circular fibres only, and results in the contents of the gut being squeezed out.

As is well known, disease of the central nervous system is apt to be followed by obstinate constipation, so that it seems clear that the sigmoid flexure of the colon and the rectum, at all events, are governed by a reflex mechanism. It is likely that a similar mechanism will eventually be shown to exist for the small intestine, and possibly the stomach.

The Removal of Altered Products from the Alimentary Canal, or Absorption.—The final products of digestion, as this term is commonly understood, are peptones, sugar, and emulsified fats, principally. Till recently it has been customary to teach that peptone was absorbed by the capillaries, and passed as such into the blood-stream; that sugar disappeared in the same manner; and that the work of the villi—at all events of their columnar cells and structures other than the blood-vessels—was largely confined to the removal of fat.

There was always a great difficulty in showing the presence of peptone in the blood-stream at all, even when digestion was in full progress; while more recent researches have made it clear that the injection of peptone, the product of artificial digestion, results in undoubted poisoning.

According to some investigators, peptone and albumoses are absent from blood and lymph during even the most active digestion.

This brings us to consider the real nature of so-called absorption. It has all along, till very recently, been assumed that "animal membranes," in which the intestine was included, acted very much as a piece of parchment, and that osmosis was the great force that determined absorption.

Certain experiments showing changes in peptone when placed in contact with the walls of an isolated loop of intestine, or even pieces of the mucous membrane, tended to shake the older views.

Recently, however, the whole subject of absorption has undergone a revision.

Not to mention the fact that certain salts and other bodies disappear from the intestine at a rate altogether different from what would be expected from their osmotic equivalent, peptone itself is found to leave the living gut much faster than through any diffusive septum.

For an account of experiments bearing on this subject which is easily accessible, the reader is referred to the outline of Dr. Weymouth Reed's researches, published in the *British Medical Journal* for February 13 and May 28, 1892. (See also *Journal of Physiology*, vol. xi., p. 312.) Dr. Reed in the first series of experiments used frog's skin, and showed that the rate of transfer of fluid through the living skin was not in accordance with the laws of osmosis.

Later, he showed that the mucous membrane of the intestine of a rabbit killed during full digestion, when exsected, does act differently from a diffusive septum; *i.e.*, even the removal of a saline fluid does not follow ordinary physical laws, or, in other words, it is a vital process.

The absorption of the fat and the functions of the villi are questions still under discussion. The "striated border" of the columnar cells has always been regarded as playing some important *rôle* in absorption, though exactly what, was not and is not yet known. Heidenhain, in some elaborate researches on the whole subject of the structure and functions of the intestinal mucous membrane (*Pflüger's Archiv*, Bd. xliii., Suppl. Heft) concludes that this striated border is made up of rods set vertically to the plane of the mucous membrane, and a homogeneous substance between them, and that either the one or the other may be withdrawn within the cell. Nevertheless the meaning of the striated border functionally has not been made clearer. There is still difference of opinion as to the part leucocytes play in the absorption of fats.

The writer believes that he was the first to teach dissent from the ordinary views on the subject of digestion and absorption, and to give expression to this in print. (See "Animal Physiology," chapter on the "Removal of Digested Products from the Alimentary Canal," etc.; "The Blood and Blood-vessels in Health and Disease," *New York Medical Journal*, September 13, 1890.)

Briefly, the views the author has held for some six years are these: The laws of physics and chemistry as ordinarily understood will not explain vital phenomena. In seeking for explanations of physiological processes we must bear in mind the course of evolution in animals and the embryological development of the organism. Accordingly, it is not possible to conceive of osmosis, etc., as an explanation of any vital phenomenon. The only solution that is in accordance with facts, is that the capillaries are not merely channels for blood, but are real constructive, ingestive, and secreting mechanisms (glands), and are such in the alimentary tract as well as elsewhere. In explaining digestion in mammals we must not forget the nature of the process in lower forms, even in amœba itself. Intra-cellular digestion, well illustrated in the invertebrates (amœba, hydra, etc.), probably exists in some degree in all animals. Taking this view, the digestion of fats and the absorption of fats become more readily comprehensible. If the capillaries are glands, if their cells be considered as not devoid of living properties, we can understand that they may convert peptones into something else, and so of all the cells that make up the alimentary tract. It is likely that we have hitherto not only been artificial in our views of the nature of digestion and absorption, but have in our conceptions restricted the work far too much both as regards the cells actually involved and the nature of the processes they perform. They do secrete fluids that are digestive, but they or other cells may also cause changes of products within themselves as in the invertebrate series of animals. It is infinitely better to be satisfied with views that are somewhat vague and general than with others more definite, but narrow and out of harmony with the great fundamental conceptions of modern biology. Time and patient research will remedy the former, because we are in this case on the right track, but having started wrong, we may continue so, as indeed we have for long enough, and with great detriment to practical medicine as well as to physiological science.

Since these views were taught by the writer a great change has come over physiology in this very quarter, though it has not extended equally to other departments. The leading English writers on physiology are embodying such views in the latest editions of their works.

As the writer years ago suggested, it would probably be well if we were to discard the term "absorption," at all events as applied to the digestive tract.

"Digestion waits on appetite," *i.e.*, the work of the alimentary canal is largely dependent on the condition of the tissues generally, a truth that it was quite impossible to harmonize in any broad way with the older views of digestion and absorption, but plain enough in the light of what physiologists are now beginning to perceive. After all, in so complicated a process as digestion, "experiments" can only go a certain distance. They are a guide, and tend to confirm rather than to "demonstrate," a term that has been somewhat misleading in physiology.

Summary.—Digestion in mammals is made up of a series of processes, part of which result in fluids being poured out which produce chemical changes in foodstuffs which are more complicated than was once supposed, as has been proved in the case of proteids; followed by other changes, which are intra-cellular and largely unknown in their exact nature, but generally

comprehensible in the light of evolution and embryology, and by bearing in mind that the processes and tissues of the body are related, and in higher animals are under the dominion of the nervous system. Digestion and absorption cannot be separated by any sharp line of demarcation.

That starches are converted into sugar, proteids into peptone, fat emulsified and saponified, are truths so far as they go, but probably take us but a little way into the real nature of digestion.

An abundant blood-supply is a usual accompaniment of the act of secretion, but is not absolutely essential to it.

The whole process of digestion is under the control of the nervous system in the higher animals, including man, in the action of which we must largely recognize reflex processes.

The whole process of the final elaboration of food (absorption) is better understood by remembering the nature of intra-cellular digestion in unicellular and the simpler multicellular animals, and the true nature of capillaries and the cells of which they are composed, and by avoiding conceptions that tend to narrow the work of nature down to the limits of the laboratory. *T. Wesley Mills.*

DIGESTION, DISORDERS OF. Within the past few years some advance has been made in the study of disorders of digestion due to faulty action of the stomach, through the use of the stomach-tube. The methods to be referred to are not to be advised in all, and probably not in the majority of, cases of dyspepsia, because, 1, they are often unnecessary ; 2, they are disagreeable to the patient ; 3, they are (very rarely) dangerous from the possibility of (*a*) injury to the stomach in case of an unsuspected ulceration ; (*b*) inhalation pneumonia from a sudden retching with the œsophageal tube *in situ*, causing food to be drawn into the trachea ; and (*c*) death from the actual nervous shock of this seemingly trivial operation.

Moreover, these methods of examination involve much time and labor for the physician, so that they have not come into general employment, and are at present probably practised chiefly in hospitals where plenty of trained assistants are available. But all these reasons are insufficient to warrant the omission of such examinations in obscure cases which have resisted other clinical study. It is only as conjoined with the clinical evidence that these chemico-physiological researches are to be taken as evidence, for, as has often been said, " the stomach is not a test-tube."

Unfortunately, as in so many other fields of medicine, the therapeutic results of these newer methods of research have as yet been incommensurate with their scientific interest.

The mechanical means for becoming acquainted with the contents of the stomach is a soft, flexible-rubber tube or catheter, twenty-five to thirty inches in length, having bevelled eyelets. It is introduced into the pharynx, either simply warmed or lubricated with warm milk, and " fed " to the patient as the latter goes through the motion of deglutition. Care must be taken that it be introduced so that its end reaches below the level of the fluid to be withdrawn, and that it be not pushed in so far as to curl up and bring its extremity again above the surface of the liquid.

The tube introduced, the stomach-contents are removed either by expression, aided perhaps by cough, or by aspiration. The fluid, which should be a half-ounce or more in quantity, is filtered, and reserved for further chemical examination. With this object in view the time of obtaining the specimen is important. Some authorities, notably Ewald, favor a small " test breakfast," consisting of a two-ounce roll and ten ounces of water or green tea, the tube to be passed one hour after the meal ; others, following Leube, believe that a more generous meal is necessary to call out the full digestive capacity, and advise a meal of twelve ounces of soup, two ounces of scraped beef, and about as much bread, the specimen to be withdrawn in four hours.

The fluid thus obtained may be subjected to the following tests :

1. *For Digestive Power.*—By putting the stomach fluid in a test-tube at the temperature of 99° F., adding a quantity of shredded egg-albumin, and noting the period of completed digestion ; this test may be controlled by others in which the fluid is acidulated with HCl, and by other tests with presumably normal gastric juice, the quantities of albumin used being constant. This is a test of the pepsine strength of the fluid, but it is practically found that the pepsine and other ferments have a pretty constant relation to the HCl strength, so that especial attention is directed to the latter constituent, which is more capable of exact determination.

2. *For General Acidity.*—To be tested by litmus or Congo red paper. This does not distinguish between the different kinds of acids, whether HCl or lactic, but if the Congo paper, for instance, is turned a deep blue, it may be interpreted to mean that there is enough HCl for the purposes of digestion.

3. *For Free HCl.*—Of many tests which have been suggested, I mention but one, the phloro-glucin-vanillin test. A solution consisting of two gms. phloro-glucin, one gm. vanillin, and thirty gms. absolute alcohol is prepared. A few drops of this are warmed in a white porcelain dish, with a cubic centimetre of the gastric fluid, when, if free HCl is present, a red color appears with the deposit of deep red crystals. This test is exceedingly delicate, and does not apply to any of the organic acids.

4. *Quantitative Test for HCl.*—The per cent. of this acid normally existing in the gastric juice has been variously stated, but may be assumed as about 0.2 per cent., with moderate limits of variation in either direction. Special importance attaches to its marked diminution or absence. At the period of full digestion HCl should be the only free acid in the stomach.

A roughly quantitative estimate of HCl may be made by diluting the gastric juice to a definitely measured amount, till it produces merely a yellowish sediment instead of one of a bright rose color. The weakest solution capable of producing a distinct tinge is 1 in 20,000. If, then, a given specimen has been diluted ten times to give this color, it originally contained .0005 of HCl.

For the accurate estimation of free HCl in the absence of other acids, a standard solution called the deci-normal solution of sodium hydrate is employed. Each cubic centimetre of this will neutralize .00364 gm. of absolute HCl. Into 10 c.c. of gastric fluid are dropped from a bottle enough of the alkaline solution to exactly neutralize it (the neutralization being determined either (*a*) by litmus paper, or better (*b*) by an alcoholic solution of phenolphthalleïn, which latter substance has the property of developing in alkaline solution a brilliant carmine color, which is absent in acid or neutral solutions). The point of exact neutralization being noted, the quantity of alkaline solution is observed ; *e.g.*, if 7 c.c. were required, there was in the 10 c.c. of stomach fluid .0255 gm. of HCl, or in 1 c.c., .00255, or about a quarter of one per cent.—rather a large quantity. Unfortunately this process is applicable only in the absence of the organic acids. If they are present their removal requires distillation of the stomach contents and the removal of the organic acids by ether.

5. *For Lactic Acid.*—The presence, however, of *lactic acid* may be demonstrated by mixing with a weak aqueous solution of chloride of iron a two per cent. carbolic acid solution. If gastric juice containing nitric acid be added to this a yellow color is produced. This test responds to a strength of lactic acid equal to $\frac{1}{4000}$, and is so delicate that the coincident presence of HCl does not usually interfere with it.

What is the significance of these conditions of acidity in the gastric juice ? Here we have to acknowledge considerable uncertainty. Absence of free HCl does not prove that none has been secreted ; for it is possible for it to have entered into combination with certain bases, and thus to have only seemed to be wanting. A few years ago it was claimed as a diagnostic point of great importance that cancer of the stomach was the cause, and

the only cause, of absence of HCl in the contents. But later observations go to show that this absence indicates a large extent rather than any special nature of structural lesion. While it is generally reduced in quantity, if not wanting, in cases of cancer, it may also disappear for months in gastric catarrh, and even in so-called nervous dyspepsia.

Riegel has claimed that in gastric ulcer the proportion of HCl is always abnormally high. Ewald has shown that it is generally in excess and always present. A conservative view would be that in a case clinically in doubt between ulcer and cancer, the presence of free HCl in large, or even in moderate amount, would be evidence of considerable weight in favor of ulcer.

Hyperacidity is a term applied to an increase in the proportion of HCl at the height of digestion; hypersecretion, to an increase in the amount of gastric juice, either continuous or occasional, and irrespective of the ingestion of food. The former may exist without the latter; but the latter generally presupposes the former. Hyperacidity, of course, contraindicates the exhibition of HCl, and calls for alkalies. Hypersecretion is to be suspected when, after thorough washing of the stomach, and some hours' fasting, a considerable quantity of gastric fluid can be expressed. This fluid is said to be generally acid, and capable of digesting albumin in the test-tube. Its presence is accompanied clinically by symptoms of pyrosis, eructations, and pain, and it occurs in some cases of so-called "nervous dyspepsia." It may be a cause of gastric dilatation. Lavage is the appropriate treatment both before and after the production of the ectasia.

The *duration of digestion* can be investigated only through the use of the stomach-tube. Seven hours should be enough to accomplish the complete digestion of any meal, and after that interval the stomach should be empty. The tube will show whether it is so. Undue quickness of digestion, while it can be detected through the same means, is of much less clinical significance.

Other evidence of value obtainable through the use of the stomach-tube relates to the size and position of the stomach. If the stomach be washed out, and so far as possible emptied, it can be inflated and its boundaries thus be made evident to percussion by attaching an ordinary rubber bulb syringe and injecting air till the organ is moderately distended. The advantage of this method over that of the separate introduction of powders which shall effervesce when conjoined is sufficiently obvious; the former method being less painful and being under the perfect control of the physician through the tube, which can be unstopped at any time. After the area of tympanites has been marked out, a small quantity of water can be introduced which will of course seek the lower border of the stomach and displace the air, thus substituting flatness for tympanites. Normally, but subject to considerable physiological variation, the cardiac orifice lies opposite the inner border of the seventh left rib; the pylorus a little below the margin of the liver, within a line connecting the right nipple with the umbilicus, the greater curvature reaching nearly to the umbilicus. But in cases of dilatation the greater curvature may extend to the sigmoid flexure. The significance of gastric dilatation is obstructed peristalsis. This is due to causes *a fronte*, chief of which is pyloric stenosis (usually malignant, less often from cicatrized ulcers), or else to causes *a tergo*, of which the commonest is lack of muscular tone.

The *kinesis*, or motor power of the stomach, is closely related in an inverse ratio to its dilatation. A test which has been used for measuring this power is the following: Salol is administered by the mouth. So long as it remains in acid gastric juice it is unaffected, but as soon as it passes out into the alkaline juices of the duodenum it forms salicylic acid, which is promptly eliminated by the kidneys. The test, applied to specimens of urine passed every fifteen minutes, is a drop of the tincture of chloride of iron added to the urine, which, when salicylic acid is present, strikes a deep red-brown color. Normally it is said that this occurs in thirty to forty-five minutes after the ingestion of the salol. But it is probable that this test, to show the actual motor power of the stomach, should be made to include the time necessary to secure the expulsion from the stomach of *all* the salol swallowed, and as the time needed for recovering this total amount of salicylic acid includes the time for emptying the stomach plus that of renal elimination, the test is left open to some doubt.

The *absorptive power* of the stomach may be very well shown by the iodine test. Five grains of iodide of potassium are administered in a gelatine capsule, which must be thoroughly wiped after it has been filled, so that none of the drug shall escape into the mouth. Beginning just before the capsule is swallowed, and at intervals of three or five minutes, the patient spits upon a piece of filter paper, which has been dipped into a solution of starch. These pieces of paper, numbered to distinguish them, are tested with a drop of fuming nitric acid. This sets free the iodine (if any exist) in the saliva, and a blue color is formed with the starch. When the absorptive power of the stomach is good, iodine should appear in the saliva in fifteen minutes.

Charles F. Withington.

DIGITALIS. Digitalis continues to maintain its position at the head of heart tonics. In England and America authorities are as one on this point. On the continent they are the same. Dujardin-Beaumetz assigns it the first rank and calls it "the type of heart tonics;" Professor Nothnagel places it above all other heart tonics, and Herr Fürbringer says, "the sovereign diuretic in cardiac disease has been, and still is, digitalis." Continued use has confirmed the confidence placed in it, and the innumerable rivals that appear serve only to bring its superior qualities into bolder relief. Not much has been added to the uses of this remedy, but we know more definitely its proper sphere, and apply it with more precision to the conditions in which it will prove of value.

In organic disease of the heart the guide for its use is the state of the compensatory action of that organ. It is not given as a remedy for the defective valves, nor with the expectation of benefiting any diseased condition of the organ; it is simply a stimulant and tonic to the muscular tissue. So long as the heart is able to overcome the impediment to the circulation and maintain a free flow of blood, nothing is to be gained by the use of the drug, but, with the earliest symptoms of failing power its administration must be commenced. The system responds quickly to the first indication of this loss of compensation, the heart beats more feebly and quicker, the pulse becomes irregular, a slight degree of dyspnœa is noticed, and œdema of the feet and ankles begins. In such conditions the beneficial action of digitalis is most marked. The heart beats more slowly and forcibly and propels the blood onward, the arteries become filled, the engorged veins relieved, and the equilibrium of the circulation is re-established. This slower action of the heart allows of a prolonged period of diastole, during which it is at rest and recuperating; the succeeding contraction is rapid and strong, due to the renewed strength and stimulating action of the remedy.

No form of organic disease contraindicates the use of digitalis when the compensatory action is failing. Its typical action is produced in mitral disease, in which it acts rapidly and for a prolonged period. In mitral stenosis it has been thought to produce a peculiarly important effect, as the prolonged dilatation of the ventricle permits a greater flow of blood from the auricle through the narrowed channel. In aortic disease it may also be given with confidence. The old idea that the prolonged diastole would allow the ventricle to become overfilled appears to be but little regarded now, as its beneficial effect outweighs any such danger. The following conclusions[1] indicate its purpose not only in aortic, but in all forms of valvular disease: (1) In all cases of valvular disease the chief desideratum in regard to the heart itself is the condition of the cardiac walls in respect to dilatation and hypertrophy; (2) that the presence, in cardiac disease of symptoms indicating a disturbance of the circulation always means failure of compensation; (3)

that the condition of over-hypertrophy or over-compensation does not exist; (4) that the dangers in aortic disease arise from the same cause as the dangers in mitral disease, that is, a failure of the ventricular muscle to perform the ever-increasing work put upon it; (5) that if digitalis is safe and beneficial in mitral disease it is equally so in aortic disease.

The one condition in which digitalis is contraindicated is fatty degeneration of the heart. In advanced stages of this disease, where the walls are thin and the cavities are much dilated, it must be used with extreme caution, as its action may be too violent for the feeble organ, and paralysis or rupture follow. In the lesser degrees of degeneration, where the evidences of such a condition are indistinct, a want of action on the part of the remedy is a sign that must not be disregarded. Dujardin-Beaumetz furnishes the following rule: "When in a patient, digitalis, administered methodically, managed with care, produces no amelioration on the part of the heart and pulse; when, above all, the quantity of urine is not augmented, be persuaded that there is a fatty degeneration of the heart and immediately cease the employment of the remedy."

A cumulative action, in the sense of an accumulation of the drug in the system followed by an outburst of increased action, is no longer feared. No such condition occurs. Toxic symptoms arise only from an overdose or from its prolonged administration, and the condition of poisoning is preceded by its regular train of symptoms. The first effect of digitalis[2] is to stimulate the vagus and the vaso-motor centres, which improves the action of the heart and increases the blood-pressure; this is followed by a relaxation of the vaso-motor apparatus, which is first evident in the renal vessels. Up to this point the drug produces its therapeutic action, the relaxed vessels in the kidneys, with a high arterial tension and powerful heart, furnishing all the conditions requisite for a free secretion of fluid. When the drug is pushed beyond this it produces the toxic symptoms: the renal vessels are relaxed, the reduced blood-pressure extends to the general circulation, the heart becomes weaker, and the circulation fails. When a fatal termination ensues it follows a continuance of this condition and ends with a failure of the heart, which is arrested in diastole. To avoid any ill effects it is safer to discontinue the drug for a few days, as soon as its action has been established; it may be administered again when required. Where the proper conditions for its use are observed there should be no danger of any toxic action; it is only when it is employed indiscriminately that any such effect arises. A case is reported[3] where no bad result followed its use for nearly three years, thirty-five drops being given three times a day.

The infusion appears to remain the popular preparation, particularly when its diuretic action is required. Among the French, a maceration in cold water is the favorite method of employing the drug, and is considered superior to the infusion. Five grains of powdered digitalis are macerated in four ounces of cold water for from eight to twelve hours, and then filtered. The dose is one tablespoonful every two hours. The tincture is preferred by some as a diuretic; it is probably the most useful preparation when a simple tonic action is required. Osler[4] considers that either preparation is efficient if the drug is of good quality and given in full doses—fifteen minims of the tincture or half an ounce of the infusion every three hours for two days, and then in reduced quantities. The subcutaneous employment of the infusion has been recommended. In this way it has been found that very small doses will act when larger doses have failed when given in the ordinary manner. The advantage over the administration by the stomach is that usually the gastro-intestinal mucous membrane is in a catarrhal and œdematous state and absorption is prevented. It is also thought that the action is retarded and altered by the passage through the liver. An infusion of three parts of the leaf in one hundred of water is prepared, and fifteen minims of this infusion have been injected twice or three times a day, it is said, with good results.

The relative value of the aqueous and alcoholic preparations assumes more importance when the solubility of the several constituents is considered. Of the four glucosides, digitoxin, digitalin, digitalein, and digitonin, the first three are freely soluble in alcohol; digitoxin is practically insoluble in water, digitalin only sparingly, and digitalein freely soluble in water. Digitonin is freely soluble in water, but hardly at all soluble in alcohol. Thus all alcoholic preparations contain the first three principles, and all aqueous solutions the last two. Therapeutically[5] the first three are very similar in action, producing the characteristic effects of digitalis; digitoxin being the most active. The fourth principle, digitonin, when isolated, has been found to be a direct poison to the muscular structure of the heart; it decreases its contractile power and produces a dilatation of the arteries. This toxic action is in a measure counteracted by the other principles when administered together. The whole question of the digitalins, however, remains very unsatisfactory; no true alkaloid has yet been separated; many varieties of digitalin are in the market, and the significance of the term varies according as it is given to a German or a French preparation.

Digitoxin—the digitalin of Nativelle—crystallized digitalin, the most active of all the principles, is the one generally employed to replace the preparation of the leaves, but it is uncertain and at times violent in its action and must be used with care. The dose is from $\frac{1}{1000}$ to $\frac{1}{600}$ grain, repeated two or three times a day. Huchard[6] uses a single large dose of $\frac{1}{200}$ grain daily, giving fifty drops of a 1 to 1,000 solution. Under this treatment he finds diuresis augmented, sometimes after a single dose, generally after a second or third. Foquet[7] recommends $\frac{1}{600}$ grain, to be followed by a daily dose of $\frac{1}{1000}$ grain. This has also been used hypodermically, but it proves painful and irritating.

Digitalis has been[8] recommended as a means of aborting pneumonia if given early and in large doses. The treatment has been followed by Professor Petresco, of Bucharest, in a large number of cases. He uses an infusion of one to three drachms of the leaves in eight ounces of water, and gives a tablespoonful every hour. As much as 120 grains of the leaves have been given in twenty-four hours. He states that these large doses abort the pulmonary process, shorten the attack, and hasten convalescence. The temperature in some instances drops from 105° to 96° F., and the pulse from 120 to 35 per minute. He thinks that this treatment would act almost as a specific if it could be commenced with the attack. In no instance were there any bad results, and the more severe the attack the better the action of the large doses. The good effects are due to the increased force of the circulation in the pulmonary tissue and the prevention of stasis and congestion. This can only follow the administration of large doses as early and as energetically administered as possible.

Professor R. Lepine[9] has employed digitalin in pneumonia also with success; $\frac{1}{200}$ grain was given in the morning and often $\frac{1}{100}$ or $\frac{1}{300}$ grain in the evening. He does not think that it has any specific action, but finds it of great value in supporting the action of a weak and feeble heart during the course of the disease.

Beaumont Small.

[1] British Medical Journal, March 12, 1892.
[2] I. Mitchell Bruce: Materia Medica and Therapeutics.
[3] New York Medical Journal, October 29, 1892.
[4] Osler: Practice of Medicine.
[5] Merck's Bulletin, December, 1892.
[6] La Semaine Médicale, July, 1890.
[7] The Therapeutic Gazette, April, 1892.
[8] New York Medical Journal, July 16, 1892.
[9] La Semaine Médicale, March, 1892.

DINAN. A watering-place and health-resort in the Department of Côtes-du-Nord, France.

Location.—Dinan is a picturesque old town, situated among some of the finest scenery in Brittany. It stands on a steep spur of land, overlooking the left bank of the river Rance. It is only about ten miles from Dinan to St.

Malo, and just as far to popular Dinard. The population of the place now exceeds 10,000.

ANALYSIS.—There is a cold chalybeate spring at Dinan, having the ordinary composition of a mild ferruginous water.

INDICATIONS.—Dinan is chiefly resorted to on account of its healthfulness and its proximity to the sea-coast. The waters are taken mainly by women and children with scrofula or chloro-anæmia.

ACCOMMODATION.—There are several moderately good hotels. The principal ones are the *Hôtel de la Poste, Hôtel de Bretagne, Hôtel de Commerce.* *Edmund C. Wendt.*

DINARD. A sea-side and climatic resort of growing fame and pretentions, in the Department of Ile and Vilaine, France.

Dinard is beautifully situated on the broad estuary of the river Rance, directly opposite to St. Malo. Little steamboats ply half-hourly between these resorts. It is favorably known on account of its agreeable climate, the fine beach, and the opportunity offered for many pretty excursions.

The old town of Dinard is nothing more than a fishing village, running along the sandy shore. The English are partly responsible for the existence of the new Dinard which overlooks the old village.

The accommodations are fairly good. The principal hotels are the *Hôtel de France, Franklin, Hôtel de Paris,* and the *Grand Hôtel de Dinard.* There is a small *Casino* and an *Établissement des Bains.* Although a typical French resort, English and Americans visit Dinard in increasing numbers. In recent years it has become more and more a resort for families, and both at Dinard itself and at the adjoining village of St. Enogat numerous furnished villas may be rented for the summer season, or for a shorter period. At the latter place the prices are somewhat more moderate than at Dinard. But in both these places, as in the great majority of French sea-side resorts, it is not quite safe to use the general water-supply for drinking purposes. The water should be boiled and then allowed to cool, or the bottled mineral waters should be used instead. During the past two or three summers a thoroughly competent English practitioner has been established at Dinard. *Edmund C. Wendt.*

DIPHTHERIA. INTRODUCTORY.—The first reference to this affection in New England, or, in fact, in America, is probably to be found in Sibley's "Harvard Graduates," vol. i., p. 94, where a number of children are said to have died from "bladders in the wind-pipe" in 1659. At various periods after this references to the disease are to be found, with some imperfect descriptions, as occurring in various parts of New England.

The modern history of diphtheria begins with the publication of Bretonneau's works, his first paper appearing in 1821. He asserted the identity of angina maligna (diphtheria) with membranous laryngitis (croup). He spoke of the continuity of the false membrane of the nose, pharynx, and respiratory tract, of its identity with some morbid processes of the skin, and asserted that diphtheria was a specific disease and not to be confounded with catarrhal or scarlatinal inflammation. He claimed also that it was a purely local disease, an opinion which he afterward modified. His completed monograph appeared in 1826.

From this time the literature of the disease becomes more and more voluminous year by year. Hardly a writer upon medicine or an investigator of the etiology of disease but has had more or less matter for publication. The points in dispute are, many of them, discussed to-day as vigorously as ever. The question of the identity of the two processes, croup and diphtheria, from a pathological stand-point, may be considered to be settled in the affirmative so far as to justify the assertion that true croup, or membranous laryngitis, may be one form of diphtheria.

The etiology of the disease, as to whether it is produced by bacteria, is no longer in doubt. This question has engaged the attention of many workers, and the solution seems to be reached at present.

Since Bretonneau the principal contributions to the history of the disease have been made by Trousseau, Bourdeoise, Baumgarten, Rilliet and Barthez, and Virchow. In 1847, the latter first made the distinction between the catarrhal, croupous, and necrobiotic varieties of laryngeal affections.

SYMPTOMATOLOGY.

SYMPTOMS IN GENERAL.—The symptoms may vary from those of the slightest sore throat to those of the most serious and malignant disease. For convenience these may be separated into several forms, according to the severity of the symptoms.

1. The typical form.
2. The catarrhal, or mild form.
3. The malignant form.
4. (Which is rare) the chronic form.

1. *The Typical Form.*—A typical case of diphtheria presents about the following phenomena: After a general feeling of malaise, or loss of tone, lasting from two to five days, the attack commences with a definite constitutional disturbance. The first stage presents a rapid rise of temperature, often reaching 103° or even 105° F., a feeling of chilliness, anorexia, nausea, and occasionally vomiting and diarrhœa. The throat early becomes dry and hot, with pain upon swallowing, and the neck is swollen, stiff, and tender. The tonsils, pillars of the fauces, uvula, and back of the pharynx, are red, swollen, turgid. The appearance of the false membrane does not occur until the arrival of the second stage. In this a viscid, yellowish secretion will be seen, gradually forming in the depressions of one or both tonsils. Later, certain points of the superficial mucous membrane become infiltrated with a yellowish material, these points being somewhat elevated above the general surface. These points, at first more or less translucent, become opaque and grayish-white. They extend and coalesce and thus a considerable surface of the fauces and pharynx may become covered with a pseudo-membrane, which is constantly being reinforced by additions to its under surface. Portions of the membrane may be drawn off, and occasionally a perfect cast of the place from which it is removed may be obtained. The neck is swollen from the enlargement of the parotid and submaxillary glands, which are frequently hard and very tender. Fever is generally lessened with the appearance of the exudation; exceptionally, however, it may remain as high as, or even rise higher than, it was at first. Swallowing is performed with difficulty, and the breath is fetid from the decomposition of the morbid secretion. The pulse is weak and compressible, and is either very rapid or very slow. The first sound of the heart is weakened, albuminuria is a frequent symptom in the earlier stages of an attack, and the urine is apt to become scanty and high-colored. Hyaline casts are not uncommon, but the occurrence of granular or epithelial casts is not constant. The morbid process may spread downward and invade the larynx and trachea, this usually occurring in from three to four days after the invasion, and making itself manifest by unmistakable signs. These are: hoarse, muffled voice, stridulous breathing, constant dry cough at first, later dyspnœa, increasing cyanosis, swelling of the face, and drowsiness passing into coma. The nasal cavities may be involved primarily, or by the extension of the disease from the fauces. This is indicated by the discharge from the nose of a fetid, dark-colored watery fluid, with the formation of false membrane in the nasal cavity. There is often, also, repeated, and sometimes fatal, nasal hemorrhage, and occasionally there occurs a blocking of the lachrymal ducts, or the disease may extend by this channel to the eye.

Trousseau goes so far as to say that he has never seen a case of diphtheria recover in which hemorrhage from the nose occurred. The morbid process may also pass through the Eustachian tube to the tympanic cavity, and eventually cause a perforation of the membrana tympani, with subsequent purulent discharge from the ear. If the

larynx be not attacked, the third stage is reached and the disease slowly disappears or death occurs very rapidly. If the result is to be favorable, a marked improvement takes place in all the symptoms by the end of the first or the beginning of the second week. The temperature becomes normal, the pulse regains its strength and regularity, and anorexia disappears, the congestion of the fauces diminishes, the exudation ceases to extend, and portions of it become detached. The patient feels very well, but the danger is not passed, for a relapse may occur which may be more severe than the initial attack.

Another danger to be feared at this time is syncope from failure of the action of the heart. If the termination of the attack is unfavorable, death may occur from a secondary blood-poisoning with typhoid symptoms or coma, or, more frequently, from cardiac embolism or syncope.

2. *The Mild Form.*—In a case of this character the symptoms are often so slight that the diagnosis must be excessively doubtful, the symptoms being those of an ordinary catarrhal sore throat. The constitutional disturbance is very slight; the elevation in temperature being but one or two degrees, and the pulse being but little affected.

There may be slight pains or dryness in the throat, and some difficulty in swallowing. The submaxillary glands may be swollen and tender; the tonsils, soft palate, and pharynx red and swollen; and in a day or two minute yellowish spots, the size of a pin-head, may make their appearance. These are easily removable.

The symptoms improve on the third or fourth day, and often the presence of persistent and general weakness is the only definite sign that the case has been one of diphtheria. This form is often, however, introductory to an acute attack, which breaks out in a few days in full force, and the definite diagnosis can only be made by means of the bacteriological examination.

3. *The Malignant Form.*—In a case of this kind there are at once rigors, headache, vomiting, and, not infrequently, epistaxis. The throat symptoms are not always very severe, but decomposition of the secretion and the resulting fetor are very marked. The temperature is not necessarily high; the pulse is small, rapid, and wavy. The patient becomes drowsy; the skin is cold and clammy; the face pale, the tongue dry, brown and tremulous; the mucous surfaces bleed easily, and petechiæ under the skin are often present. All the symptoms of a typical case develop rapidly one after the other, and the patient dies comatose or in syncope.

4. *Chronic Diphtheria* is rare. Mackenzie ("Diphtheria," p. 31) quotes a case in which the membrane persisted in reforming for a period of three months. Other cases have also been reported in which this repeated formation of membrane was a characteristic feature.

Symptoms in Detail.—*Prodromes.*—In a majority of cases there is a prodromic stage lasting for a day or two. The patient feels indisposed to exertion; is slightly feverish, and is apt to have some difficulty in deglutition. There may be headache with occasional vomiting.

Pharynx and Soft Palate.—The pharynx and soft palate are the principal seats of the local diphtheritic disturbance; larger or smaller deposits being found there, loosely attached or deeply embedded according to the location. Sometimes there is but one spot, but usually there are several, and in a short time (twelve to twenty-four hours) they coalesce to form a membrane. On the uvula, soft palate, and posterior wall of the pharynx the membrane is superficial and may sometimes be easily removed. It is more firmly attached upon the tonsils, and sometimes extends into the deeper tissues. There is, occasionally, no actual membranous formation, and in such cases the tissues are swollen, the mucous membrane is more or less reddened, and the infiltration into the tissues gives a somewhat grayish-white discoloration. When the uvula is involved the swelling is usually more conspicuous than when the rest of the fauces alone is affected.

Jacobi speaks of three distinct processes in the throat: 1, A membrane lying on the mucous membrane, and which can be separated without much, if any, injury to the subjacent epithelium; 2, a membrane implicating the upper layer of the mucous membrane; 3, a whitish or grayish infiltration of the surface and deeper tissues which may occasion necrotic changes. When the symptoms are of long duration, and deep infiltration occurs, hemorrhages from the affected parts are not uncommon. They may be slight, but occasionally large vessels are opened and death may result. Gangrene sometimes occurs after extensive infiltration has taken place, and a decided loss of substance is revealed after the falling off of the membrane, which loss of substance more usually takes place upon the tonsils.

The Nasal Cavities.—The morbid process often passes into the nasal cavities from the posterior aspect of the soft palate or pharynx, especially when the uvula is affected. The disease may also occur primarily in the nose, and this happens more often after an acute catarrh. The secretion is very profuse, slightly flocculent, and frequently very offensive. The first certain indication of nasal diphtheria is the occurrence of tumefaction of the cervical glands. Before this it is often impossible to diagnosticate the disease in this situation. This adenitis is often found very persistent, a permanent induration sometimes remaining. Chronic nasal catarrh, with elongated uvula and enlarged tonsils, are frequent results of the disease.

The Eye.—The eye is frequently affected by extension of the process from the nose through the nasal duct, although it may also be a seat of primary infection. Diphtheritic conjunctivitis is an exceedingly grave affection, as regards the safety of the eye; the cornea often being destroyed by pressure, from diphtheritic keratitis, in twenty-four hours. Von Graefe first studied diphtheria of the eye in 1854. It is not a frequent affection. Sometimes a single eyelid is the seat of the disease. The process may first appear on the conjunctiva bulbi, and pass from this to the conjunctiva palpebrarum. The cornea becomes hazy very early, and ulceration occurs, as a result of which perforation is to be feared, with possible prolapse of the iris and consequent destruction of the eye, or, at least, loss of sight.

The Ear.—The ear may become affected by way of the Eustachian tube, and an acute otitis media may develop, with perforation of the membrana tympani, and even necrosis of the mastoid bone. An otitis interna is also sometimes observed.

The Epiglottis.—It is not rare to find patches of membrane in the depression at either side of the face of the epiglottis, which is then swollen, with hard and reddened edges; the great part of the diphtheritic process occurring upon its upper surface. Dyspnœa and hoarseness are only occasional, and only when there is accompanying œdema at the entrance to the larynx. This œdema produces a functional paralysis of the vocal cord, with marked dyspnœa upon inspiration.

Larynx.—When membrane forms in the larynx inspiration and expiration are both interfered with. Fever and pain are not necessarily prominent, but, as the process goes on, the respiration becomes more difficult, complete aphonia comes on, and the hoarse, croupy cough becomes more and more suppressed. If the affection progresses, all the symptoms of suffocation and poisoning by carbonic acid gas may be observed. The supra-clavicular and intercostal regions are retracted with each inspiration, sometimes also the ensiform cartilage. Usually a number of days elapse between the first laryngeal symptoms and death. At times, however, a fatal result occurs in a few hours.

Trachea.—Jacobi and a few others claim that the trachea and bronchi may be the original seat of the disease, and that the diphtheritic process may spread upward to the larynx and into the fauces. This is denied, however, by Henoch, Oertel, and Steiner. Cases of genuine adhesions between the arytenoid cartilages, with a resulting paralysis of the internal thyro-arytenoid muscles, have been occasionally reported.

The Lungs.—Lobular pneumonia is the occasional result of the inhalation of pieces of false membrane into the

smallest bronchi. Fibrinous pneumonia is also known to occur. Broncho-pneumonia frequently develops after the trachea becomes affected. In all these forms the diagnosis is extremely difficult if the larynx be affected, because of the noisy respiration which interferes with the recognition of the signs upon auscultation. If the trachea is open, this difficulty is done away with.

The Mouth.—Primary infection of the mouth is not common. Diphtheria often occurs in this situation, however, in association with the same affection in the nose and the fauces. The morbid changes occur on the cheek, tongue, angles of the mouth, gums, and lips, appearing here as in other places by preference where there has been a solution of continuity in the mucous membrane. Diphtheria of the mouth is an indication of a probable long duration of the disease, with the danger of septic poisoning following.

Œsophagus and Cardiac Orifice of the Stomach.—The occurrence of genuine diphtheria of these parts is asserted by some authorities, while others say that the formation of membrane ceases at the upper portion of the œsophagus. Intestinal diphtheria occurs, but is rare in the human subject, although not uncommon in cows and certain other of the lower animals. Wounds of all kinds are easily and rapidly infected and may quickly become covered with the false membrane. Death occurs by general infection from such a source, and may come as well from diphtheritic infection of abrasions of the skin as from that of wounds resulting from amputation or other surgical interference.

The Skin.—At the beginning of an attack, sometimes not for two or three days, a more or less general erythema may appear upon the skin. Its principal seat is over the shoulders, chest, or back, and it is very similar to, and often indistinguishable from, the eruption of scarlatina. Erysipelas also often occurs, and is a complication much to be dreaded.

Genito-Urinary Organs.—The diphtheritic process may occur in these organs secondarily, but not often. Sometimes it is primary in this locality. The disease has occurred in the vulva, the vagina, and the bladder, and in circumcision wounds.

The Kidneys.—These are the most actively involved of any of the internal organs during the progress of diphtheria. Wade, in 1858, first spoke of albuminuria in this disease, and was followed some months later by Sée (in the *Union Médicale* for 1858, p. 407). The presence of albumin is not of such great significance as was at first supposed. It occurs in large quantities in mild cases, and in small amounts or not at all in severe attacks. It may appear either before or after tracheotomy. It is often unaccompanied by any other sign of renal disease, but may be accompanied by various kinds of casts and epithelial cells.

The Heart and Blood.—There may be weakness of the cardiac muscles, sluggish circulation, dyspnœa, and muffled heart-sounds, cool and pale skin, feeble and frequent, sometimes slow, pulse. Occasionally there is actual endocarditis affecting the valves, more especially the mitral. This is characterized by high fever, precordial pain, syncope, and a systolic murmur.

The Nervous System.—This is often affected, and frequently very seriously. The influence exerted was supposed for a long time to be localized in certain nerves, or groups of nerves, and that the first points attacked were always the arches of the soft palate. This is not true, however, nor is the assertion that severe paralyses follow severe local manifestations, for the opposite is very often the case, viz., that a very mild attack of diphtheria may be followed by a very severe form of paralysis. Many theories of the method of production of this paresis are put forward, such as, that they are produced by fatty or granular degeneration of the muscular fibres, or by capillary hemorrhages, or by amyloid degeneration, or by œdematous infiltration of the part and consequent pressure. All of these, however, are more speculative than based upon actual facts observed.

The most frequent paralysis is that of the soft palate, which appears, as a rule in the second week, although often earlier and sometimes later. Paralysis of the constrictor muscles of the pharynx also may occur, and these two conditions produce imperfect speech and difficult deglutition, with frequent regurgitation of fluid through the nose. In such cases sometimes life can only be sustained by the use of the œsophageal tube. Paralysis of the power of accommodation comes next in frequency. Then follow paralyses of the lower and upper extremities, these rarely occurring suddenly, and usually involving only one set of muscles at the same time. Complete fatty degeneration, although rare, may occur. The muscles of the neck are sometimes affected, producing inability to hold the head erect. The fingers alone may be paralyzed. The bladder and sphincters may be affected, but this is not a common occurrence. Sometimes the muscles of respiration are attacked, such cases being very apt to terminate fatally. We have thus far spoken only of motor paralysis, but affections of the sensory apparatus may also occur. Anæsthesia of the entire upper part of the body has been observed. Sometimes the two are combined and locomotor ataxia is the result. Diphtheritic paralyses are irregular in regard to the place of appearance, their severity, their duration, and their responsiveness to treatment. They may last from six weeks to six months, may recover with treatment and without it, and may prove refractory to anything that can be done to remove them.

Pathological Anatomy.

The most important part of the diphtheritic process is the false membrane. It is the most prominent characteristic, as well as the one most frequently met with. It is tough, dry, yellowish, or grayish-white, firm and elastic. It swells upon the addition of acetic acid and becomes more or less transparent. It is soluble in caustic alkali, insoluble in water, and yields neither gelatine nor albumin. It varies in appearance from a thin transparent pellicle to a skin of considerable thickness. On separation, if the attack has been a mild one, the subjacent mucous membrane is found to be smooth and paler than normal; if the attack has been severe, more or less ulceration is left behind. The membrane consists, first, in great part of fibrin, the result of epithelial changes, or a direct product from the exuded blood-serum. It contains, also, epithelium, more or less degenerated blood, mucus, and bacteria.

Its method of formation is somewhat as follows: The pavement epithelium becomes cloudy, swollen, and dentated, and dissolves into a net-work. It becomes, later, the recipient of newly formed cells. There is a considerable infiltration of the mucous membrane with pus cells and granules. The cellular tissue is studded with granules also, its decomposition resulting in a fine granular deposit and necrosis—a process considered by Virchow to be an important element in severe forms of diphtheria.

The clinical differences between the membrane of croup and that of diphtheria are not borne out by the microscopical examination, which shows no essential discoverable difference.

The Heart.—This organ is often found to be perfectly healthy. It may present numerous petechiæ and there is often fatty degeneration of the muscular tissue, and parenchymatous inflammation or hemorrhages may occur. Endocarditis is found affecting the mitral more often than the tricuspid or pulmonary valves. Perforation of the septum of the right auricle and of the aorta has been seen.

Lungs.—These organs present various inflammatory or congested appearances; œdema, broncho-pneumonia, atelectasis, emphysema, ecchymoses, and infarction are all found at various times. The lungs may also be entirely unaffected.

The *spleen* is often increased in size and congested, and it may be friable, with more or less extensive infarctions.

The *kidneys* may be normal, simply congested, or the seat of parenchymatous or interstitial nephritis.

In the *muscles* are sometimes found ecchymoses, myositis, gray degeneration, or atrophy.

The *lymphatic glands* are also swollen and inflamed. They may be hard or yielding to pressure. Abscesses are not common. The tissue about the glands is often involved in the inflammatory process also.

Intestinal Canal.—Unless the actual seat of the disease this tract presents no peculiar appearance. Virchow considers that diphtheria of the intestinal canal is characterized by fibrinous deposits on the surface and in the tissues of the intestine, with a subsequent granular degeneration of the tissues, and Radjewsky claims that his experiments prove that bacteria are important factors in the production of the diphtheritic membrane after previous inflammation has taken place in the intestine.

The Brain.—If death has occurred from asphyxia, the brain presents a venous engorgement of the membranes and cerebral structure, with minute extravasations of blood. Pus and lymph have also been found on the arytenoid in cases in which mental disturbances have been very marked. In many cases, however, there are no perceptible alterations in the cranial cavity.

Etiology.

Diphtheria is pre-eminently a disease of early life, the proportionate number of cases diminishing very rapidly as the age increases. Of five hundred deaths in Vienna from this disease in 1868, but one case had reached the age of sixty. Sex seems to exert no special influence. It occurs mostly in children; the predisposition of this age is explained by the softer condition of the mucous membrane of the mouth and pharynx, and by the narrowness of the pharynx, the protuberant condition of the tonsils, the large number and size of the lymphatics, and the greater communicability between them and the system at large, all of which aids in the development of the disease. On the other hand, the free acid secretions of the mouth after the third month tend to hinder its occurrence after this period. There seem to be families in which there is an apparent predisposition to this disease.

Climatic and Atmospheric Conditions.—The disease is most common in temperate climates, but it occurs almost everywhere. It is probable that moisture favors the development of the poison, and also that it can lie dormant for a long time, and until some special agency calls it into activity.

The disease prevails more extensively during the winter months, apparently at the time when catarrhal conditions are most common, and the mucous membrane is in a receptive condition. Social position offers no safeguard during an epidemic, although sporadic cases seem to especially attack those living under bad hygienic surroundings. Exhalations from sewers and filthy personal habits are also said to produce the disease, but the weight of evidence is against their possessing anything more than a favoring action.

Manner of Infection.—Whether diphtheria be a local disease with constitutional sequelæ, or whether it be a general disease making its most marked appearance at certain points, is a question which has been much discussed. If, however, as is practically certain, it is excited by the activity of a micro-organism, the question is settled that the local manifestations are usually the signs of the place of entrance, and the constitutional disturbances the evidence of the general distribution of the poison.

The infectiousness of diphtheria is undoubted. The infectious material may be communicated directly by the patient, and it seems to cling to solid bodies, and may be transported in this way to a distance, but how far is, as yet, undetermined.

The methods of transportation which have been thought to offer the most usual channel for the spread of the disease are milk of diseased cows and infected animals. Many researches make it certain that the disease occurs among domesticated animals, although the more recent investigations seem to indicate that it is really a disease resembling human diphtheria as regards its clinical symptoms, but differing from it in the fact that it is produced by a micro-organism which differs somewhat from the true diphtheria bacillus. The question being determined in the affirmative may furnish a probable explanation of the origin of many cases in human beings in which the source of infection has been obscure.

The Nature of the Diphtheritic Poison.—Investigation of this point has occupied the attention of observers for years past. As long ago as in 1840 Henle expressed his belief in a contagium vivum, and Buhl first found micro-organisms in the diphtheritic membrane, but he expressed no opinion as to their special import.

The work of Loeffler, first published in 1884, described a specific micro-organism which he had found in the tissues of individuals suffering from diphtheria. This discovery has been confirmed by so many observations and by so many different observers since that time, that the question of the specific infectious agent in diphtheria must be considered as definitely settled at the present time. This question is one of such great importance, and the disease is one in which positive therapeutic results seem to be so clearly promised, that it has been thought best to give a full description of the organisms found in the diphtheria of men and of the lower animals.

The Bacteria Occurring in Diphtheria.—For the following summary of the present state of opinion in regard to the bacteria of diphtheria, we are very largely indebted to the admirable *résumé* of the work done, and the views entertained, by various authors, to be found in Sternberg's "Manual of Bacteriology" (published by William Wood & Co., New York, 1892).

The condition of the question in regard to a specific organism occurring in diphtheria is such that to-day we have a very precise knowledge of the specific infecting agent, together with evidence that it produces during its growth a very potent toxic substance, the absorption of which from the seat of local infection accounts, in a satisfactory manner, for the general symptoms of the disease, which are due to a toxæmia and not to an invasion of the blood and tissues by the pathogenic micro-organisms producing it, although the latter statement seems likely to be more or less modified by future investigation, as is indicated by the work of Frosch, quoted in this article. Many examinations have failed to demonstrate the presence of bacteria in the blood of patients suffering from diphtheria, but a variety of micro-organisms have been obtained in cultures from diphtheritic pseudo-membranes, and among them are the well-known pus organisms, especially the streptococcus pyogenes, that is apparently very commonly present and is perhaps the active agent in the production of certain forms of pseudo-diphtheria. But the malignant specific diphtheria has been shown to be due to a bacillus first recognized by Klebs in 1883, and cultivated and described by Loeffler in 1884. In his first article, the latter author did not claim to have fully demonstrated the etiological relationship of this organism, but his own later work and that of many others show constant success in finding the same bacilius in other cases of diphtheria, and the same successful result from inoculation experiments with pure cultures of the organism in certain of the lower animals.

There has also been found, by Loeffler and others, an organism that does not possess pathogenic properties, but which resembles very closely the diphtheritic bacillus. And to this organism has been given the name of the *pseudo-diphtheritic bacillus*. It is still uncertain whether this bacillus is to be considered a distinct species or a non-pathogenic variety of the true diphtheria bacillus, as is maintained by the French authors Roux and Yersin.

The evidence upon which the bacillus of diphtheria is now generally conceded to be the specific infectious agent in true diphtheria rests upon the following principal points:

1. It is found in all undoubted cases of diphtheria, and in support of this there are the results of experiments and researches made by a very large number of experimentalists who, in nearly every case, have demonstrated without difficulty the presence of this bacillus. The one

eminent observer who failed to find the organism, in a series of twenty-four cases studied by him, was Prudden, of New York. But later, in a subsequent series of twelve cases, Prudden obtained Loeffler's bacillus in cultures from eleven, and he says, "We are now, it would seem, justified (as it did not appear to the writer that we were two years ago), owing to the large number of important researches which have been made in the interim, to maintain that the name diphtheria, or, at least, primary diphtheria, should be applied, and explicitly applied, to that acute infectious disease usually associated with a pseudo-membranous inflammation of the mucous membrane, which is primarily caused by the bacillus called bacillus diphtheriæ of Loeffler."

In this country Welsh and Abbott have also demonstrated the presence of the Loeffler bacillus in a series of cases occurring in Baltimore, and have proved its specific pathogenic power by inoculation in animals.

Loeffler attempted to show how long after convalescence the diphtheria bacillus may be present in the throat of an infected person, and, in a typical case, a bacteriological examination was made daily, from the commencement until fourteen days after its termination. The fever disappeared on the fifth day and the exudation had all disappeared on the sixteenth day. Up to this time the bacillus was daily obtained in cultures, and subsequently nearly every day up to the twenty-fifth, that is, for three weeks after the febrile symptoms had disappeared.

Roux and Yersin have also obtained the bacillus in cultures from mucus scraped from the throat of convalescents several days after the disappearance of all evidence of the disease.

2. The Klebs-Loeffler bacillus is found only in diphtheria. In his earlier researches Loeffler obtained the bacillus in a single instance from the mouth of a healthy child, and this fact led him to hesitate in announcing it as his conviction that it was the true cause of diphtheria.

But in extended researches made subsequently, he has not again succeeded in finding it except in association with diphtheria, and he admits now that he may have been mistaken as to the identity of the bacillus found. This seems not improbable, in view of the fact that very similar bacilli have been found by various bacteriologists. Von Hoffman obtained a similar, but non-pathogenic bacillus from the mucus of chronic nasal catarrh, and from a healthy mucous membrane; Babes, from cases of trachoma; Neisser, from ulcers; Zarinko, from the surface of various mucous membranes; but all of these were shown to possess certain differences in their biological character by which they could be differentiated from the true diphtheria bacillus.

Welsh and Abbott in their comparative studies did not find the Loeffler bacillus, "or any bacillus that an experienced bacteriologist would be likely to confound with it." They examined mucus from the throat of healthy children; from those suffering from simple inflammation of the tonsils and pharynx; and from four cases of so-called follicular tonsillitis. As a result of their investigations they agree with Loeffler and with Roux and Yersin as to the great practical value, for diagnostic purposes, of a bacteriological examination, by cover-glass specimens and by cultures, of cases in which there is any doubt of the true character of the disease. They say further, "the only species of bacteria which we have found constantly in the cases of diphtheria have been the Loeffler bacillus. Two other species have been present in many cases, namely, the well-known streptococcus, which grows in much smaller colonies and less rapidly than the Loeffler bacillus, and a short, oval, often slightly pointed bacillus, growing in long chains running parallel to each other. There are often marked irregularities in shape, and especially in size, of this bacillus, even in individuals of the same chain. The colonies of this bacillus are grayish-white, moist, larger than those of the streptococcus but smaller than those of the Loeffler bacillus."

3. As shown by Loeffler's earlier researches, pure cultures of this bacillus induce characteristic diphtheritic inflammation when inoculated into the mucous membrane of certain of the lower animals. Roux and Yersin have also shown that local paralysis is as likely to occur in inoculated animals as it is in a case of diphtheria in man.

In speaking of their inoculations into the trachea in rabbits these investigators say the affection which is thus induced in the rabbit resembles croup in man. The difficulty which the animal experiences in breathing; the noise made by the air in passing through the obstructed trachea; the aspect of the trachea, which is congested and covered with false membrane, and the œdematous swelling of the tissues and glands of the neck make the resemblance absolutely remarkable.

Welsh and Abbott give the following account of the results of inoculation into the trachea in kittens. A half-grown kitten is inoculated in the trachea with one platinum loop from a pure culture of the Loeffler bacillus on glycerine-agar eleven days old. For this inoculation a small median incision was made over the trachea, and in the latter a hole just large enough to admit the platinum loop was made. The culture was rubbed over the mucosa of the trachea for an extent of about three centimetres in length, and in this process sufficient force was used to abrade the mucous membrane. On the day following the inoculation no special alteration in the animal was observed, but on the morning of the second day it was found to be in a very weak condition. In the course of this day it became so very weak as to lie completely motionless, apparently unconscious, with very feeble, shallow respiration. Several times it was thought to be dead, but on careful examination it was found still to be breathing feebly. It was discovered dead on the morning of the third day. At the autopsy the wound was found gaping and covered with a grayish, adherent, necrotic, distinctly diphtheritic layer. For a considerable distance around the wound the subcutaneous tissues were very œdematous, the œdema extending from the lower jaw down over the sternum and to the side of the neck, and along the anterior extremities. The lymphatic glands at the end of the jaw were markedly swollen and red. The mucous membrane of the trachea, beginning at the larynx and extending down for six centimetres, was covered with a tolerably firm, grayish-white, loosely attached pseudo-membrane, in all respects identical with the croupous membrane observed in the same situation in cases of human diphtheria.

The account which we have just given, together with many others that might be quoted, seems to show that the organism spoken of and studied by so many observers, is unquestionably the cause of the specific disease, diphtheria. As has already been inferred, it is also unquestionably true that there may be other processes *clinically resembling diphtheria* which involve the throat and other mucous surfaces, and which owe their origin to other bacteria.

Description of the Bacillus of Diphtheria.—It was first observed in 1883 by Klebs in diphtheritic false membrane. It was first isolated in pure culture and its pathogenic power demonstrated by Loeffler in 1884. It was found in diphtheritic pseudo-membranes, and especially in the deeper portions, intermingled with numerous other bacteria, while the superficial layers of the membrane commonly contained a few cells or bacilli, or were invaded by other species, especially by the streptococcus pyogenes. The bacilli may not be found in the affected mucous membrane, or in sections from the internal organs in fatal cases of this disease, although recent bacteriological examinations by various authors have shown their pretty constant occurrence in these situations (see Frosch, *infra*).

Morphology.—The organism is a rod, straight or slightly curved, with rounded ends, having a diameter of from one-half to eight-tenths of a micromillimetre, and from two to three micromillimetres in length. Irregular forms are very common, and, indeed, are characteristic of this bacillus. In the same culture, and especially in an unfavorable culture-medium, very great differences in form and dimensions may be observed, one or both ends appearing swollen or the central portion be-

ing notably thicker than the extremities, or the rod may be made up of irregular, spherical, or oval cells. Multiplication occurs by transverse subdivision only, and the bacilli do not appear in long chains at any time. In unstained preparations certain portions of the rod, and especially the extremities, are observed to be more highly refractive than the remaining portion, and in stained

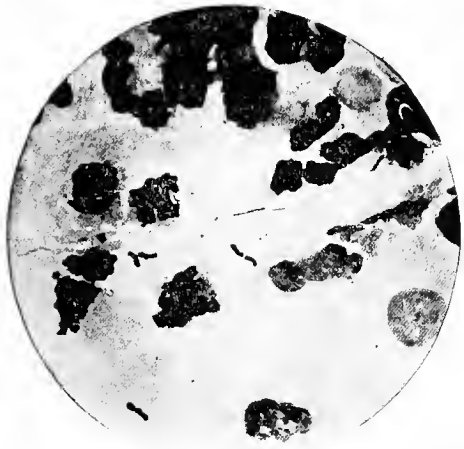


FIG. 152.—Diphtheria Bacillus, from a Diphtheritic Membrane in the Trachea. Cover-glass preparation, stained with alkaline methylene blue. (× 1,000.) (Fraenkel.)

preparations these portions are seen to be more deeply colored. The bacillus may be stained by the use of Loeffler's alkaline solution of methylene blue, but is not so readily stained with some of the other aniline colors commonly employed. It is stained also by Gramm's method.

For the demonstration of the bacillus in sections of diphtheritic membrane, nothing can surpass in brilliancy and sharp differentiation, sections stained doubly by the modified Weigert fibrin stain and picro-carmine (according to Welsh and Abbott).

Biological Character.—The diphtheria bacillus is aëro-

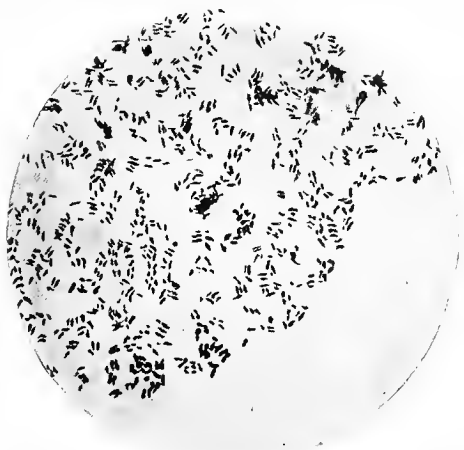


FIG. 153.—Diphtheria Bacillus. Colony on agar plate, twenty-four hours old. Impression preparation, stained with alkaline methylene blue. (× 1,000.) (Fraenkel.)

bic, non-motile, and non-liquefying. It does not form spores. It grows most freely in the presence of oxygen, but is also a facultative anaërobic organism. Development occurs in various culture-media at a temperature of from 20° to 42° C., the most favorable temperature being about 35° C. It grows very readily in nutrient gelatine, having a slightly alkaline reaction, in nutrient agar, in glycerine agar, or in alkaline bouillon. But the most favorable medium appears to be that first recommended by Loeffler, which consists of a mixture of three parts of blood-serum with one part of bouillon, the latter containing one per cent. of peptone, one per cent. of grape-sugar, and one-half of one per cent. of sodium chloride.

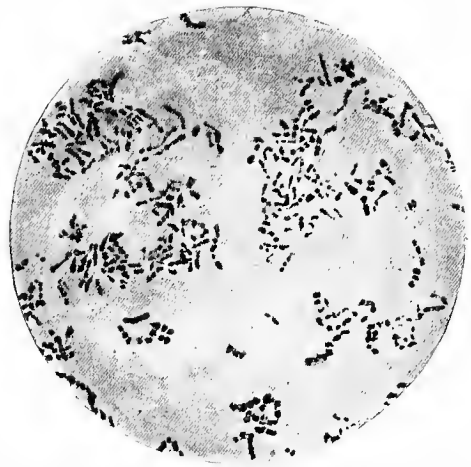


FIG. 154.—Diphtheria Bacillus. Culture on solidified blood-serum. Cover-glass preparation, stained with alkaline methylene blue. (× 1,000.) (Fraenkel.)

This mixture is sterilized and solidified at the temperatures usual with blood-serum, and upon it the development is so rapid in the incubating oven that at the end of twenty-four hours the large, round, elevated colonies of a grayish-white color and moist appearance may be easily recognized, while other associated bacteria have, as a rule, not yet developed colonies large enough to interfere with the recognition of those of the diphtheria bacillus. Upon nutrient agar plates the deep-lying colonies, when magnified about eighty diameters, appear as round or oval, coarsely granular disks, with rather ill-defined margins, or, when several colonies are in juxta-

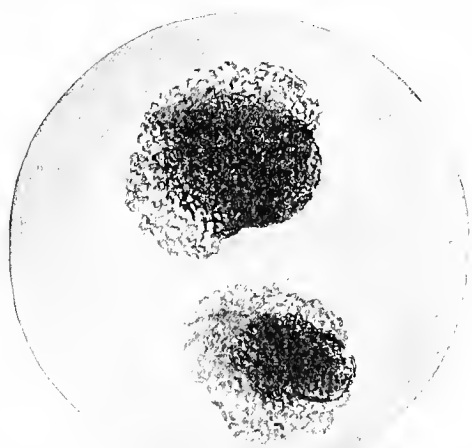


FIG. 155.—Diphtheria Bacillus. Colony on agar plate, twenty-four hours old. Unstained. (× 100.) (Fraenkel.)

position, as figures of irregular form. The superficial colonies are grayish-yellow in color, have an irregular, not well-defined outline, and a rough, almost reticulated surface. The growth upon glycerine agar is very similar.

The first inoculation in a plain nutrient agar tube often gives a comparatively feeble growth, which becomes

more abundant in subsequent inoculations in the same medium. In needle cultures in glycerine, or plain agar, growth occurs to the bottom of the line of inoculation, and also upon the surface, but is not at all characteristic. The same may be said in reference to cultures in nutrient gelatine. Plate cultures in this medium containing fifteen per cent. of gelatine at 24° C., give rather small colonies, which are white by reflected light, and under the microscope are seen as yellowish-brown opaque disks, having a more or less irregular outline and a granular structure. In alkaline bouillon the growth is sometimes in the form of small whitish masses along the side and bottom of the tubes, but at other times a diffusely clouded growth occurs in this medium. After standing for some time in the incubating oven, a thin white pellicle may form upon the surface of the bouillon. The reaction of the bouillon becomes at first acid, but later it is alkaline.

With reference to the growth on potato, authors have differed, probably because the growth is slightly visible. Welsh and Abbott say: "Our experience has been that the bacillus of diphtheria grows on ordinary sterilized potato without any preliminary treatment, but that the growth is usually entirely invisible, or is indicated by a dry thin glaze after several days. Doubtless the invisible character of the growth has led most observers into the error of supposing that no growth existed, whereas a microscopical examination reveals a tolerably abundant growth, which on the first potato is often feebler than on succeeding ones. Irregular forms are particularly numerous in potato cultures, and in general the rods are thicker than on other media. In twenty-four hours, at a temperature of 35° C., microscopical examination showed distinct growth. We have cultivated the bacillus for many generations on potato."

Milk is a favorable medium for the growth of this bacillus, and as it grows at a comparatively low temperature in it—20° C.—it is evident that this fluid may become a medium for conveying the bacillus from an infected source to the throat of a previously healthy person.

Cultures of the diphtheria bacillus may retain their vitality for several months, and when dried upon silk thread for several weeks, colonies may still develop in a suitable medium. Its drying has been found not to destroy its vitality for a period as long as from three to four weeks, when the desiccation process took place in a room, or for a period of from five to ten weeks (in one instance fourteen weeks), when the desiccation took place in an exsiccator. In dried diphtheritic membranes, preserved in small fragments, the bacillus retained its vitality for a period of nine weeks, and in larger fragments for one of from twelve to fourteen weeks. The thermal death-point, as determined by Welsh and Abbott, is 58° C., the time of exposure being ten minutes. Loeffler had previously found that it did not survive exposure for half an hour to a temperature of 60° C.

Pathogenesis.—In view of the evidence that has heretofore been recorded, it may be considered as demonstrated that this bacillus gives rise to the morbid phenomena which characterize the fatal disease in man known as diphtheria.

The effects of inoculation in rabbits and cats have already been referred to, these giving rise to a characteristic diphtheritic inflammation with general toxæmia and death from the absorption of soluble toxic products formed at the seat of local infection.

This inference as to the cause of death seems justified by what we know in regard to the life history of the bacillus, and is supported by additional experimental evidence given below.

Subcutaneous inoculations in guinea-pigs of a small quantity of a pure culture of the bacillus (from one tenth to one half a cubic centimetre of a bouillon culture) caused death in from one to five days. The usual changes observed are an extensive local œdema, with more or less hyperæmia and ecchymosis at the seat of inoculation. Frequently there are swollen and reddened lymphatic glands; increased serous fluid in the peritoneum, pleura, and pericardium; enlarged and hemorrhagic supra-renal capsules; occasionally slightly swollen spleen; sometimes fatty degeneration in the liver, kidney, and myocardium.

"We have always found the Loeffler bacilli at the seat of inoculation, most abundant in a grayish-white fibrino-purulent exudate present at the point of inoculation, and becoming fewer at a distance from this, so that the more remote part of the œdematous fluid does not contain any bacilli" (from Welsh and Abbott). The authors quoted also agree with Loeffler and others in stating that the bacillus is only found at the point of inoculation. In all cases their cultures from the blood and from the various organs gave a negative result, but this is purely negative evidence, and cannot stand as against the positive results of Martin, Behring, and Frosch.

Rabbits are not so susceptible, and may recover after the subcutaneous inoculation of very small doses, but they usually die in from four to twenty days when from two to four cubic centimetres of a bouillon culture have been introduced beneath the skin. In these animals also there is an extensive œdema, enlargement of the neighboring lymphatic glands, and a fatty degeneration of the liver. Roux and Yersin have shown that in these animals, when death does not ensue too quickly, paralysis of the posterior extremities frequently occurs, thus completing the experimental proof of the specific pathogenic power of pure cultures of this bacillus.

Similar symptoms are produced in pigeons by the subcutaneous inoculation of one-half a cubic centimetre or more, but they commonly recover when the quantity is reduced to two-tenths of a centimetre (according to Roux and Yersin).

The rat and the mouse have a remarkable immunity from the effect of this poison, and, according to the authors just spoken of, a dose of two centimetres, which would kill in fifty hours a rabbit weighing three kilogrammes, is without effect upon a mouse that only weighs ten grammes. Old cultures are somewhat less virulent than fresh ones, but when replanted in a fresh culture-medium they manifest their original virulence. Thus a culture upon blood-serum, five months old, was found by Roux and Yersin to kill a guinea-pig in five days, but when replanted, it killed a second animal of the same species in twenty-four hours.

Evidently a micro-organism which destroys the life of a susceptible animal when injected beneath its skin in small quantities, and which, nevertheless, is usually only found in the vicinity of the point of inoculation, must owe its pathogenic power to the formation of a potent toxic substance, which being absorbed gives rise to toxæmia and death.

This inference in the case of the diphtheria bacillus is fully sustained by the results of recent experimental investigations. Roux and Yersin first demonstrated the pathogenic power of cultures which had been filtered through porous porcelain. Old cultures were found by these experimentalists to contain more of the toxic substance than recent ones, and to cause the death of a guinea-pig, in the dose of two centimetres, in less than thirty-four hours. The filtered culture produced in these animals the same effects as those containing bacilli, viz., local œdema, hemorrhagic congestion of the organ, and effusion into the pleural cavities. Somewhat larger doses were fatal to rabbits, and a few drops injected subcutaneously sufficed to kill a small bird within a few hours.

In their second paper, published in 1889, a year after the first, the same authors state that so long as the reaction of a culture in bouillon is acid, its toxic power is comparatively slight, but that in old cultures the reaction is alkaline, and in these the toxic potency is greatly augmented. With such a culture, filtered after having been kept thirty days, a dose of one-eighth of a centimetre injected subcutaneously sufficed to kill a guinea-pig, and in larger amounts it proved to be fatal to dogs when injected directly into the circulation through a vein.

The same authors, in describing the nature of the poison in their filtered cultures, say that it is related to the

diastases, and state that its toxic potency is very much reduced by exposure to a comparatively low temperature (58° C., for two hours), and completely destroyed by the boiling temperature (100° C., for twenty minutes). It was found to be insoluble in alcohol, and the precipitate obtained by adding alcohol to an old culture proved to contain the toxic substance. Loeffler also has obtained, by adding five volumes of alcohol to one of a pure culture, a white precipitate, soluble in water, which killed rabbits in a dose of one-tenth to two-tenths of a gramme when injected beneath the skin of these animals. It gave rise to a local œdema and necrosis of the skin in the vicinity of the point of inoculation, and to hyperæmia of the internal organs. This deadly toxine appears to be an albuminous substance, but its exact chemical composition has not yet been determined.

Brieger and Fraenkel have succeeded in rendering guinea-pigs immune against virulent cultures of the diphtheria bacillus by injecting bouillon cultures three weeks old, which had been sterilized by exposure for an hour to a temperature of from 60° to 70° C., into the subcutaneous tissues; to the amount of from ten to twenty centimetres.

At first the susceptibility of the animal is rather increased than diminished, but at the end of two weeks immunity is said to be complete. Fraenkel is of the opinion that immunity results from the introduction of a substance which is not identical with the toxic product to which the cultures owe their pathogenic power. This latter is destroyed by a temperature of from 55° to 60° C., while the substance which gives immunity is still present in the culture after an exposure to a temperature of from 60° to 70° C., as is shown by the protective results of inoculation made with such cultures.

The recent researches of Behring show that the blood of immune animals contains some substance that neutralizes the toxic product contained in virulent cultures of the diphtheria bacillus. This effect is said to be produced when blood from such an animal is added to a filtered culture without the body as well as when the culture is injected into the living animal. This remarkable fact, if fully confirmed by further investigation, opens up a new field of experimental research, and may lead to important results in the therapeutics of diphtheria and other infectious diseases.

According to Roux and Yersin, attenuated varieties of the diphtheria bacillus may be obtained by cultivating it at a temperature of from 39.5° to 40° C., in a current of air. And these authors suggest that a similar attenuation of pathogenic power may occur in the fauces of convalescents from the disease, and that possibly a similar non-pathogenic bacillus, which has been described by various investigators, has originated in this way from the true diphtheria bacillus.

These authors further state, in favor of this view, that from diphtheritic false membranes preserved by them in a desiccated condition for five months, they obtained numerous colonies of the bacillus in question, but that the cultures were destitute of pathogenic virulence. They say it is then possible, by commencing with a virulent bacillus of diphtheria to obtain artificially a bacillus without virulence, quite similar to the attenuated bacilli which may be obtained from a benign diphtheritic angina, or even from the mouth of certain persons in good health. This microbe, obtained artificially, resembles completely the pseudo-diphtheritic bacillus. Like it, it grows more abundantly at a low temperature; it renders bouillon more rapidly alkaline; it grows with difficulty in the absence of oxygen.

Generalized Occurrence of the Bacillus of Diphtheria.—Frosch (*Zeits. f. Hygiene*, vol. xiii., part 12, p. 49) gives the result of a series of his investigations upon this subject, prefacing them by the remark that the idea seems to have taken a pretty firm hold among observers that the diphtheria bacillus occurs only in those organs where there is a possibility for the formation of membrane, this observation having been made by Babes, Kolisko, and Paltaus and Spronck.

Frosch extended his study over fifteen cases of diphtheria, of which but ten turned out to be true diphtheria, according to the bacteriological examination. Of the remaining five, one was excluded after a critical examination had been made; the second was also excluded because it was impossible to find the bacillus of diphtheria; two of the remaining three proved to be cases of pneumonia produced by a bacillus; and finally the fifth case was found to be one of tonsillitis, characterized by the presence of a new organism that will be described later by him. In the remaining ten cases *the diphtheria bacillus was found in the blood and in the internal organs* in every instance.

After describing the method which he followed in making these observations, Frosch says that in these cases the diphtheria bacilli were found in the brain, the lungs, the liver, the spleen, the kidneys, in the cervical and bronchial lymphatic glands, as well as in the heart, blood, pericardial and pleural fluid, in greater or less numbers. Their occurrence in all of these organs was not uniform, but in all of the cases the bacilli were found in a number of the organs, and, therefore, the observations go to prove that diphtheria may be a generalized disease with only a local manifestation, and that the local manifestation in the throat need not of necessity always be due to the diphtheria bacillus: and finally, that the only way definitely to prove whether the case is one of true diphtheria or no, is the discovery of the bacillus of diphtheria by means of bacteriological examination.

Description of the Pseudo-Diphtheritic Bacillus.—The organism which we are now about to consider is one of great interest, whether it be considered distinct from, or a modified form of, the true bacillus of diphtheria. Loeffler, Von Hoffman, and others have reported finding bacilli which closely resemble the bacillus diphtheriæ, but which differ from it chiefly in being non-pathogenic.

The following account we take from the latest paper upon the subject by Roux and Yersin (their third paper, 1890): Out of 45 children in a Paris hospital, suffering from various non-diphtheritic affections, they found this variety of bacillus in the mucus from the pharynx and tonsils in 15 instances. Out of 59 healthy children in a village school on the seaboard, they found this organism 26 times. Of 6 children with a simple angina, but 2 furnished cultures of this bacillus. Finally, out of 7 cases of measles they found 5 in which they discovered this bacillus. The description which they give of it is as follows:

The colonies of the pseudo-diphtheritic bacillus cultivated on blood-serum are identical with those of the true diphtheria bacillus. At a temperature of from 33° to 35° C. multiplication begins and continues at an ordinary temperature, although slowly. Under the microscope the appearance of the bacillus which forms these colonies is the same as that of the bacillus diphtheriæ. It stains readily with Loeffler's solution of methylene blue, and intensely by Gramm's method. Sometimes it colors uniformly, at other times it appears granular. It grows in alkaline bouillon, leaving a deposit upon the walls of the vessel containing the culture, and in this medium it often presents the "inflated" forms—pear-shaped or club-shaped. It is destroyed in a liquid medium by a temperature of 58° C. maintained for ten minutes. All of these characters are common to the pseudo-diphtheritic bacillus and the true bacillus diphtheriæ. As points of difference between them we may note that the pseudo-diphtheritic bacillus is often shorter in the colonies grown upon blood-serum; that its cultures in bouillon are more abundant; that they continue to grow at a temperature of from 20° to 22° C., at which the true bacillus grows very slowly; finally, that when comparisons of cultures in bouillon are made, it is observed that they both become acid and then alkaline, but that the change occurs much sooner in the case of the pseudo-diphtheritic bacillus. Like the true diphtheritic bacillus, the pseudo-diphtheritic grows in a vacuum, but less abundantly than the other.

Inoculation of animals with cultures of this bacillus has never caused their death, but it is to be noted that

in some experiments a decided œdema has been produced in guinea-pigs at the point of inoculation, while in others there has been no local lesion. The most marked œdema resulted from cultures obtained from cases of measles.

Do the facts that have been reported explain the question which occupies us? Can it be concluded that there is a relation between the two bacilli? On the one side, the presence of the pseudo-diphtheritic bacillus in the mouths of healthy persons, and of those who have angina manifestly not diphtheritic, seems to be opposed to the idea of a relationship between them. On the other hand, when it is considered that the non-virulent bacillus is very rare in cases of diphtheria; that it is more abundant in "benign" diphtheria; that it becomes more common in severe cases as they progress toward recovery; and finally, that they are more numerous in persons who have recently had diphtheria than in healthy persons, it is difficult to accept the idea that the two microbes are entirely distinct. The morphological differences which have been referred to are so slight that they prove nothing. The two micro-organisms can only be distinguished by their action upon animals, but the difference of virulence does not at all correspond with the difference of origin.

As regards the forms and the aspect of cultures the true and the false diphtheria bacilli differ less than virulent anthrax differs from a very attenuated anthrax bacillus originating from the same source. Besides, the sharp distinction which is made between the virulent and non-virulent bacilli is arbitrary. It depends upon the susceptibility of guinea-pigs. If we inoculate animals still more susceptible, there are pseudo-diphtheritic bacilli which must be classed as virulent. If, on the contrary, we substitute rabbits for guinea-pigs in our experiments, there are diphtheritic bacilli which must be called pseudo-diphtheritic. In our experiments we do not simply encounter bacilli which are very virulent, and bacilli which are non-virulent: between these two extremes there are bacilli of every degree of virulence.

Abbott has recently (1891) published the result of his researches with reference to the presence of the pseudo-diphtheritic bacillus in benign throat affections. He made a bacteriological study of 53 patients, 9 of whom were suffering from acute pharyngitis, 14 from acute follicular tonsillitis, 8 from ordinary post-nasal catarrh, 2 from simple enlarged tonsils, 15 from chronic pharyngitis, 1 from subacute laryngitis, 1 from chronic laryngitis, 1 from rhinitis, and 2 from an affection of the tonsils and pharynx. In 49 cases nothing of particular interest was observed. A variety of micro-organisms were isolated, and of these the pyogenic micrococci were the most common. In four cases micro-organisms were found which resembled the bacillus diphtheriæ of Loeffler in their morphology and growth in the culture-media, but which proved not to be pathogenic. Abbott says the single point of distinction that can be made out between the organism obtained in three of his cases and the true bacillus of diphtheria is in the absence of pathogenic properties from the former; whereas, in addition to this point of distinction, the organism from a fourth case gives, as he states, a decided and distinct growth upon the surface of sterilized potato.

Experiments have been made which tend to show that diphtheria, as it is observed in the lower animals, is not the same thing as the diphtheria which affects man. It has been found that there are distinct varieties of bacteria in these different forms of diphtheria. Descriptions of these will now be given.

The Bacillus Diphtheriæ Columbarum.—This was described in 1884 by Loeffler, who obtained it from diphtheritic pseudo-membranes in the mouths of pigeons dead of a form of diphtheria which prevailed in some parts of Germany among these birds, and among chickens. Reddened patches first appear upon the mucous membrane of the mouth and fauces, and these are covered later with a rather thick yellowish layer of fibrinous exudate. In pigeons, the back part of the tongue, the fauces, and the corners of the mouth are especially affected; in chickens, the tongue, the gums, the nares, the laryux, and the conjunctival mucous membrane.

The disease is especially fatal among chickens—the young, and those of choice varieties being most susceptible. It is attended at the outset by fever, and usually proves fatal within two or three weeks, but may last for several months.

Morphology.—They are short bacilli, with rounded ends, usually associated in irregular masses, and resembling the bacilli of rabbit septicæmia, but a little longer and not quite so broad. In sections from the liver they are seen in irregular groups in the interior of the vessels. It is an aërobic, non-motile, non-liquefying bacillus. It grows in nutrient gelatine in the form of spherical white colonies along the line of puncture, and upon the surface it has a whitish layer. Under the microscope the colonies in gelatine plates have a yellowish-brown color and a slightly granular surface. Upon blood-serum the growth consists of a semi-transparent grayish-white layer; upon potato a thin layer is formed having a grayish tint.

Pathogenesis.—Pigeons inoculated with a pure culture in the mucous membrane of the mouth are affected exactly as are those which acquire the disease naturally.

Subcutaneous inoculation in pigeons gives rise to an inflammation resulting in local necrotic changes.

Pathogenesis for Rabbits and for Mice.—Subcutaneous injections in mice give rise to a fatal result in about five days. The bacillus is found in the blood and in the various organs, in the interior of the vessels, and sometimes in the interior of the leucocytes, and they are especially numerous in the liver. The lungs are dotted with red spots; the spleen is greatly enlarged, and the liver has a marbled appearance from the presence of numerous irregular white masses scattered through the pale red parenchyma of the organ. These white masses are seen in sections to consist of necrotic liver tissue, in the centre of which the bacilli are found in great numbers, in the interior of the vessels. This appearance is so characteristic that Loeffler considers inoculation in mice to be the most reliable method of establishing the identity of the bacillus. It is not pathogenic for chickens, guinea-pigs, rats, or dogs. There seems to be some doubt whether the form of diphtheria which prevails among pigeons, and which Loeffler has shown to be due to the bacillus above described, is identical with the diphtheria of chickens. Diphtheria in man has been supposed by some authors to be identical with that which prevails among fowls, and, possibly, this may be the case, under certain circumstances. But the evidence seems to be convincing that there is an infectious diphtheria of fowls which is peculiar to them, and which, under ordinary circumstances, is not communicated to man.

The Bacillus Diphtheriæ Vitulorum.—This was described by Loeffler in 1884, and was obtained by him from the pseudo-membranous exudation in the mouths of calves suffering from an infectious form of diphtheria.

The disease is characterized by the appearance of yellow patches upon the mucous membranes of the cheeks, the tongue, and sometimes the larynx and nares of infected animals. There is a yellowish discharge from the nose, an abundant flow of saliva, occasional attacks of coughing and diarrhœa. Death may occur at the end of four or five days, but usually the animal survives for several weeks. Diphtheritic patches, similar to those in the mouth, are also found in the large intestine, and there are scattered abscesses in the lungs. Loeffler, in a series of seven cases examined, obtained from the deep portion of the pseudo-membranous deposit a long bacillus which appeared to be the cause of the disease.

Morphology.—They are bacilli five to six times as long as they are broad, usually united in long filaments. The diameter of the rod is about half that of the bacillus of malignant œdema.

Biological Characters.—Attempts to cultivate this bacillus in nutrient gelatine, blood-serum from sheep, and various other media, were unsuccessful. But when fragments of tissue containing the bacillus were placed in blood-serum from the calf, a white border consisting

of the long bacilli was developed. These could not, however, be made to grow when transferred to fresh blood-serum.

Pathogenesis.—Mice inoculated subcutaneously with the fresh diphtheritic exudation died in from seven to thirty days. The autopsy disclosed an extensive infiltration of the entire walls of the abdomen, which often penetrated the peritoneal cavity and enveloped the liver, the kidneys, and the intestines in a yellowish exudate. The bacillus was found in this exudate, and by inoculating a little of it into another animal of the same species a similar result was obtained. It is not pathogenic for rabbits or guinea-pigs.

The Bacillus of Intestinal Diphtheria in Rabbits.—This was described by Ribbert, in 1887, and was obtained by him from the organs of rabbits which had an affection characterized by a diphtheritic inflammation of the mucous membrane of the intestines. The autopsy revealed, also, swelling of the mesenteric gland, and minute necrotic foci in the liver and spleen.

Morphology.—Bacilli with slightly rounded ends, from three to four micromiltimetres long and from one to one and four-tenths micromillimetre in diameter. Often united in pairs or in filaments containing several elements. Stain with the usual aniline colors, but not so readily in sections as do some other bacteria.

Ribbert recommends staining with aniline-water, fuchsine solution, washing in water, then placing the section in methylene blue solution and decolorizing in alcohol. The bacilli cannot be stained by Gramm's method.

Biological Character.—It is an aërobic, non-liquefying bacillus. The question of its motility is not yet settled. Upon gelatine plates semi-transparent, grayish colonies are formed, which later turn a brownish color. The surface of these is finely granular and of a pearly lustre. In needle cultures in nutrient gelatine the growth along the line of puncture is very scanty. On potato a flat, whitish layer is formed which extends slowly over the surface. It grows best at a temperature of from 30° to 35° C.

Pathogenesis.—Pure cultures injected into the peritoneal cavity, or subcutaneously, in rabbits cause the death of these animals in from three to fourteen days, according to the quantity used. At the autopsy necrotic foci are found in the liver and spleen and the mesenteric glands are enlarged, but the intestines present a healthy appearance; but when cultures are introduced into the alimentary canal the characteristic diphtheritic inflammation of the mucous membrane of the intestines is produced. This result was obtained both by direct injection into the interior of the intestines and by injecting cultures into the mouth.

Diagnosis.

The characteristic sign of diphtheria is the presence of a circumscribed membrane with more or less congestion of the surrounding parts. The fever is not always a prominent symptom, and but little importance can be attached to it. High fever at the beginning of the disease should make the diagnosis doubtful for the time. Swelling of the glands of the neck, especially about the angle of the jaw, is an important aid in the diagnosis. The absence of this sign is, however, of no weight as negative evidence. It is of especial value when the process is seated in the nose, and its exact location cannot be readily ascertained.

Diphtheria of the vagina and conjunctiva and of wounds can only be confounded with a simple purulent coating where ocular examination alone is at command: confusion between the two processes can very seldom occur. The eruption, when it is present, occurs about the chest, neck, and abdomen, and is to be distinguished from that of scarlatina, according to Jacobi, in that this latter first appears about the hips and extremities. Not infrequently, however, the differential diagnosis is extremely difficult, and can be made only after sufficient time for observation of the efflorescence has elapsed. Albuminuria, if present in the first few days of attack, is an indication of diphtheria; if it appears later, of scarlatina. The diagnosis of diphtheritic paralysis presents no difficulties if the case has been watched from the beginning and the diagnosis of the primary disease has been satisfactorily made.

The settlement of the question as to whether a paresis is a sequel of diphtheria or not, is often impossible if the previous history be obscure. The special characteristics of the diphtheritic paralysis are, that it very frequently starts from the pharynx; that its course is exceedingly irregular; and that it is mostly peripheral in character, generally motor, and sometimes sensory.

Differential Diagnosis.—Diphtheria may be confounded with scarlet fever, confluent herpes of the throat, acute tonsillitis, and acute laryngitis.

In addition to the points already touched upon, the following aids to diagnosis may be mentioned:

The disease may be differentiated from scarlet fever by a consideration of the following facts: In scarlet fever there is less constitutional disturbance; the throat is less uniformly reddened; the membrane, if any exists at all, is more easily detached; and the larynx is almost never attacked; but, on the other hand, hæmaturia is common, while it is rare in diphtheria. The rash is different in the two diseases. In diphtheria it is not commonly present; it appears at irregular periods, is partial, appears suddenly in patches, and is of an uniform erythematous redness, without the punctated appearance peculiar to the scarlatinal eruption (Meigs and Pepper).

It is very often impossible to differentiate acute tonsillitis from diphtheria at first. If the case be one of tonsillitis, however, the inflammation either subsides or suppuration occurs, which at once makes the diagnosis plain. In such cases aid must be sought from the bacteriological examination. Confluent herpes has the peculiarity of a rapid rise in temperature, followed by an equally rapid fall. The pain in the throat is of a peculiar smarting character, and there is no tendency to spread. The presence of herpes of the lips is often of very great help in making out the diagnosis. Catarrhal laryngitis of a severe form is oftentimes impossible to differentiate from diphtheria, especially in the early stages. When the disease is fully developed it is easier to distinguish it correctly, for catarrhal laryngitis nearly always ends in recovery and without the severe sequelæ of diphtheria.

Recent investigations show that it is not possible to make a certain diagnosis of diphtheria excepting by the bacteriological examination; the discovery of the true bacillus of diphtheria, in material taken from the suspected spots of inflammatory reaction, settles the question.

That there are other throat affections very closely resembling, from a clinical point of view, true diphtheria, is unquestionable, and in this connection the work of Martin (to be found in the *Annales de l'Inst. Pasteur*, May, 1892, p. 335) is of very great interest. In this article the author reports that he has made both a clinical and a bacteriological examination of two hundred children who were sent into the diphtheria ward with a clinical diagnosis of diphtheria. The very full extracts that we shall give from this article are justified by the extreme importance of the subject.

He says that when a child arrives at the hospital, it is likely to present one of these two different conditions, viz.: 1. There may be a white angina, with or without laryngeal trouble; or, 2. there may be no visible false membrane, the child presenting only the symptoms of a laryngitis; in other words, as the parents say, it has the croup.

The rapid examinations to which these patients are submitted are necessarily inconclusive, but usually, as a result, they are sent into the diphtheria ward.

In order to arrive at a certain diagnosis, bacteriology, according to this author, now furnishes two methods of procedure, first, the examination of the false membrane, and second, cultivation upon coagulated serum and examination of the cultures after twenty-four hours.

1. *The Direct Examination of the False Membrane.*—This examination was made after the method of Roux and Yersin (in the *Annales de l'Inst. Pasteur*, 1890), and in many cases it was possible to discover at once a bacil-

lus of diphtheria, thus facilitating the making of a rapid diagnosis. This, however, was not always practicable, much care and great expertness being required for such work; many preparations had to be examined, and it had to be definitely determined that the bacillus seen stained well according to Gramm's method. Very often it is exceedingly difficult to recognize the bacillus of diphtheria among a great number of other bacteria, and when it is not discovered it is not permissible to say that the case is not one of diphtheria.

2. *Cultivations from the Suspected Spots.*—In certain cases of croup without false membranes the microscopic examination of the mucus of the posterior portions of the throat, spread out upon a cover-glass and colored with methyleue blue, did not permit a definite diagnosis, and at the same time this same mucus sowed upon serum gave very numerous colonies of the bacilli of diphtheria.

The best method is to *always* use coagulated serum, which is a medium that is very favorable for the development of the bacillus of diphtheria, and upon which it develops in a few hours, before any—or at any rate most—of the other bacteria of the mouth.

The culture is to be taken directly from the throat with a platinum needle flattened into the shape of a spatula at the end; the false membranes, when they exist, are to be touched, or simply the mucus in the apparently simple cases of laryngitis without false membrane; then the spatula is drawn over two or three tubes of serum without retouching the throat. The tubes are then to be placed for twenty-four hours in a thermostat at 37° C., and, if it be a case of true diphtheria, numerous colonies will soon appear, especially upon the first tubes that were inoculated; even after the lapse of eighteen hours they can be recognized and examined, and it was never found necessary for the author to wait more than twenty-four hours. After a longer time than this the other bacteria commenced to develop and rendered the diagnosis more difficult. In cases of severe diphtheria the colonies of the bacillus of Loeffler are more numerous than in mild cases. In certain anginas that were not diphtheritic no colonies developed during the first twenty-four hours. The presence of a great number of colonies upon the tubes make probable the diagnosis of diphtheria, especially if this occurs soon; but there are certain anginas produced by a coccus that also gives numerous colonies after the lapse of twenty-four hours, upon inoculation upon blood-serum. In the latter case the microscopic examination will determine the truth and render all confusion impossible.

Upon the serum the colonies of the diphtheria-bacillus are round and very regular, of a yellowish-white color, and more opaque in their centre by transmitted light; as they grow older they increase in size, remain regular, and become sometimes of a pale yellow color. Certain cocci give, also, colonies resembling those of diphtheria, but their surface is more moist, while their centre is not thicker than the edges.

The colonies of the streptococci are still very small at the end of twenty-four hours, and it is not possible to confound them with those of the bacillus of diphtheria, which are at least six or seven times as large. Colonies of the staphylococcus aureus have also been found, as well as other bacteria that liquefy the serum. These colonies develop especially after twenty-four hours, and do not trouble the observer. In the entire observation only those colonies need be considered that develop upon serum, and this is the only nutrient medium that it is at all necessary to employ.

When the diphtheria colonies were in a great majority, the cases were regarded as pure diphtheria; but if with the bacillus of diphtheria numerous colonies of different species were found, then the bacteria mixed in the secretions were considered. Those most often associated with the bacillus of diphtheria were micrococci and streptococci, their presence seeming to have an influence upon the progress of the disease, and furnishing, also, a basis for a prognosis.

The author claims that the examination of the number and of the form of the colonies is only a preparatory work, and must be followed by the microscopical examination, which shows that the bacillus of diphtheria does not always present itself under the same form. He distinguishes three varieties: (1) Long bacilli, which are the typical organisms of diphtheria described by all the authors; there are also (2) small bacilli that are placed side by side, and appear thicker than the ordinary bacilli, because they are shorter; and finally, between these two, there is (3) an intermediate form of bacillus of a medium length, the individuals of which are also placed side by side. The colonies of these three forms are not distinguishable upon serum, although the short bacilli often give whiter, more moist colonies, which continue to increase, even outside of the thermostat, and answer very closely the description given by Loeffler of the pseudo-diphtheritic bacillus.

From the point of view of virulence there are differences between these bacilli of different forms, but they are considered to be, all of them, bacilli of diphtheria. Martin found the short bacilli very mild in their action, the medium-sized bacilli a little more toxic, while the long bacilli are the most infectious. Among a number of cases of diphtheria which he had verified by bacteriological examination there were several fatal ones in which the short bacilli were found, but these were always associated with the streptococci; and often, in cases of measles with sore throat, were found the short bacilli, which, although mild under ordinary conditions, seemed, in these particular cases, to take on more virulent properties.

The author, in discussing further the question of diphtheria, lays especial stress upon what appears to be an exceedingly important point, particularly in the light of the investigation of Frosch, already quoted in this article. He says, that at autopsies he often looked for the bacilli of diphtheria in the respiratory tract, especially in the pulmonary parenchyma, and that he very often succeeded in finding them in these places. In all cases there was an inflammation of the lungs, which appeared under the form of a lobular broncho-pneumonia. Many times it was in the lungs that the greatest quantity of the bacilli was found, and in these observations there was no false membrane in the throat and very little in the trachea. It appeared to be the pulmonary parenchyma that was the principal seat of the infection. It even appeared to him, in certain cases, that *the lungs were primarily attacked*, and that the trachea and the larynx were only the *secondary* seats of the disease.

By this study of two hundred cases of supposed diphtheria it has been established that there are in reality three great classes of disease: the non-diphtheritic anginas, of which there were forty-three cases; the diphtheritic anginas of which there were sixty-nine cases; and croup, of which there were eighty-eight cases. In other words, *forty-three cases had been sent to the diphtheria ward that did not have diphtheria at all.* Among these cases four were attacked with measles. This point alone emphasizes, more than anything well could, the extreme importance of a correct differential diagnosis, and that this diagnosis should be made before the patient is sent in to the diphtheria ward. In other words, every hospital should have a detention-room or observation ward, in which suspected cases of diphtheria should be detained long enough to determine whether or not they be cases of true diphtheria, and whether, as a consequence, they should or should not be sent to the diphtheria ward. There can be no doubt but that this is a matter of very great importance.

More remarkable still is the observation that out of these forty-three cases thirty-six, in which it was not possible to determine the presence of the diphtheria bacillus, showed the occurrence of false membranes in some portions of the throat. There were, therefore, this number of clinical errors in diagnosis, and the sufferers were put in jeopardy of their lives by reason of the omission of this extremely important point in diagnosis.

The non-diphtheritic cases are divided into angina produced by micrococci—the most common of these occurring in the form of a diplococcus, which has already been

described by Roux and Yersin, and which is found in immense numbers in the false membrane, where it appears in places as a pure culture. This diplococcus is to be regarded as the cause of the process. If we sow the cocci taken from one of the false membranes which they have produced, upon serum, there will be developed, in less than twenty-four hours, non-liquefying colonies that are as numerous and as pure as the colonies of the true diphtheria-bacillus obtained from typical cases. Upon a superficial examination these colonies appear to resemble those of diphtheria, but they are more moist and more transparent. Loeffler's methylene blue easily stains the coccus, which also stains by the method of Gramm, and it can also be cultivated upon nutrient agar. The false membranes produced by the activity of this organism resemble so closely true diphtheritic membranes that they are almost invariably regarded as such. Like the latter, they are reformed very quickly if they be torn away.

The progress of the cases is characterized by the exhibition of extreme prostration, and a marked characteristic of these false membranes is their tendency to recurrence. The sore throats produced by this coccus do not as a rule terminate fatally; they generally become better very rapidly and leave no evidences of systemic poisoning behind them.

A second class of non-diphtheritic cases owe their origin to the presence of streptococci. The streptococcus pyogenes is an organism which is very commonly found in the mouth, and which can produce alterations of the mucous membrane resulting in fibrinous exudation and the formation of pseudo-membranes. A number of observers have seen this occur, notably Prudden, who worked upon cases of apparent diphtheria produced by this streptococcus, and confounded these cases with those of true diphtheria. Cases produced by this streptococcus are not virulent any more than are those of the preceding coccus, at least to anything like the same degree as the cases resulting from the activity of the true diphtheria bacillus.

The second class into which the 200 cases are divided is that of diphtheritic anginas without croup. Of these there were 62 cases of pure diphtheritic anginas, following out the ordinary clinical history of cases of diphtheria. Of the remainder, some of the cases were diphtheritic anginas mixed with the streptococci, and diphtheritic anginas mixed with the micrococci. The general history of these tended to show that a mixed infection produces a *milder form of diphtheria* than when the diphtheria bacillus is present by itself.

Another division of the cases was into croup—croup with false membranes—of which there were 54 cases, and of these there were 17 cases which were shown to be non-diphtheritic, and 13 cases of diphtheritic croup with mixed bacterial infection—some of them with the streptococcus and some with the coccus alone. And then there were cases of pure diphtheritic angina accompanying croup. Finally, the last division of cases is that of croup without false membrane in the throat; and of these there were 34, 21 of which were proved to be diphtheritic, while 12 were not.

The author, in concluding his work, says that his first object in undertaking it had been to find out how far bacteriology could aid the clinician in the diagnosis of diphtheria; and he makes the statement, which can scarcely be disputed, that the most accurate clinician is deceived once out of five times—whether it be in the direction of mistaking a non-diphtheritic angina for diphtheria, or in that of not recognizing a case of true diphtheria. Bacteriological researches have furnished many extremely interesting and important points bearing upon the clinical and bacteriological history of the pseudo-membranous anginas that are non-diphtheritic. Bacteria play an exceedingly important part in affections of the throat, and it is bacteriology alone that can clear up the question of the anginas, for their clinical characteristics are entirely insufficient to distinguish them.

As a conclusion to this remarkable and important paper the author makes the following statements:

Many anginas with false membranes, and, also, many cases of croup, are confounded with diphtheria. Bacteriological examination furnishes the most certain and the most rapid means for making the exact diagnosis of diphtheria. There are pure diphtherias and diphtherias associated with other bacterial infections, and among the latter—the diphtherias with other bacteria—those in which the streptococci are found are the most severe, while those in which the micrococci are found are the most benign. The temperature curve furnishes an excellent method for determining the prognosis, and upon this point the author has laid very great stress, instancing many cases (accompanied by reproductions of charts) in which a study of the temperature observations, made at the same hour morning and night, revealed the fact that there appeared to be a curve almost as characteristic for diphtheria as that which is usually supposed to belong to typhoid fever.

In a recent number of the *Philadelphia Medical News* (December 10, 1892) Wyatt Johnston, of Montreal, makes a suggestion for the ready diagnosis of diphtheria that seems to be entirely practicable. It consists in boiling an egg hard, which, of course, solidifies the albuminous contents, and, at the same time, sterilizes the shell. There is prepared at the same time an ordinary egg-cup, which may be sterilized by burning a little alcohol in its hollow. A small portion of the shell of the egg is then chipped off at one end, and a minute portion of material from the throat of the suspected case is drawn over it with a platinum needle, three or four separate times, without retouching the platinum needle to the throat, and the egg is then inverted in the egg-cup and the whole placed in a warm place over-night. By this means it is often possible to make a perfectly satisfactory diagnosis of diphtheria in a comparatively short time, and with the simplest form of apparatus. For if the diphtheria bacillus is present it will grow rapidly upon this solidified egg-albumen, and the characteristic colonies will be present upon the following morning, when the diagnosis may be further verified by microscopic examinations of the colonies that have made their appearance. Park, in a recent number of the *Medical Record* (February 11, 1893), expresses some doubt in regard to the trustworthiness of the method just described.

Among those who have expressed themselves strongly in regard to the importance of resorting to bacteriological examinations in making a diagnosis of diphtheria may be mentioned Martin, from whose paper we have already given very full extracts; Park (*Medical Record*, July 30 and August 5, 1892, and February 11, 1893); Baginsky (*Berliner klin. Wochenschr.*, February 29, 1892); and Koplik (*New York Medical Journal*, August 25, 1892). There is doubt whether in the course of time clinical features will be discovered by means of which true diphtheria can be distinguished from the forms of disease which resemble it.

Prognosis.

The prognosis in each individual case should be very guarded. To assume that recovery is probable, before the disease has run its course, is exceedingly unsafe, and even then relapses may occur and the result be once more placed in doubt. The general course of an epidemic may have some influence upon prognosis, but that influence is exceedingly small, for it is the mild cases that are often the most deceptive. Speaking very generally, the prognosis is favorable where the local manifestation of the disease is of small extent and is situated on a part that has but little communication, by way of the lymphatics, with the rest of the system. An indication of sluggishness in the course of the disease, as in diphtheria of the womb or the angles of the mouth, is unfavorable, as is also the extension of the disease to the larynx. The septic or gangrenous forms of diphtheria are especially dangerous, but the elevation of the body temperature has not been thought to have any particular bearing on the final result. Martin, however (*loc. cit.*), lays great stress upon the temperature curve as a guide in prognosis. A rapid, small, and irregular pulse is a sign of failure of the heart, but is not a very bad sign so long

as there is an approximately normal relation between it and the rate of respiration. Every complication adds to the gravity of the prognosis. During convalescence the extension of the paralysis to the muscles of respiration is a very alarming sign. The indications of immediate danger are croupy symptoms arising from the extension of the membrane into the larynx, a brown or black appearance of the false membrane, a hemorrhage from the nose, throat, bronchi, or intestines, copious discharge from the nostrils, intense albuminuria, great swelling of the cervical glands, decided fall of temperature, and nausea or diarrhœa at an advanced period of the disease. Any one of these may occur without being necessarily fatal, but two or more mean extreme danger.

Treatment.

There is no specific for diphtheria. Treatment is to be based, first, upon general principles, and, second, upon local applications. Measures to sustain the general health are of the greatest importance, and should receive special attention. The room should have a temperature of from 62° to 65° F.; it should also have, if possible, a sunny exposure, and there should be an open fire. The diet should be very nutritious, consisting of beef-tea, milk, and the like, given regularly in small quantities and at short intervals, especially during the night, for it is then that the vital powers are in their least resistant state.

If signs of failure of the heart appear, the patient's head should be kept as low as possible. High fever should be treated with sponge-baths of tepid water; quinine and salicylate of sodium are also recommended. Collapse should be met with the free exhibition of stimulants, and severe vomiting or diarrhœa should be checked at once. Quinine and the method of employing it should be left to the judgment of the physician. As complete isolation of the case as is possible should be practised; the sick-room should be kept cool (the temperature spoken of above is the best), and plenty of fresh air should be admitted. The nurses should keep the mouth closed when over the patient, and any caressing or fondling should be absolutely prohibited. It is also a good plan to wear cotton in the nostrils as a filter.

The general treatment should be begun early, as there is no typical course to the disease, and, therefore, delay is dangerous. There is small chance of giving too much stimulant, and a tonic never does harm, whereas its omission may be seriously felt.

An exceedingly important measure is the disinfection of the room, and of all objects which may have come in contact, in any way, with the patient. In the case of a room this may (?) be effected by fumigation; two pounds of rolled sulphur to every seventeen hundred and twenty-eight cubic feet of space being burned for this purpose. A copperas solution, one and a half pound to a gallon of water, may be used for everything that can be placed in it. Better than this is a solution of corrosive sublimate (one part to ten thousand of water) which should be freely used in all drains, privies, and so on, and for soaking all soiled linen or clothing.

The instructions given for disinfection by the National Board of Health, Bulletin No. 10, September 6, 1879, are simple and effective, provided the corrosive sublimate solution be substituted for the other agents mentioned. Best of all, however, is prolonged boiling of all infected material.

The infectious agent is confined, as we know, to the affected area, and in diphtheria of the mouth and air-passages, it will be found only in these situations or in material coming from them. The spread of infection should therefore be a comparatively easy matter. All saliva, mucus, blood, etc., coming from the patient, should be received upon towels or old rags that may be at once folded inward and subjected to boiling for at least half an hour. The same treatment should be given to the bed-clothing of the patients. Spoons and other articles coming in direct contact with the affected parts should be dropped *at once* into a vessel containing water, and then also boiled as in the case of the other articles. Nurses and other attendants may avoid infection, themselves, or the danger of carrying it in their clothing, if they put on a loose gown, tight at the wrists and neck, at the entrance to the sick room, and remove this article of dress immediately upon leaving the room. The hands should *at once* be thoroughly cleansed by soap and water as hot as can be borne.

The *special precautions* that are needed in the case of diphtheria of the air-passages, for the safety of the observer, are to avoid inhalation of the breath of the patient, and this especially at the time of coughing. The infectious material of diphtheria is so well known now, its localization is so defined, and at the same time so limited, that there should be no especial danger in the future of its being transported.

Special Treatment.—There is, at present, no specific for diphtheria. The first indications are to employ those remedies which have, or seem to have, an effect in softening or destroying the false membrane. The principal among these are steam inhalations, which have been employed in various ways, as from the nozzle of a kettle and by dropping hot bricks into water. The best method of employment is by means of the atomizer, used very frequently in conjunction with some therapeutic agent, such as carbolic acid, salicylic acid, salt, or chlorate of potassium. This latter remedy is one very widely employed and of especial benefit—not, however, as a specific against the disease. Its beneficial effects arise from its alleviating the laryngitis and stomatitis accompanying the disease, and from its placing the surrounding parts in such a condition that the false membrane rarely spreads. It should be given freely, that is, in small doses and frequently. One of the best methods of application is by the steam atomizer;—using the spray for five or ten minutes every hour has been followed by the most successful results. The strength of the solution to be used is that of saturation; a sufficient dilution for safety being effected by the steam. For children the solution should be weakened so that a child of three years will not get more than twenty grains in the twenty-four hours. Serious results, such as acute nephritis, have been recorded from overdoses of this drug, but properly employed its great value is unquestionable. It does not have any marked effect in dissolving the diphtheritic membrane, as has been supposed.

Steam is of value only in those cases in which the membrane is upon the surface. Water, to promote the secretions, is of value, either given alone or combined in hot drinks of various kinds. Cold water and cold applications in the form of ice-bags are useful in many ways in easing the discomfort of the swollen and sore throat. Cracked ice, water ices, and ice-cream, give relief. Sponging with tepid water when the body temperature is high, and the skin hot and parched in consequence, gives great comfort to the patient. If there are signs of a weakened circulation, however, this remedy is contraindicated. Lime-water, either alone or in combination with glycerine, applied locally to the throat by means of spraying, sponges, or gargles, has been very highly thought of as exerting some solvent effect upon the membrane. The action is so slow, however, that the good results obtained are probably due, as suggested when speaking of chlorate of potash, more to their cleansing effects than to any specific action; and the same is probably true of acetic acid and other well-known remedies.

Peroxide of hydrogen is one of the more recent and highly endorsed remedies in the treatment of diphtheria. I have obtained good results, apparently, from the use of the following formula:

℞. Acid. sulphuros. dil.	.....	♏ x.–xxx.
Tinct. ferri chlor.	.....	ʒ v.
Syrup. aurant. cort.	.....	℥ jss.
Aq. dest	.....	℥ ijss.

M. Sig.: Half a teaspoonful to a teaspoonful in a tablespoonful of water.

This may be repeated every two to four hours, and should be given through a glass tube.

Inhalations of the oil of turpentine are recommended to be administered for ten or fifteen minutes every hour. A better method of employment is by boiling some water, containing half an ounce of the spirits of turpentine, in the room. This should be kept going continuously,

Chloride of ammonium seems to be of use occasionally. Dose, internally, from one to two grains every two or three hours, for a child of two years; or half a drachm to be burned over a flame in the room.

Mercury has been extensively used, and is very strongly supported by Jacobi, of New York.

Astringents, such as alum, tannin, nitrate of silver, have almost entirely passed out of use; their employment seeming to retard, rather than to favor, the subsidence of the exudative process.

Chloride of iron, introduced by Gigot, in France, in 1848, has been used very extensively and beneficially, if given freely and at frequent intervals. As much as from five to ten drops of the tincture every half hour may be given.

Carbolic acid is helpful merely as a cleansing agent, and perhaps not even for that. Ozone has been recommended, with no very great results from its employment.

Salicylic acid, quinine, potassa fusa, and other strong salts, bromine, and so on, are among the remedies that have been proposed. Boric acid solution (one to thirty), used as a gargle, and benzoate of sodium (one to eighteen parts of water), are among the other remedies that have been proposed. Sulphur and cubebs (used in capsules) nearly complete the list of remedies.

Gargles, sprays, and local applications of watery solutions of corrosive sublimate (varying from one in three thousand to even greater strengths) have also been employed.

Mechanical removal of the membranes must not be practised. When these can be detached without force they will come off of themselves, and this time should be patiently awaited.

Swelling of the lymphatic glands in diphtheria must be treated as if an idiopathic affection, by applications of cold water or ice compresses, and, if absolutely necessary, by incision.

Nasal diphtheria must be combated by the assiduous use of douches composed of some of the remedies spoken of above; they should be used every hour.

Laryngeal diphtheria is occasionally helped by the employment of emetics. It is when the symptoms become urgent, in this form of disease, that tracheotomy is resorted to; the indications for the operation being the danger of suffocation from stenosis of the larynx. The mortality after the operation increases in proportion to the delay in its performance.

As a substitute for tracheotomy in stenosis of the larynx in diphtheria, the famous procedure of intubation has been very widely employed. The success attending this substitute for the cutting operation has not been so great as was hoped at first; doubts of its effectiveness in practice have increased very much of late. Farther on in this volume, under its appropriate heading, will be found a fresh contribution to the subject of intubation, by the inventor of the procedure, Dr. Joseph O'Dwyer, of New York. The reader is referred to this for additional information on the subject.

Diphtheritic paralysis may in many cases be treated simply by rest, good food, stimulants, tonics, such as iron and quinine, and sometimes by electricity. Strychnia is recommended, but its usefulness is very doubtful.

Diphtheritic conjunctivitis must be attacked at once, and vigorously, with ice applied locally, and boric acid in concentrated watery solution, every hour. The uninfected eye must be carefully protected from inoculation, and this is best done by covering it with lint and collodion, or with lint, cotton, and adhesive plaster.

General Investigations for Methods of Treatment by Bacteriological Research.—In order to understand clearly the attempts which have been made to obtain something in the way of a cure for diphtheria by bacteriological methods, a statement should be made of the general way in which immunity and cure, in infectious diseases, has been sought by different observers, along bacteriological lines. These methods are well summarized by Behring in the tables given by him in the first part of his work upon "Blood-serum Therapeutics," published in Leipzig, 1892. In this first part he gives three tables:

Table I. A Method of Obtaining Immunity against Infectious Disease.—A. *Immunity with the help of disease-producing materials, similar to those against which immunity is sought.*

1. The Attenuation Method (Pasteur's method; Vaccination). Of general applicability. (*a*) Immunity by the employment of attenuated cultures of living bacteria. (*b*) Immunity by attenuated poisons. In both of these cases one has the choice of producing the attenuated material by the following methods: (a) Attenuation by high temperature; (b) attenuation by low temperature; (c) attenuation by means of chemical agents; (d) attenuation by atmospheric influences, especially insolation.

2. The method by dilution. Of limited applicability. Consists in the employment of (*a*) cultures of full virulence, (*b*) culture-fluids of full toxicity.

3. The combined method (Behring's method). Of general applicability. Consists in the obtaining of immunity by the help of the attenuation method first, and then following it by the employment of cultures of full virulence and full toxicity in order to obtain a very high degree of immunity.

B. *Obtaining immunity by the help of disease-producing materials of a different kind from those against which immunity is sought.*

1. The employment of living bacteria cultures, or of specific chemical materials which are contained in it.

2. The employment of chemical preparations.

3. The obtaining of immunity by the direct transference of the immunity-containing agent. This is Behring's blood-serum therapeutics.

Table II. The Method of Action of the Agent Producing Immunity.—1. By the destruction of the living cause of the disease.

2. By hindering the growth of this living cause.

3. By the destruction of its infectious properties, which result, according to Behring, is effected by taking away from the bacteria their power of producing their poisonous products.

4. By the destruction in the infected organism of the poisonous material produced there.

5. By such a change of the central organs, or of the living cells, that they obtain a higher degree of resisting power against the nerve toxines and cell toxines produced by the bacteria.

Table III. Conditions Necessary for the Production of Immunity.—A. *A passive state of the organism* (the exhaustion theory, and the theory of non-favorable culture media).

B. *A functional condition of the organism,* divided into: 1, A function of the living condition of the organism (the contest theory); 2, a function of the dead condition of the organism.

These three tables give a very accurate view of the various theories upon which experimental work has been based in order to secure immunity from, or cure of, infectious diseases.

Of all these the one which has been especially applied to the study of diphtheria, is that of Behring, marked (c) in Table I., and is included in what Behring has called "blood-serum therapeutics."

The history of the investigations which have been made in the domain of diphtheria is exceedingly interesting. The first paper that appeared on the subject was by Behring and Kitasato, in 1890 (in No. 49 of the *Deut. Med. Wochenschrift*); the second was by the same authors in the same year (No. 50 of the same journal); the third was by Boer (a monograph upon the methods of treating guinea-pigs infected with diphtheria with chemical preparations); and the fourth was by Behring and Wernicke, in 1892 (*Zeitschrift f. Hyg.*, 1892, vol. xi.), upon

the immunity and cure of animals affected with diphtheria. The result of all this work is to furnish a promise of something of great value in the future. Certainly great results have been obtained by similar work in the domain of tetanus in man, and the outlook for something really satisfactory in the domain of diphtheria is very promising.

The theory acted upon in the production of immunity against diphtheria may be best explained as follows: It is a long time since the theory that immunity might be due to the presence of a deterrent substance in the blood entered the mind of scientific men,—this substance being something that would prevent the growth of the invading bacteria or prevent the development of their toxic poison; but it has been an exceedingly difficult matter to secure evidence upon the point.

The first experimental researches were negative (those of Grawitz and Gamaleia), but in 1884 Grohmann showed that fresh serum exerted an attenuating influence upon the bacilli of symptomatic anthrax. Fodor found that fresh blood destroyed them, while Nuttall established the fact that organic fluids, blood-serum, aqueous humor, pericardial fluid, etc., really possessed the power of destroying bacteria, and that this germicidal action was taken away by raising these fluids to a temperature of about 60° C. Buchner showed that this power rested solely in the serum, and that the breaking up or mixing in of the blood-corpuscles masked or diminished its activity. He also showed that repeated freezing divided the serum into layers, of which the lowest was the most active in destroying bacteria, and that this power of the serum is destroyed if it be diluted with distilled water, or if it be dialyzed against it. After Buchner, the most important work has been done by Ogata and Iasuhara, and Behring and Kitasato, in showing the great influence of the fluid portion of the animal tissues in the acquisition of immunity. According to the work of these authors, immunity is due to the action of albuminoid substances, called by Hankin defensive proteids, which have the power of destroying pathogenic bacteria, of attenuating them, and of destroying their toxic products.

It is necessary that one should have a clear idea in regard to these defensive proteids, if one is to understand what extreme importance is to be attached to their discovery, and to the prosecution of researches upon them.

First, in regard to germicidal proteids. Certain animals have in their blood, and the other fluids of the body, substances endowed with a very considerable germicidal power, and an example that has been better studied than some others is found in the blood of the white rat. These animals are refractory to inoculation with anthrax, and the reason for this immunity to so virulent a disease has been found by Behring to exist in the fact that the animal's blood-serum destroys the bacteria. By comparative tests it was shown that two and one-half centimetres of rat serum possessed the same germicidal action as would the same quantity of corrosive sublimate in the strength of one to one thousand, or of carbolic acid (one to fifty). To appreciate this fact it is necessary to consider another quality of chemical germicides, viz., the toxic action of these materials upon the animal. Thus, for example, it appears that both the sublimate and the carbolic acid will kill the animal in a dose five to seven times smaller than is necessary to secure their germicidal action, and that they cannot therefore be thought of for internal antiseptics, while the germicidal proteids are present in quantity sufficient for the perfect accomplishment of such germicidal action in the serum of the perfectly healthy white rat. This is the most striking and valuable property of these defensive proteids, viz., that they are the least toxic of all germicides known, and this leads up to the more important fact that it seems possible to employ them in active measures for the treatment and cure of infectious disease.

Many points, of course, still remain to be cleared up, as, for instance, such an apparent contradiction as that the serum germicidal power does not, in all cases, correspond with the natural immunity of the animal furnishing the serum; but thus far investigation has only served to show that these apparent discrepancies can be easily explained.

The second class of these proteids is made up of the attenuating varieties, the existence of which was first suggested by the fact that the bacteria of symptomatic anthrax were attenuated in virulence when injected into animals refractory to the disease, and yet at the same time their vitality was not interfered with. It is to the work of Ogata and Iasuhara that we owe the first experimental determination that this attenuating property resided in the serum of the animals experimented upon, and not elsewhere.

Such an attenuating action upon bacteria would explain very naturally the immunity of the animal in whose blood it was found, and the authors, by further experiments, showed that this property continued to exist in the serum after its removal from the body of the animal in which it was found, and could be made to serve as a retarding influence, and even as a curative agent, in animals inoculated with true anthrax. The existence of these attenuating proteids has been confirmed by other observers in the case of anthrax and in other diseases, and the establishment of the fact would be exceedingly important if this were all; but further research has shown the existence of a third class of these proteids.

We know now that there are not only germicidal and attenuating, but also *antitoxic proteids*, and their discovery is the most important of all. The former classes act directly upon the bacteria themselves, either by actually destroying them, or by so limiting their development in the animal's body that their growth becomes a matter of slight moment as affecting the health of the individual attacked.

The first announcement of results in this direction was made by Behring and Kitasato in 1890 (see the quotations above). They had found that the blood of rabbits protected against tetanus had the power of destroying the toxic alkaloid of tetanus (tetanin) in the lifetime of the animal attacked. They also found that it was not only possible to protect animals against an inoculation of the tetanus bacilli, but also to cure it after this inoculation had taken place, and even after the appearance of the symptoms of the disease.

The importance of such results, especially as they have been repeatedly verified by independent observers, can hardly be over-estimated. Almost in the same week with the announcement of the discovery made by Behring and Kitasato with reference to tetanus came those of Fraenkel and Brieger in regard to diphtheria; and it is with regard to these latter, of course, that we are especially interested. So far as tetanus is concerned, if later reports can be trusted, the method of cure has been successfully applied in a number of cases which, as we have every reason to believe, would have terminated fatally, as such cases almost invariably do. Results similar to these have been obtained in animals in the case of some of the suppurative bacteria, in anthrax and in erysipelas, and the variety and extent to which experiments must go in the elucidation of the points brought up by these new facts, are almost unlimited.

As will be readily seen, we have at last caught sight of materials effective for the destruction of the bacteria, or their toxic products—materials that at the same time will leave the animal tissues unharmed after their application. Hitherto we have been able to employ for such a purpose only materials that were in themselves destructive to the vital organism, and the remedy, when effectively employed, has been worse than the disease.

The Toxalbumins of the Diphtheria Bacillus.—The toxalbumins of the diphtheria bacillus are at present attracting so much attention that the following account of the work of Wassermann and Proskauer (*Deut. Med. Woch.*, April 23, 1891) in extracting them can scarcely fail to be of interest.

Employing methods very similar to those of Brieger and Fraenkel (detailed in the *Berliner klin. Woch.*, 1890, Nos. 11 and 12) they attempted to follow out the same line of investigation. For their observations they used

a culture of the bacillus of diphtheria in bouillon which was about three weeks old and whose activity against animals was proved by experiments. This bouillon culture was made in the usual meat-water-peptone bouillon, with one per cent. of peptone and one-half per cent. of common salt. Its virulence was tested upon animals. One-tenth of a cubic centimetre of it injected into the animal was found to kill guinea-pigs after from twenty-four to thirty-six hours. Of such a bouillon culture three litres were made bacteria-free by passing through Kitasato's filter. That the filtrate was free from bacteria was proved by a double method of testing it: by cultivation upon nutrient agar, and further by leaving it in the brooding-oven for from twenty-four to forty-eight hours. After it was shown to be sterile by these tests, it was reduced to one-third of its bulk in a vacuum exsiccator at a temperature of from 27° to 30° C., having been made strongly acid with acetic acid. Absolute alcohol was added in the proportion of eight to ten times its mass, and the resulting precipitate was filtered after standing for twenty-four hours. This precipitate was then dissolved in water and further treated, and the operation was repeated as often as was found necessary to render the watery solution perfectly clear. Then it was three times dialyzed for twenty-four hours, and after dialyzing it was further treated with alcohol, and the precipitate collected and dried *in vacuo* at 37° C.

The observation was made that after leaving the precipitate in solution for one or two days in alcohol it became manifestly smaller in bulk. If this were then filtered and the filtrate again treated with absolute alcohol, *another precipitate* was obtained, differing markedly from the first.

It thus appeared clear that a part of the precipitate was more soluble in alcohol than the other, and as the alcohol was made more dilute it passed again into solution. This observation coincided with that of Brieger and Fraenkel, who, in their solutions, were able to isolate two bodies possessed of different solubility in dilute and absolute alcohol.

It was further observed that both bodies dialyzed very slowly; that they both gave the albumin reaction, and that only one of them was possessed of pathogenic properties. After a large mass of this bacteria-free material had been obtained, it was treated *in vacuo* at between 27° and 30° C., and was reduced to a tenth of its volume. Then at a low temperature it was dialyzed against distilled water for twenty-four hours three times, in order to get rid of the peptone and globuline. The authors were able to observe in neither of these—the peptone or the globuline—any pathogenic or poisonous properties. The peptone was obtained in fair quantity, but the globuline in very small quantity. The fluid obtained in the dialyzer was filtered clear, and only when it was obtained clear were the next procedures carried on. Seven times its volume of from sixty to seventy per cent. alcohol was added to the clear filtrate (freed of globuline and of the greater part of the peptone), the alcohol having previously been made acid with a drop or two of acetic acid. The precipitate thus obtained remained in alcohol for twenty-four hours, after having been allowed to settle for some time. It was then filtered and the dilute alcohol—the filtrate—was again treated with alcohol, and as often as a new precipitate was obtained it was again collected on the filter. Both substances were treated with water and the solution thus obtained again precipitated and treated as before. In order to free it as far as possible from peptone, it was treated with twice its bulk of a saturated solution of sulphate of ammonia, and the precipitate resulting from this, which contained the albumoses, was again brought into solution with distilled water, then passed through the dialyzer in flowing water until the reaction with sulphuric acid and ammonia disappeared, and finally was brought into solution with as small a quantity of absolute alcohol as was possible. This procedure—dissolving in water and precipitating with alcohol—was repeated until the solution became as perfectly clear as water. When this point was reached the precipitate was collected from the filter and dried *in vacuo* at 37° C.

In this way were obtained from cultures of diphtheria two albuminoid substances which resembled very closely those of Brieger and Fraenkel. The body precipitated by dilute alcohol was a finely granular white powder, while that thrown down by absolute alcohol, after drying, appeared in the form of a yellowish-brown, crystalline body. Both dissolved very easily in water, and these solutions gave simply albuminoid reactions. These bodies were broken up by concentrated mineral acids, by strong metallic salts, and by acetic acid, but this was not effected by nitric acid, by bisulphate of soda, or by warming the solution. They also gave the typical color reaction for albuminoid bodies.

The elementary analysis of the white toxic body gave the following from its ash: Carbon, 44.82 per cent.; hydrogen, 6.91 per cent.; nitrogen, 16.18 per cent.; sulphur, 1.69 per cent.; oxygen, 30.40 per cent.

The same analysis obtained by Brieger and Fraenkel, for their material gave: Carbon, 45.35 per cent.; hydrogen, 7.13 per cent.; nitrogen, 16.33 per cent.; sulphur, 1.39 per cent.; oxygen, 29.81 per cent.

The difference between the two analyses can be easily accounted for by the difficulty of the task. It was found that only the pure white, easily precipitated material had any toxic effect upon animals, while the other, even in considerable mass, could be injected without any unfortunate results following its use.

Investigations of this kind, as well as those of Behring, give promise of future results that are almost boundless in their extent and importance. The pity of it all lies in the fact that we in this country must stand idly by, powerless to help in pushing on these investigations, because of the lack of support for them in the way of money and institutions endowed for such researches.

Harold C. Ernst.

DIPHTHERIA IN CHILDREN. Membranous formation occurs very rarely in children under one year, but it has been seen even in the newly born. Most cases occur between the ages of three and fifteen. The clinical diagnosis of diphtheria covers at least two diseases, caused, one by the Klebs-Loeffler bacillus, the other by a streptococcus, and according as the disease is the one or the other, the symptoms vary somewhat, and the prognosis differs widely. A mixed infection is, however, not infrequent. A bacteriological examination is the only means of distinguishing positively between the two.

True Diphtheria, Due to the Klebs-Loeffler Bacillus.—The patient presents local and constitutional symptoms, the former the result of the position and extent of the membrane, the latter the result of the absorbed products of the bacilli.

Local Symptoms.—The membrane may be visible, or, by reason of its location, invisible. When visible it may be a mere point on one tonsil, or it may cover both tonsils, the soft palate, uvula, pillars of the fauces, and pharynx. It may extend up through the naso-pharynx and the nose, involve the conjunctivæ, and even appear in the ears. It may also cover the inner surfaces of the cheeks and extend out upon the skin. On the other hand, it may be confined to an area out of sight, or it may extend into the larynx, down the trachea and small bronchi, and rarely down the œsophagus. The membrane may be thin, transparent, and like a white veil, or thick and opaque; and in the latter case it may be yellow, green, gray, or black. It may be firm and closely adherent when young, or loose, shreddy, and soft when old. It may disappear in less than two days, and may last three or four weeks. Usually, however, the membrane begins to separate on the fourth or fifth day, and in about ten days the throat clears and convalescence begins. When the disease affects the neighborhood of the larynx there may be dyspnœa, due to a functional paralysis of the vocal cords, or to actual obstruction by membrane. With the dyspnœa come an altered voice, perhaps aphonia, and a cough. If the obstruction is considerable, cyanosis and retraction of the intercostal, supra-sternal, and supra-clavicular spaces are evident. If the naso-pharynx or nose

is affected, there may be complete occlusion of either or both nostrils, epistaxis, and there is regularly an acrid, watery, or purulent discharge.

Constitutional Symptoms.—The constitutional symptoms may be almost entirely absent, and on the other hand, when the local signs are slight, prostration may yet be extreme. Initial chilliness, aching of body or limbs, anorexia, and some soreness of the throat, are customary. The temperature may be very slightly raised, normal, or subnormal. Albuminuria, which is present in about half the cases, may begin the first day, and there may rarely follow a severe nephritis with uræmia. Rapid, feeble pulse, emaciation, prostration, and intense pallor are characteristic of toxæmia from absorption of ptomaïnes, and this toxæmia in a mild form may persist for weeks after the disappearance of the membrane. It is then probably due to continued slow absorption of ptomaïnes stored near the original site of infection. Paralysis, the result of a multiple neuritis, is frequent, and may come at any time from three days to six weeks after the beginning of the disease, but occurs oftenest in the second or third week of convalescence. The parts affected are primarily the soft palate and the muscles of accommodation, but all the muscles, even those of respiration and the sphincters, may be involved. The knee-jerk may be absent from the first day of the disease. There may be some slight cervical glandular enlargement, but in such a case there are usually streptococci present with the bacilli. With the mixed infection, too, there may be a broncho-pneumonia, which, like the persistent toxæmia, may kill the patient after the active disease is over. Various skin rashes may appear at the onset or later, and temporarily confuse the diagnosis.

Prognosis.—True diphtheria is extremely fatal in children under two years; children under one year almost never recover. Death is usually the result of one of the following causes: (1) Laryngeal stenosis; (2) septic infection; (3) broncho-pneumonia; (4) diphtheritic paralysis; (5) uræmia. Factors which increase the gravity of the prognosis, in any case, are marked prostration, great extent, thickness, and rapid spread of the membrane, long persistence of the membrane, its presence in the larynx, much albumin in the urine, the supervention of broncho-pneumonia, complications with other diseases, and persistent vomiting, especially if nourishment is taken poorly. On the other hand, a thin, slowly spreading membrane is favorable, as is one confined to a small area. Membrane which spreads to the naso-pharynx is unfavorable, but if it is confined to the nose, recovery is to be expected. From paralysis recovery is usual, after a period varying from one week to six months.

Pseudo-diphtheria, the Result of Infection by Streptococci.—As in the true diphtheria, the symptoms are local, due to the membrane, and constitutional, due to the penetration into the tissues of the cocci and to the entrance into the circulation of their poisonous products.

Local Symptoms.—The membrane cannot be positively distinguished in site or appearance from that of true diphtheria, and the symptoms due to its presence are the same.

Constitutional Symptoms.—There is frequently considerable temperature—103° to 104° F.—without any corresponding prostration. Glandular swelling is usually quite marked. Frequently, too, a broncho-pneumonia develops, sometimes late, but usually in the first week; if this does not happen, however, convalescence is extremely rapid.

Prognosis.—The prognosis is much better than in the true form, the mortality being about three per cent. in uncomplicated cases of the pseudo-diphtheria, as compared with a mortality of about thirty per cent. in the real diphtheria. Factors which are unfavorable are: (1) Complication with other infectious disease; (2) broncho-pneumonia; and (3) laryngeal stenosis. In the last case, if intubation or tracheotomy be performed, the prognosis for recovery is good.

Treatment.—Prophylactic treatment should be advised for children, especially those in institutions. Such consists in reduction of hypertrophied tonsils, care of the teeth, and the use of antiseptic gargles. All, old or young, exposed to cases showing membrane in the throat, should use frequently some antiseptic gargle.

Isolation of the patient should be absolute in the true form, but need not be so rigid in the pseudo-diphtheria. In the latter, however, contact with children should be carefully avoided. It is as yet uncertain whether bacilli are, or are not, found in the throat after the membrane has disappeared. It is wise, therefore, to continue such isolation for a week after the membrane has gone, and to continue antiseptic gargles during that time.

Local Treatment.—Any injury to the mucous membrane allows the membrane to spread; therefore all rough applications and swabbing are to be avoided.

Sprays are not notably efficient; but of the beneficial effect of steam in laryngeal cases, before and after operation, there is no doubt. The steam from kettle, steam-pipe, or other source, should be delivered close to the face of the patient.

Fumigation by calomel is certainly successful in coating the larynx, trachea, and larger bronchi with the powder, and with this substance there is, in addition to the local effect, a constitutional action. The method is to construct a close tent of sheets over the bed, and then to volatilize within the tent, on a metal plate, over an alcohol or oil flame, twenty grains of calomel. The tent should be kept closed except for frequent inspection of the patient, till the odor of the calomel has nearly disappeared, *i.e.*, usually about half an hour. This fumigation should be repeated at hourly intervals till the constitutional effect is reached, and this means hourly fumigations for at least twenty-four, and sometimes for forty-eight hours.

Irrigation with an antiseptic solution is probably the most efficient local treatment. The solution can be directed by an ounce-syringe fitted with a short, soft rubber cap over the point, so as not to hurt the tissues touched, and the solution should be forced up one nostril and made to return by the mouth or other nostril. To do this it may be necessary to push the piston home with considerable force, but the nozzle should not plug the nostril so tightly that, if the obstruction is considerable, fluid may not pass back out around the nozzle. Perhaps the best solution for this purpose is corrosive sublimate in strength from $\frac{1}{4000}$ to $\frac{1}{1000}$. Some will be swallowed accidentally, but not enough to be injurious. The mouth is to be irrigated in every case, the nose when there is any discharge. The irrigation should be made every half-hour or hour. It is very regularly the rule that after the irrigations are begun the membrane stops spreading.

Constitutional Treatment.—The three drugs most to be relied on are alcohol, mercury, and iron.

Alcohol is best given in the form of brandy or whiskey, and the dose should be at one-hour or at most two-hour intervals. Its use should be begun early, and in grave cases pushed to the utmost short of narcotism. Nearly every case at all ill, will take three ounces in twenty-four hours, and a child, six years old, may need ten or twelve ounces in the same time.

Mercury is given internally in the form of the bichloride, one-sixtieth of a grain every hour for children under five years, and one-fortieth of a grain for those over five.

Iron, as the tincture of the chloride, in glycerine, to prolong the local effect, should be given frequently in small doses, two to five minims every half-hour, for a child six years old.

Food, in easily digestible form, should be given in as large quantities and as frequently as the patient will take and digest it.

Treatment of Laryngeal Stenosis.—In the beginning, steam inhalations and emesis are advisable. If operation becomes necessary, it is to be remembered that mortality is less in early operations. If the consent of the parents is obtained for either intubation or tracheotomy, the choice depends mainly on: 1, The experience of the physician; 2, the age of the patient. A physician without

considerable practice will usually do better with tracheotomy, and it is wise to be prepared always, at an intubation, to do an immediate tracheotomy if the first operation fails. Intubation is to be preferred if the patient is less than two years old. *John H. Huddleston.*

DIURETICS. Two diuretics of striking power have lately come into use. One of them, calomel, was formerly much used in combination with squill and digitalis; the other, sodio-theobromine salicylate, or diuretin, was introduced in 1890.

Calomel.—The diuretic power of calomel was discovered by Jendrassik[1] and announced by him in 1886. It had, however, been observed long before that calomel, in cases of dropsy, sometimes caused very profuse diuresis; but this was forgotten, and the writers on therapeutics in the last two decades either entirely ignored the use of calomel as a diuretic, or recommended it only as an adjuvant to squill and digitalis.

Jendrassik accidentally, in a case of dropsy, with syphilis, found that calomel acted as a powerful diuretic. He then tried it in other cases of dropsy. In cardiac dropsy its use was almost uniformly followed by profuse diuresis, but in renal dropsy, in ascites, and in pleuritic effusion, no very decided effect resulted, and in most cases none at all. Jendrassik's success led others to try calomel. On the whole, their reports show that in cardiac dropsy calomel produces marked diuresis, but acts feebly or fails to act in other forms, but especially in renal dropsy.

All observers found that the polyuria does not begin on the first day of administration, but usually on the second, the third, the fourth, or the fifth day. The quantity of urine then augments very rapidly, is most profuse on the second day, and subsequently slowly diminishes. As a rule, the polyuria continues until the symptoms of dropsy have completely disappeared. In cases of extensive dropsy the maximum quantity of urine voided in one day was twenty pints.

As the quantity of calomel necessary to produce such profuse diuresis is quite large, the ordinary effects of large doses supervene, unless prevented by prophylactic measures. Diarrhœa nearly always results. If not more than two or three stools occur daily, diuresis may still take place; but if the stools are very numerous no increase of the quantity of urine will result, doubtless because the calomel is expelled from the intestines before absorption can take place. To prevent such rapid discharge of the medicine, opium in small doses should be combined with it.

Some of the general symptoms of acute mercurialism usually become manifest—a disagreeable metallic taste, some soreness of the gums, increased secretion of saliva, and offensiveness of the breath. Some patients, however, have taken calomel in moderate doses for ten or twelve days without any of these effects. In most cases, if the calomel be long continued, the effects on the mouth become very severe, and some cases have been reported in which extensive ulceration and even gangrene resulted. Hence no more calomel should be employed than is necessary to cause decided diuresis. To prevent the effects upon the mouth, prophylactics should be used from the beginning of the treatment. Generally chlorate of potassium is preferred, the mouth being rinsed every two or three hours with a three or four per cent. solution of the salt. Jendrassik supposes that an acid reaction in the mouth, especially in the vicinity of decaying teeth, greatly favors stomatitis, and he has used with success a three or four per cent. solution of carbonate of sodium. Tincture of myrrh, tincture of krameria, and permanganate of potassium have also been used as preventives. If, notwithstanding the employment of these means, stomatitis should take place, the use of calomel must be discontinued. But it is not likely to occur, or only very mildly, if the calomel be given in the cautious manner lately recommended by Jendrassik.[2]

Calomel as a diuretic is indicated in cardiac dropsy when other appropriate means, such as digitalis, strophanthus, caffeine, diuretin, etc., fail to give relief. The presence of albumin in the urine does not interfere with the action of calomel, and generally the urine, if it contain albumin, will become normal after the subsidence of the dropsy. It should be recollected that the mere removal of the dropsy does not restore compensation in cases of cardiac insufficiency, and that, after the diuretic has proved successful, it will be necessary to administer remedies to improve the heart's action. Should these not succeed and the dropsy return, calomel should again be used, and, if necessary, it may be employed as often as the dropsy becomes extensive. Its employment at intervals of some weeks becomes necessary in some cases of heart disease in which the rupture of compensation cannot be rectified. If the calomel be carefully used no harm will result, and the patient may be made comfortable and life be prolonged for some years. Jendrassik states that he treated a patient whose life had been prolonged for five years; each year it was necessary to give calomel from fifteen to twenty times to remove the dropsical symptoms. In the intervening periods the patient was able to lead a tolerably active life. Another patient that had marked insufficiency of the heart had been treated seven times since 1886. On each occasion he came to the hospital with grave symptoms—enormous anasarca and ascites, with severe dyspnœa and sleeplessness. His urine always contained albumin. Once the ascites was so extreme that, to save life, it was necessary to tap the abdomen. In this case the calomel always acted well and enabled the patient to return to active life. Jordan has recorded a case in which twenty-three successful trials with calomel were made, and during the treatment the patient took, without perceptible injury, 107.5 grammes (nearly 3¾ ounces) of calomel.

The dose of calomel in most of the reported clinical experiments was three grains, given from three to five times daily for several days, usually together with one-sixth grain of opium to prevent catharsis. Lately Jendrassik has stated, after further experience, that one and a half grain is the best single dose, and that this should be given eight or ten times within a day. After the administration for one day the polyuria, he says, is just as profuse on the third or fourth day as if the medicine had been given on the intermediate days, and that it is certainly erroneous to persist in the administration of calomel after the urine has begun to increase in quantity.

Jendrassik holds that the diuretic effect is caused by increased resorption of the dropsical fluid by the blood. In the cases in which calomel acted very decidedly no changes in the circulation took place that would account for the polyuria; hence it does not act like digitalis and some other medicines that increase blood-pressure. In experiments Jendrassik found that a very dilute solution of chloride of sodium diffused into a solution of albuminate of oxide of mercury, placed in a suitable dialyser, in much greater quantity in a given time than into a simple solution of albumin of the same strength. As calomel after absorption doubtless circulates in the blood as an albuminate, Jendrassik supposes that it causes the dropsical fluid to pass by endosmosis into the inspissated blood in greatly increased quantity, thus rendering the blood more watery. The excess of water in the blood, as soon as it reaches the kidneys, is rapidly excreted.

Experiments made by Benczur and Csatary[3] support this view. They determined the quantity of hæmoglobin in the blood of patients for several days before and during the administration of diuretics. From the quantity of hæmoglobin found they calculated the degree of concentration of the blood. In a case of dropsy they gave forty drops of tincture of strophanthus for three days. The quantity of urine voided in the three days was, respectively, 900, 1,900, and 3,200 c.c. On these days 100 c.c. of blood contained 7.851, 8.659, and 8.730 grammes of hæmoglobin. This shows, say Benczur and Csatary, that the diuresis produced by strophanthus is associated with a simultaneous inspissation of the blood. In a case of severe cardiac dropsy they gave 0.2 of calomel six times daily for two days. The quantity of urine in these two days, and in the following four

days, was as follows: 950, 1,000, 3,900, 4,500, 2,400, and 1,000 c.c. The quantity of hæmoglobin contained in 100 c.c. of blood in the same days was as follows: 7.19, 5.32, 7.93, 7.85, 9.31, and 8.32. These figures seem to show that when calomel produces free diuresis the blood at first becomes hydræmic, and that inspissation takes place only during the progress of the polyuria. Hence Benczur and Csatary contend that calomel increases resorption, thus rendering the blood very watery, and that the kidneys simply remove the excess of water in the blood.

Stintzing and some others hold that calomel acts directly upon the kidneys, because they observed an increase of the urine of some patients not affected with dropsy. Some clinicians concluded that it acts upon the epithelium of the kidneys because it manifests no diuretic action in the dropsy of chronic parenchymatous nephritis.

Recently Cohnstein[4] experimented upon healthy rabbits to determine the mode of action of calomel, without, however, succeeding in solving the question. He used a solution of calomel in hypophosphite of sodium. When this was injected into the subcutaneous tissue or into the jugular vein a decided increase of diuresis resulted, showing conclusively that calomel acts as a diuretic in healthy rabbits. When before the injection he had placed the animals under the influence of chloral in order to depress the vaso-motor centre, no increase of the urine took place; so, also, no augmentation of the urine resulted from one of the kidneys when, before the injection, its nerves had been severed. But in both series of experiments, after calomel had failed, the administration of caffeine decidedly increased the quantity of urine. From these experiments Cohnstein concluded that some change in the circulation is a necessary condition of the diuresis, and that calomel does not act by stimulating the epithelium of the kidneys. In some of his experiments Cohnstein determined the blood-pressure after small doses of calomel, and found that simultaneously with the increase of diuresis an augmentation of arterial pressure took place, but this was slight and evanescent, and could not have caused the heightened secretion of urine.

Diuretin.—The term diuretin is applied to a preparation of theobromine, as a convenient substitute for the unwieldy chemical name sodio-theobromine salicylate. As this chemical name indicates, diuretin is a double compound of sodium theobromine, $C_7H_7NaN_4O_2$, and sodium salicylate, $C_6H_4(OH)COONa$.

Diuretin is a white, odorless powder, having a bitter taste. It dissolves in less than its weight of water when warmed, and remains in solution on cooling. It is a very unstable compound, and when exposed to the air gradually decomposes, the theobromine separating from the sodium. On account of this instability aqueous solutions undergo change in a few days, and, when administered soon after meals, become decomposed by the acid of the gastric juice.

W. von Schroeder[5] discovered, in experiments upon rabbits, that theobromine greatly increases the secretion of urine by acting directly upon the epithelium of the kidneys, and that it has no action on the vaso-motor centre, in this respect differing from caffeine. As the human kidneys are affected in the same manner as the kidneys of the rabbit by caffeine, he supposed that theobromine would in man also produce a very decided diuretic effect, and, on account of its slight action on the nerve-centres, in many cases be preferable to caffeine.

Chr. Gram,[6] at the suggestion of von Schroeder, tried free theobromine in cases of dropsy. It acted effectively as a diuretic, but frequently caused vomiting, and was inconstant in its diuretic action, owing to its slow and uncertain absorption. After unsuccessful trials of various preparations of theobromine, he finally found one that is easily absorbed, namely, diuretin.

Gram administered diuretin in cases of dropsy in which other diuretics, digitalis and strophanthus, had failed. He states that he purposely selected cases in which as a rule we are utterly helpless. Diuretin always increased the quantity of urine, except in those cases in which the renal epithelium was so degenerated that no action could be expected. In some cases a relative cure resulted, or at least decided improvement, a result that may be called a good one when it is considered that in severe organic heart disease and in chronic nephritis only a relative cure can be attained. Gram says that the therapeutic results of his experiments were not very remarkable, but yet, as the patients were in such a desolate state that other diuretics (cardiac tonics) could not act efficiently, these results appear to have been very favorable. The usual dose of diuretin was 1.0 (fifteen grains), which was given five or six times daily. No changes in the circulation took place, and hence the increase in diuresis resulted from a direct action upon the kidneys. The remedy never produced disagreeable incidental effects, and only once, in a very cachectic patient, did it cause slight giddiness.

A. Hoffmann[7] tried diuretin in numerous cases. In four cases of cardiac dropsy he employed it on fourteen different occasions, and always obtained good results. Usually diuretin was not given until digitalis had failed to act. The polyuria began on the first day of administration, augmented gradually, and reached the maximum in from two to six days. It rapidly diminished when the diuretin was withdrawn, or when the dropsy had subsided. Sometimes the diuretic action was delayed for several days, perhaps on account of slow absorption. The quantity of urine voided depended upon the extent of the dropsy; when this was very decided the quantity at the maximum amounted to five or six litres a day.

Hoffmann agrees with von Schroeder that diuretin acts directly upon the kidneys, but he supposes that it also influences the heart. He observed that the pulse often became regular, stronger, and slower; that dyspnœa was relieved before the disappearance of the dropsy; and that quiet sleep ensued without the use of hypnotics. No incidental effects took place, except some vomiting in a few cases; but this soon ceased. In several cases a light, painless diarrhœa occurred, but stopped although the medicine was continued. Excitement, such as sometimes occurs from caffeine, was never observed. Hoffmann concluded that diuretin is a powerful diuretic in general dropsy, but has little effect upon inflammatory exudations, such as that of pleuritis, and still less upon ascites from portal obstruction.

Dr. Koritschoner[8] employed diuretin in thirty-eight cases of severe dropsy of cardiac, renal, and hepatic origin. In twenty-three cases the effect was better than from other diuretics, and in eight of them very remarkable, the quantity of urine having increased to ten or twelve litres. In ten cases the effect was moderate, but was not excelled or equalled by any other diuretic. Only in one case was complete failure observed. On the average the action of diuretin was best in cardiac dropsy, next in portal obstruction, and least in nephritis. But this pertains only to the absolute action; relatively to other diuretics the action in chronic Bright's disease was very satisfactory. Koritschoner supposes that diuretin acts directly upon the kidneys, as he observed no influence on the heart. He knows of no contraindications to its use. Even when employed for a long time it proved innocuous. He began with 4.0 (one drachm) daily, and increased by one gramme daily until the quantity of urine, compared with the ingested fluid and the subsidence of the dropsy, gave a satisfactory result. In sixty per cent. of the cases 5.0 daily sufficed; in thirty per cent., 6.0 daily; and in ten per cent., larger doses up to 10.0. The medicine was given in solution, made with hot water, in tablespoonful doses, at intervals of one or two hours, beginning three hours after the principal meal.

R. Demme[9] tried diuretin with good results in dropsy occurring in children. The dropsy of scarlatinous nephritis seemed, after the first stage of the nephritis had passed, to be removed more rapidly by diuretin than by all other diuretics. Anasarca and effusions in the serous cavities resulting from mitral insufficiency subsided, after the valvular disease had been compensated by digitalis, very speedily when diuretin was given. The dose for children from two to five years old was 0.5 to 1.5, and from six to ten years old, 1.5 to 3.0 daily. Diuretin

should not be given to infants under one year, as in them it easily causes irritatiou of the stomach and intestines.

Von Schroeder states[10] that some preparations of diuretin found in commerce contain only from thirty to thirty-eight per cent. of theobromine, as found in the analyses made by Vulpius. Knoll's preparation was found to contain forty-eight per cent., and hence should be preferred by the practitioner. Von Schroeder recommends the following formula :

℞. Diuretini (Knoll)..... 5.0–7.0
Aq. destill..... 90.0
Aq. menth. pip..... 100.0
Syr. simpl..... 10.0
M. S.: One tablespoonful every two or three hours.

Samuel Nickles.

[1] E. Jendrassik : Deutsch. Archiv f. klin. Medicin, Bd. xxxviii., p. 499.
[2] E. Jendrassik : Arch. f. kl. Med., xlvii., p. 226.
[3] Benczur and Csatary : Arch. f. kl. Med., xlvi., p. 478.
[4] W. Cohnstein : Arch. f. exp. Path. u. Pharm., xxx., p. 126.
[5] Von Schroeder : Arch. f. exp. Path. u. Pharm., xxiv., p. 102.
[6] Chr. Gram : Ther. Monatssh., 1890, p. 10.
[7] A. Hoffmann: Arch. f. exp. Path. u. Pharm., xxviii., p. 1.
[8] Dr. Koritschoner : Ther. Monatssh., 1892, p. 559.
[9] R. Demme : Ther. Monatssh., 1892, p. 96.
[10] W. von Schroeder : Ther. Monatssh., 1890, p. 374.

DIURETIN. This name was given by Dr. Christian Gram, of Copenhagen, to the salicylate of theobromine and sodium which he introduced as a substitute for caffeine. Professor Schroeder, of Strasbourg, had experimented with the alkaloid theobromine, and had reported upon its important diuretic properties at the meeting of the German Medical Congress in 1889. He had found that caffeine in small doses often failed to produce diuresis, and where the vascular tension of the kidneys was increased, the flow of urine sometimes diminished on account of the increased blood-pressure produced by the caffeine. Large doses overcame this effect, but they were liable to cause nervousness and insomnia, and other distressing symptoms. Theobromine he found to be an equally efficient diuretic without producing any nervous symptoms or affecting the blood-pressure ; chemically, it differed from caffeine by containing one equivalent less of methyl, it being the dimethyl-xanthine and caffeine the trimethyl-xanthine. The difficulty in using the alkaloid was its insolubility, it requiring 1,600 parts of water for its solution. At his suggestion Dr. Gram instituted a series of experiments, and succeeded in producing a soluble salt by combining it with salicylate of sodium. It is said to be prepared by dissolving one molecule (180) of theobromine in one molecule (40) of soda hydrate, and adding to the solution one molecule (160) of salicylate of sodium ; when evaporated to dryness it should yield 362 parts of the double salt, which theoretically contains 49.7 per cent. of theobromine and 38.1 per cent. of salicylic acid. It is a white powder with a slightly bitter and disagreeable taste, very soluble ; by the aid of heat it dissolves in less than half its weight of water, and no precipitation occurs upon cooling. Its solution is very unstable and rapidly decomposes. It burns without leaving any residue.

To estimate the amount of the alkaloid an aqueous solution is acidified, then made alkaline with ammonia, and the precipitated theobromine collected on a filter, washed, and dried. The amount of salicylic acid may be determined by treating the filtrate and washings with ether, separating the ethereal solution and evaporating.

Theobromine exerts its diuretic properties by its direct action on the secreting tissue of the kidneys. It acts promptly and energetically, and its effect is maintained for a day or two after the cessation of the drug. Its action is not cumulative. The solids as well as the fluid are increased ; there is no marked change in the blood-pressure, but the heart becomes slower, stronger, and less irregular. An improvement in the general condition of the patient is also experienced. It does not produce any excitement nor influence the nervous system unfavorably, nor does it derange the digestive organs. Reports of its prolonged use, however, show that it may be accompanied by diarrhœa and other signs of intestinal irritation. In all forms of dropsy due to renal disease its action is most efficient ; there is no irritant effect on the secreting cells, and no unfavorable results follow its use. It is of service in all dropsies accompanying heart-disease, but is said to be of greatest service where there is organic disease and failing compensation. Where digitalis and other cardiac tonics have been used without success, it will generally be found to succeed, by its action on the kidneys following that of the other forms of diuretics. A combination of digitalis and diuretin will form a very active diuretic mixture in dropsies where the blood-pressure requires to be raised. It has not been found of so much value where the dropsy arises from inflamed serous membranes, or where the liver is congested. The following are the conclusions of Dr. Dujardin-Beaumetz :

(1) When given in doses of fifteen grains it is a much stronger diuretic than caffeine ; (2) when there is considerable cardiac degeneration it should be used with some caution, especially when there is albuminuria ; (3) under its influence the cardiac contractions are scarcely affected ; (4) diuretin rapidly increases the quantity of urine passed, and the diuretic effect lasts twice or three times as long as that produced by caffeine ; (5) the activity does not wear off as the patient becomes accustomed to the drug ; (6) micturition is not rendered difficult or painful ; (7) diuretin has no action on the central nervous system.

The dose is from sixty to ninety grains daily. It has been found most active in fifteen-grain doses every two or three hours, in water with some aromatic essence to disguise its bitter taste. Care should be observed in selecting the remedy, on account of its instability. When exposed to the atmosphere it absorbs carbonic acid and separates the alkaloid, which is insoluble. The addition of acids or acid vegetable juice also decomposes the solution by throwing down the alkaloid. It has been found a safe remedy for children above one year of age, and has proved of marked benefit in scarlatinal nephritis. At the age of from two to five years the dose may be from eight to twenty-five grains in the day, and at the age of from six to twelve, from twenty-five to forty-five grains. The total amount for the day may be dissolved in four ounces of water with ten or twelve drops of brandy and a little sugar. It has been given for weeks without producing any ill effects or lessening its therapeutic action.

Beaumont Small.

DROITWICH. A watering-place chiefly noted for its brine baths, in Worcestershire, England.

Location.—Droitwich is pleasantly situated, about 3½ hours by rail from London. The town itself is dull. Its saline waters are among the most powerful known, and are now extensively used in the form of brine baths.

Analysis.—It is claimed that the Droitwich brine is stronger than any other European water of similar kind. It is fully ten times as rich in salts as the ocean, and has four times the density of the waters of the Dead Sea.

Indications.—Like the famous baths of Kreuznach, the Droitwich brine has been found useful in rheumatic gout, rheumatoid arthritis, muscular rheumatism, inflammatory exudations and periarticular thickenings, sciatica, neuralgia, nervous debility, pelvic cellulitis, uterine derangements, bronchitis, and various conditions of cachexia.

Accommodation.—A large swimming-bath has been recently added to the other conveniences of the town. The *Royal Brine Baths Hotel*, in connection with the above, has been placed under an experienced manager, and the comforts of home are now insured to invalids and others. It affords warm and comfortable winter quarters. The St. Andrew's Baths is the oldest establishment. *Edmund C. Wendt.*

DYSPEPSIA, NERVOUS. We will give the personal history of aggravated cases of the special form under consideration, which being of extreme gravity—the symptoms of some of them almost unparalleled—and the

treatment being successful, the chief features of the disease will be clearly indicated. One of these resulted in violent temporary insanity, another in threatened softening of the brain, a third in absolute loss of mental control, and others in melancholia, nervous depression, diplopia, etc.; in all of these cases the trouble being dependent solely upon malassimilation of food.

Case 1 is that of a young man whose time had been devoted chiefly to literary pursuits. In a personal sketch, which we give briefly in his own words, he states:

"My sufferings increased daily; I often felt that I was dying, while the terrors of death at such moments were intensified a hundred-fold. In the meantime a perceptible change was going on in my heart and mind, and friends united in censuring me for my eccentric conduct. They did not and could not understand that the morbid effects of the disease were slowly but surely gaining complete control over my thoughts and feelings, nor that when the functions of the nervous system are perverted the victim becomes, to a certain extent, an irresponsible agent and suffers complete transformation of character. I can truthfully say, from dreadful experience, that there are stages of this disease when the victim, like the drowning man grasping at a straw, will swallow anything in the shape of anodynes or stimulants for relief. Finding that alcoholic beverages mitigated my sufferings, I used them liberally at times; but knowing that such excesses must end in insanity or death, and not being able to use spirituous liquors at any time in moderation, I determined to discontinue them altogether. But without a stimulant I could not walk fifty yards without being seized with a nervous attack and dizziness. I could attend to no regular business, and had diminished in weight from 135 to 117 pounds."

He reported that he suffered severely from vertigo after any exertion, and had constant torpor of the bowels, with inability to sleep at night without recourse to stimulants or anodynes.

As the first step an immediate abstinence from tobacco, which he used to excess, was required; alcohol was allowed in moderation, and a hepatic stimulant and alterative, consisting of stillingia, belladonna, nux vomica, and physostigma, was prescribed. The improvement was marked and continuous; he now no longer suffers from vertigo, and sleeps without any anodyne.

Notwithstanding that some physicians inveigh against the use of lactopeptine, and deny to it the possession of any value whatever, we would say here that for such symptoms, namely, defective or complete loss of appetite, indigestion, and deficient activity of the digestive organs—whether in adults or children,—we find no remedy to compare with the following combination, to which we have recourse incessantly:

℞. Lactopeptine (Am. Pharmacal Co.)...	ʒ ij.
Subnitrate of bismuth.....	ʒ ij.
Comp. tinct. of gentian.....	ʒ j.
Simple syrup.....	ʒ j.
Ess. peppermint.....	ʒ ij.
Water..... to	ʒ iv.

M. Dessertspoonful in a wineglass of water before meals.

A half grain of strychnia added to the above, when indicated, increases its efficacy.

Case 2. *Nervous Dyspepsia Due to Poor Assimilation in Old Age.*—Mrs. B., a lady, aged eighty, had during her whole life been noted for ceaseless industry, physical activity, and mental soundness. She was a highly cultivated woman, of unusual good sense and excellent judgment; her digestion was always good, with no constipation, no malarial poisoning, nor any other disturbance of the system. She had during the war and of late years been subject to much harassment of mind—with, at times, more or less poor nutrition.

The first indication of the approaching attack was a tendency to garrulity, with a certain wilfulness of manner. She next exhibited extreme excitement; and, strange to relate, it was invariably most violent upon awakening in the morning just after sleeping soundly for hours, or at any time after sleeping; at such times she frequently screamed aloud. Her talk was incessant, coherent and incoherent, generally of a pleasant character; in her disordered fancies she would enjoy and describe visions of flowers, of bright parterres, decorated tapestries; she would repeat poetry and long reminiscences of her earlier life, all delivered in pleasant, but in highly figurative language. But at times she was beyond control, and may be said to have lost her mind, so entirely irresponsible were her actions.

Knowing the calming and soothing effect which sleep usually exerts upon violent inebriates with delirium and persons with various neurastheniæ, we were forced to the conclusion that she could not stand the depressing effects of sleep, which left her a prey to the uncontrollable excitement and loss of mental balance; all of these symptoms depending upon a lack of assimilative power, together with the absence of full and suitable nourishment. All hypnotics were therefore discontinued; she certainly did not require sedatives, for the compound "bromidia," and others freely used, had failed to give any relief.

A complete change in treatment was ordered, as follows: Fellows's syrup of the hypophosphites, C. P., *ter in die;* spiritus frumenti in substantial amounts, frequently repeated; beef extract, and other concentrated nourishment, with hot coffee upon first awakening. She yielded surprisingly well to these measures, which were kept up without any interruption until complete and entire control of herself was obtained.

The attacks have returned several times, at long intervals, and each time have yielded to the liberal use of stimulants, food, and the syrup of hypophosphites with strychnia; and the correctness of the diagnosis was absolutely proved by the almost immediate relief afforded by the treatment. She lived long afterward—dying at eighty-six,—having been, during these last years, in perfect health of mind and body.

Case 3.—A gentleman in middle age, after having passed through a great affliction, and being extremely imprudent in eating—indulging freely in nuts, raisins, and other indigestible substances in the intervals of his regular meals,—began to suffer from complete loss of appetite, and a train of nervous symptoms. He had attacks of dizziness to such a degree that he would have to lie prone upon the floor, or the ground, as the case might be; he could stand none of the ordinary draughts upon the reason or the intelligence, being unable to perform the daily duties of his calling; he could not write a letter, and feared to walk around the square upon which he lived. This culminated in such a low condition of the nervous system that he was twice prostrated, thought that he was about to die, and once asked a friend "if he did not know better than to look at him—that he could not stand it;" surpassing in this the weakest and most nervous female.

Complete recovery of appetite, health, and strength took place after a month's absence in a Northern city for rest and change of scene, with the prudent use of stimulants taken with the most nourishing food, but without any medicines whatever.

Case 4.—A gentleman, aged twenty-five, was so much afflicted with dyspepsia and ill-health, after prolonged confinement to books at school and college, that he repeatedly believed that he was dying, saw visions by night and day, was so timorous and fearful that he would not sit in the open seat of a vehicle without the grasp of some one's hand, neither would he leave a room for fear that he would die before his return.

These and other exhibitions of groundless apprehension and timidity were presented by a man who had previously, and has since, given striking instances of his manliness and courage. Dyspeptic symptoms so marked and violent, some of them approaching closely to those of hysteria, were also complicated with spermatorrhœa caused by ascarides.

He became much reduced in flesh and strength, but recovered perfectly after two operations by Lallemand's *porte-caustique*, efficiently applied, and some tonic remedies.

Case 5.—A patient, aged thirty-eight, after about a year of suffering from insomnia, constant constipation, and extreme nervousness, was thought by his friends to have softening of the brain and to be doomed to the lunatic asylum. It was at once apparent that his mind must be set at rest and some hope instilled into him. This was done by assuring him in the most confident manner that there was no serious organic disease present, that his nervous symptoms, being functional and neurotic, could be controlled, and that he would surely recover under judicious management.

An occasional mercurial laxative was given, his digestive organs were strengthened, and the tonic hepatic stimulant referred to in Case 1 was administered. As a result, his insomnia, general depression, and all fears of hereditary disease disappeared, and he is now in complete possession of health and strength.

Case 6.—The patient, a gentleman over fifty years of age, was strictly temperate in his habits; he had never any constitutional, malarial, or other disease, except at an early period, when he suffered from bronchitis, from which he recovered perfectly. He had once also experienced a severe attack of dyspepsia. Double vision, lasting each time from three to six weeks, occurred repeatedly—there being four separate attacks at intervals of months and years,—apparently from digestive derangements due to overtasking the organs by too free ingestion of some special article of food. There was no diarrhœa, colic, or other disturbance; no cerebral complication whatever, or any of the nervous symptoms characterizing the other cases reported here; the whole ill effect being a reflex influence upon the muscles of the eyes. Without employing the scientific minuteness of the specialist, we only say that there were no degenerative changes of the cerebro-spinal system, no disseminated spinal sclerosis, nor any diplopia such as is sometimes seen in locomotor ataxia. Furthermore, there was no inherent paralysis of the ocular muscles, but simply a reflex functional paresis by which the power of adjustment was lost. But when this occurs, be the cause what it may, then every object is duplicated. The man who walks upon the streets sees four lines of pavements stretching away in the distance instead of two, and the temporary loss of this habitual power of adjustment, which has been unconsciously possessed and exercised by him all his life, suffices to throw every visual object into confusion.

Each attack came on gradually, increasing in intensity, until each eye acted independently, every object beyond near reading distance, at which vision was normal, being seen separately, and one eye had often to be closed to relieve the inconvenience caused by the diplopia. In some of the attacks there was moderate strabismus; in one it was marked.

On the first appearance of the trouble, years ago, the reflex effects upon the eyes seemed to result from weakness of the entire system following an attack of bronchitis. The later attacks occurred in the midst of robust health, being directly connected with the stomach. As in two of these he had suffered from severe lumbago and rheumatism of the muscles of an arm lasting for weeks, it was thought that the condition might be dependent—as has been claimed by some authors—upon a gouty or rheumatic diathesis. It is susceptible of proof that all the attacks were not complicated by a rheumatic element.

The following prescription completely relieved every attack, when given in repeated doses and persevered with:

℞. Potassii iodid..... ʒ ij.
Tinct. cinchonæ comp..... ℥ j.
Aquæ.....ad ʒ iv.
M. S.: Dessertspoonful in wineglass of water, *t. i. d.*, between meals.

Fellows's syrup of the hypophosphites, one drachm, in water, before meals, was used simultaneously.

In two of the attacks when the rheumatism was prominent, the wine of colchicum and the tincture of guaiac were added to the above combination. Recovery was always gradual, and double vision for distant objects was always the last symptom to be relieved,—a picture on the wall being seen single, when a distant steeple or star was perceived as two objects far apart. By pressing on the left eye or slightly closing it the double vision could be prevented. Good appetite and general health, save in the attacks complicated by rheumatism, were maintained throughout, and, for the present, recovery is again complete.

In our own experience, which embraces the care of hospitals for a very long period, cases of this affection are of extreme rarity. We have personal knowledge of but three. Reference may be made to a paper by Dr. George T. Stevens, of New York, on "Sudden Attacks of Diplopia," in the *Annals of Ophthalmology and Otology*, Kansas City, 1892.

Such examples, which are met, doubtless, by every physician, show what a powerful disturbing influence dyspepsia can exert upon the mind and body—producing bodily weakness and depression of the general powers; lessening the energy, and even the inclination and the capacity to will and to act; specially giving rise to unmanly fears, indecision, causeless scruples, and apprehensions of impending death; and in many cases dizziness is a marked symptom.

We believe that in the impaired condition caused by malassimilation, defective quantity and quality, and irregularity in the taking of food, and consequent anæmia, by which the blood becomes impaired and the nourishment and the integrity of the nerves and the brain fail to be maintained, will be found the true pathology of cases such as these, which give rise to so much loss of time, painful anxiety, and suffering to the patient and to his friends. The recoveries under judicious management, change of air and scene, good nourishment, moderate use of stimulants—if they can be tolerated—strychnia, tonics, etc., support the correctness of this view.

It will be noticed that the above cases, marked by nervous disturbance, mental excitement or depression, do not include dyspepsias of reflex, or cardiac, or ovarian origin, referred to by Fothergill and others; nor is there any special implication of the liver or renal organs, no gastric catarrh, pyrosis, biliousness, vomiting of bile, or morbid deposits in excess in the urine, such as urates, phosphates, etc.—which morbid conditions are found so commonly in other types of dyspepsia.

We are induced to add a brief notice of another and very common form of dyspepsia, which is in striking contrast with that described above, in cause, nature, symptoms, and treatment. This is the gastro-intestinal type, characterized by acidity, water-brash, fermentation, distention, pain, etc., and which requires a distinct management with drugs quite different from those used in cases where there is simply malassimilation of food followed by marked nervous symptoms.

We are indebted to a leading article in the Boston *Medical and Surgical Journal*, for March 17, 1892, for suggestions as regards the management of such cases as follows:

"As this form of dyspepsia (intestinal dyspepsia) is generally predominantly a dyspepsia of starches, there is a leading indication to abstain from amylaceous and saccharine articles of diet. There should be a maximum of albuminoids—meat, eggs, fish—and a minimum of carbohydrates and fats. Brilliant results have been attained by a diet of raw meat—six to ten ounces of lean beef or mutton reduced to a pulp and cooked but slightly, if at all; to be eaten, well-seasoned, with a little bread, but without vegetables. Three slices of underdone roast meat, fresh broiled fish, raw oysters and other shell-fish, soft boiled eggs, boiled ham, together with sour-crout, smoked herring, a little stale cheese, etc., have been recommended, the latter articles being particularly unlikely to undergo putrefactive decomposition.

"Chronic indigestion of this type is the result," it is

added, "of long-continued dietetic errors, and in its treatment the dietetic plan marked out above should be adhered to as closely as possible. By way of medication intestinal antisepsis is indicated. For this purpose combinations of chalk, bismuth, magnesia, salol, salicylate of soda and naptbol are valuable. The patient may take after each meal a powder consisting of five grains each of prepared chalk, magnesia, and salol, or five grains each of salicylate of bismuth and naphthol; nux vomica and colombo are also valuable. Diastases often are of service. Either malt or pancreatic diastases may be used. They are to he given during the meal. [They probably act by digesting the starch in the stomach and favoring absorption of the resulting sugar before it reaches the intestine.] Laxatives often prove useful in emptying the bowels of its fermenting contents."

Certain forms of dyspepsia require acids distinctly in their treatment, but this is beyond the province of this paper. *F. Peyre Porcher.*

EAR DISEASES, NOMENCLATURE AND STATISTICS OF. The nomenclature herewith presented is based upon the one prepared and used by the aural surgeons of the Massachusetts Charitable Eye and Ear Infirmary in Boston. Many changes and a goodly number of additions have been made—some in the interest of a scientific nomenclature, others for statistical utility. On the whole it has suffered by these changes, but they were made necessary by the loose method of recording diseases in the various hospital reports, from which the statistical material for this article was gotten. As all additions are in brackets, the original can be seen practically undisturbed.

The statistical portion is based upon a study of 104,412 cases of ear disease, taken from the thirty-two annual reports of the nine eye and ear hospitals, as indicated in the list given at the end of the article. The different nomenclatures followed in these reports, and their inexact records of diseases, have added much to the labor of preparing, and have materially interfered with the scientific accuracy of, this article.

The tables are self-explanatory. Each disease is credited in the first column of figures with the number of cases of such affection found in the grand total of 104,412 tabulated cases, while the second column shows the proportionate frequency of the affection in every thousand cases of ear disease in general. Where the frequency is less than one in a thousand the fraction expressing this small frequency will be omitted altogether.

	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.*
I. Morbi Auris Externæ:		
Auriculæ—cutis:		
Congestiones, activæ:		
Congelatio	12	
Erythema	6	
Passivæ:		
Angioneurosis	0	
Cyanosis ex corde	0	
" vaso-paralytica	0	
" ex emphysema pulmonum	0	
Inflammationes:		
[Abscessus auriculæ]	152	1.5
Abscessus lobulæ	53	
Dermatitis congelationis	8	
" erysipelatosa	20	
" phlegmonosa	70	
" traumatica	11	
Eczema papulosum	23	
" pustulosum	4	
" rubrum	2	
" vesiculosum	8	
Carried forward	369	

* The cases of "ear disease in general" here referred to, are those represented by the grand total of 104,412.

	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.
Brought forward	369	
I. Morbi Auris Externæ:—(*Cont.*)		
Auriculæ—cutis:—(*Cont.*)		
Eczema squamosum:		
acutum vel chronicum.	1,575	15
Herpes zoster	25	
[Impetigo contagiosa]	2	
Intertrigo	7	
Lupus exulcerans	0	
" hypertrophia	1	
" vulgaris	0	
Fibroma lobulæ*	0	
Fissura lobulæ	9	
[Pruritus]	8	
Syphilis gummosa	0	
" papulosa	0	
" pustulosa	1	
" squamosa	2	
Auriculæ—perichondrii et cartilaginis:		
Inflammationes:		
Hæmatoma iodiopathicum	48	
" traumaticum	12	
Perichondritis	48	
Deformitates:	30	
[Ectopia]	3	
Imperfectæ:		
Microtia	3	
Profusæ:		
Polyotia	8	
Neoplasmata:	107	1
Angioma	4	
Atheroma	0	
Calcificatio	0	
Cornu	1	
[Cystis]	66	
Enchondroma	2	
Epithelioma	80	
Fibroma	21	
Lipoma	3	
[Lympho-adenoma]	1	
Myxo-fibroma	1	
Ossificatio	0	
Sarcoma	0	
[Trauma]	71	
[Ulcus]	12	
Total	2,520	Equal to a little over 2½ per cent. of all ear cases.
Meatus—cutis:		
Anomaliæ secretionum:		
Accumulatio ceruminis	16,897	159
Diminutio ceruminis	0	
Inflammationes:		
[Abscessus]	183	2
Eczema papulosum	5	
" pustulosum	1	
" rubrum	2	
" squamosum	27	
" vesiculosum: acutum vel chronicum	741	7
[Furunculus]	1,537	15
Granulatio	5	
Herpes zoster	1	
Carried forward	19,399	

* See Neoplasmata, farther on.

	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.
Brought forward.....	19,399	
I. Morbi Auris Externæ :—(*Cont.*)		
Meatus—cutis :—(Cont.)		
Sypbilis ; condyloma.....	0	
" gummosa	0	
" ulceratio	2	
[Otitis externa circumscripta].	727	7
Otitis externa desquamativa..	56	
" " diphtheritica ..	4	
" " diffusa :		
acuta.....	1,058	10
chronica....	266	2
acuta vel chronica ..	880	8
" " erysipelatosa ..	1	
" " [granulosa]	1	
" " follicularis	200	2
" " [furunculosa]..	78	
" " hæmorrhagica..	13	
" " parasitica.....	71	
" " syphilitica.....	9	
" " traumatica....	22	
Contractio membranosa :.....	25	
" ossea	3	
Corpus adventitium :	675	6
animalis	25	
inanimalis	52	
Pruritus	57	
Tranma :		
directa...	47	
indirecta.....	1	
Verruca	3	
Neoplasmata :		
cystis	10	
enchondroma.....	2	
epithelioma.....	3	
[polypus].....	388	4
sarcoma.....	0	
Deformitates :		
atresia acquisita	16	
" congenita.....	18	
fistula auris congenita.....	11	
Meatus—ossis :		
Caries.....	2	
Exostosis circumscripta..	41	
Hyperostosis circumscripta	7	
Hyperostosis universalis	0	
Periostitis	10	
Total	24,183	Equal to nearly 23 per cent. of all ear cases.

	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.
II. Morbi Auris Mediæ :		
Membranæ tympani :		
Abscessus	5	
Atrophia.....	17	
Cystis.....	2	
Myringitis acuta	14	
" chronica.....	1	
" acuta vel chronica..	62	
" hæmorrhagica.....	3	
" traumatica	5	
Trauma directa.....	220	2
Carried forward.....	329	

	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.
Brought forward.....	329	
II. Morbi Auris Mediæ :—(*Cont.*)		
Membranæ tympani :—(Cont.)		
Trauma indirecta :		
ex fractura calvariæ.	4	
ex ictu aërio.....	9	
ex vi opposita.....	3	
Tympani, Tubæ Eustachii, et Portionis Mastoideæ:		
Otitis catarrhalis secernens :		
mucosa acuta)		
serosa acuta)	6,616	62
serosa subacuta.....	2,246	21
[mucosa chronica]) ex inflam-		
serosa chronica) matione.	28,221	266
ex tuba..	558	5
Otitis catarrhalis adhæsiva :		
ex secernente	1,230	11
insidiosa :		
cum morbo labyrinthi.....	161	1
sine morbo labyrinthe.....	25	
Otitis media acuta simplei	803	8
" " [cum ostitide mastoideæ].	24	
" " [hæmorrhagica].....	39	
Otitis media suppurativa :		
acuta :	7,487	71
cum perforatione	2,150	20
sine perforatione.....	40	
[cum ostitide mastoideæ] ..	37	
[subacuta] :	1,163	11
chronica :	15,928	150
cum carie mastoidea.....	98	1
cum carie meatus.....	13	
cum carie ossiculæ	4	
cum carie tympani	3	
cum exostose meatus... ..	7	
cum granulatione meatus ..	162	2
cum granulatione membranæ tympani.....	65	
cum granulatione tympani.	120	1
cum hyperostose meatus...	0	
cum hyperostose universale.	0	
cum ostitide mastoidea	251	2
cum periostitide mastoidea.	28	
cum perforatione membranæ flaccidæ	103	1
cum perforatione membranæ tympani	6,323	60
cum polypo tympani	807	8
" " fibromatosa ...	0	
" " mucoso	0	
" " myxomatoso...	2	
" " membranæ tympani	1	
Effectus otitidis mediæ acutæ simplicis :.....	68	
cum perforatione.....	75	1
cum perforatione conglutinata.....	188	2
[Otitis media syphilitica]	11	
[Otitis media traumatica].....	8	
[Otitis media tuberculosa]	6	
Surditas senilis	7	
Neuroses Auris Mediæ :		
Sensoriæ :		
Otalgia dentalis.....	70	
" ex anæmia	1	
Carried forward.....	75,464	

	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.
Brought forward	75,464	
II. Morbi Auris Mediæ :—(*Cont.*)		
Neuroses Auris Mediæ :—(Cont.)		
Otalgia ex carie calvariæ	0	
" ex caric vertebræ	0	
" ex ictu aërio	0	
" ex tumore cerebri	0	
" perineuritide	0	
" ex pressu nervi	0	
" hysterica	3	
" laryngealis	0	
" nasalis	0	
" [neuralgica]	1,412	14
" pharyngealis	0	
Motoriæ :		
Contractiones musculorum aurieulæ	0	
Contractiones musculorum auriculæ tubæ	0	
Contractiones musculorum auriculæ tympani	2	
Vaso-motoriæ :		
Congestio vaso-affecta	0	
Total	75,881	Equal to nearly 73 per cent. of all ear cases.

III. Morbi Labyrinthi et Acustici :	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.
Anæmia labyrinthi	5	
Cochlitis	5	
Concussio :	9	
ex fractura calvariæ	8	
ex ictu aërio	3	
ex vi opposita	4	
Hæmorrhagia	3	
Hyperæmia labyrinthi	1	
Labyrinthitis :	107	1
acuta	7	
primaria	1	
secundaria	3	
chronica :	8	
primaria	1	
secundaria	9	
Morbus acustici	786	7
Neoplasmata in labyrintho	0	
Neuroses acustici :		
Hyperæsthesia	5	
Paralysis	30	
angioneurotica	2	
hysterica	4	
rheumatica	2	
Panotitis :		
diphtheritica	1	
idiopathica	0	
scarlatinosa	3	
Propriæ notæ Menière	41	
Trauma labyrinthi :	9	
directa	0	
indirecta	1	
Total	1,058	Equal to a little over 1 per cent. of all ear cases.

IV. [Morbi Mastoideæ] :	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.
[Abscessus]	141	1
[Caries]	4	
[Fistula]	4	
[Fractura]	1	
[Herpes]	1	
[Necrosis]	77	
[Neoplasmata]	5	
[Osteitis]	133	1
[Periostitis]	66	
Total	432	Equal to about $\frac{1}{14}$ of 1 per cent. of all ear cases.

V. Unclassified :	Total number of cases.	Number of times occurring in 1,000 cases of ear disease in general.
Cholesteatoma	5	
[Keratosis obturans]	56	
[Luxatio mallei]	1	
[Presbyacousis]	52	
[Surditas artificis lebetum]	19	
[Surditas totalis congenita]	15	
[Surditas totalis acquisita ex meningitide]	36	
[Tinnitus aurium]	152	1
[Vertigo ab aure læsa]	2	
Total	338	Equal to nearly $\frac{1}{3}$ of 1 per cent. of all ear cases.

Reports Consulted.

Massachusetts Chronic Eye and Ear Infirmary, Boston, 1885, 1886, 1888, 1889, 1890, 1891.
New York Eye and Ear Infirmary, New York city, 1882, 1884, 1885, 1887, 1888, 1889, 1890, 1891.
Presbyterian Eye, Ear, and Throat Charitable Hospital, Baltimore, Md., 1877 to 1891, inclusive.
Brooklyn Eye and Ear Hospital, Brooklyn, N. Y., 1869 to 1892, inclusive.
Manhattan Eye and Ear Hospital, New York City, 1885, 1886, 1887, 1888, 1889, 1890, 1891.
New York Ophthalmic and Aural Institute, New York City, 1885, 1886, 1891.
Newark Charitable Eye and Ear Infirmary, Newark, N. J., 1887, 1888, 1889, 1890.
Buffalo Eye and Ear Infirmary, Buffalo, N. Y., 1887.
Maine Eye and Ear Infirmary, Portland, Me., 1892.

James Lancelot Minor.

EAR: OPERATIONS UPON THE MIDDLE EAR.

Ever since Sir Astley Cooper, in 1801, improved the hearing of a patient by perforating the membrana tympani, surgical procedures upon the middle ear have afforded a fruitful field for study, speculation, and argument. In no other branch of surgery, probably, have certain procedures been so strenuously advocated for a short time, and, upon further investigation, been found to be disappointing in their results, and consequently abandoned for other measures equally useless. A glance at the history of middle-ear surgery will, I think, partially explain this, by diselosing the fact that every new procedure was employed without proper discrimination, in a large class of eases where more care in defining exactly the indications for the operation would have prevented its performance. It is not strange, therefore, that every advance in this branch of our art is looked upon with suspicion, and that its efficacy must be proven beyond a peradventure

before it is adopted. Clearly before any operative measure can stand this test the indications for its application must be distinctly defined, and the determination of these indications very often proves to be more difficult than the operation itself.

It is evident that operations upon the tympanum can be of benefit only when the pathological process is limited entirely, or almost entirely, to this part of the auditory apparatus, and has not involved the adjoining parts secondarily. To be more clear, we can hope to relieve an impairment of hearing or a distressing tinnitus by operation upon the tympanic structures, only when we are assured, by a careful examination, that the receptive apparatus is in a fairly normal condition, thus locating the disease in the conducting apparatus. Again, if we are questioned as to the probable result of such a procedure in a case of long-standing otorrhœa, it must be determined by careful examination that the bony necrosis is confined to those parts of the middle ear which can be reached by instruments introduced through the meatus; otherwise a complete removal of the affected parts would be impossible, and the result of an operation unsatisfactory.

The above suggestion seems almost unnecessary, but one has only to study the reports of cases operated upon to be convinced that often the exact location of the pathological process was undetermined before the operation.

Operative measures within the middle ear are undertaken:

1. For the improvement of hearing.
2. For the relief of subjective noises, or certain nervous phenomena, such as giddiness, etc.
3. For the relief of a persistent discharge.

Any one of these conditions may exist alone, or all or any two may occur together and demand relief.

As before stated, the success of operative treatment depends primarily upon our ability to locate the pathological process in the tympanum. I shall therefore preface what is to be said concerning the surgery of the tympanum by a few suggestions as to how we are best able to determine that, in any particular case, the middle ear is the part of the auditory apparatus at fault. If the purpose of our operation is to relieve a persistent discharge, careful ocular inspection and manipulation with the probe will enable us, in many instances, to determine the extent of the morbid process; more will be said upon this point when we come to consider the operative methods for the relief of discharge. Most frequently, however, aid is sought for an impairment of the hearing, or a persistent tinnitus, and physical examination alone, in many instances, may mislead us as to the result of operative measures. It is not enough to find, in such a case, that the tympanum is the seat of a chronic inflammation, or that as the result of a preceding inflammatory affection the tympanic structures have been bound down to such an extent that they cannot transmit the sound-waves, but we must be certain that the receptive apparatus is in a fairly normal condition before a favorable prognosis can be given as to the result of relieving the tension of the conducting apparatus by surgical means.

For this determination a series of tuning-forks has been found of great service. In my own work six forks are used, as follows: one, the lowest ($C-^1$) making 32 vibrations per second; the next (C) making 128 vibrations per second; the other four (C^1, C^2, C^3, C^4) being C forks of the next four octaves, the highest registering 2,048 vibrations per second. The last five forks constitute the series used by Hartmann,[1] and are really all that are necessary for determining the probable outcome of operative procedures, although the other fork ($C-^1$) is sometimes of use.

It is well known that any rigidity of the conducting mechanism so alters the relation of air-conduction to bone-conduction that in affections of the middle ear the duration of bone-conduction, as compared with that of air-conduction is increased, and frequently may be greater. Further observation teaches us that the change begins with the lowest notes of the scale, and that as the parts become more rigid the higher notes are affected. Thus in a slight rigidity of the middle-ear mechanism, consequent upon a temporary narrowing of the Eustachian tube, or congestion of the lining of the tympanum, the lowest fork of the series will be heard longer from the mastoid than when held in front of the meatus, while all the other forks may be heard better through the air than through the bone. If now, instead of a slight rigidity, we have the conducting apparatus bound down by adhesions, either as the result of a chronic purulent inflammation (with more or less complete destruction of the membrana tympani) or as the result of a non-suppurative inflammation of long standing, the membrana tympani being present and partaking perhaps in the pathological process, to the extent of being thickened in places, and even adherent here and there to the inner wall of the tympanum, we shall find as the power of audition becomes more and more impaired, that the bone-conduction for the successive higher forks of the scale will gradually become equal to, and at last better than, air-conduction. In other words, the degree of impairment of hearing, and the increased duration of bone-conduction for the higher forks, as compared with air-conduction, always bear a direct relation to each other, if the lesion is located in the conducting apparatus. If the hearing distance for speech was so reduced that loud voice was only heard close to the ear, and the duration of bone-conduction exceeded that of air-conduction for the first two or three octaves only, we should not be justified in locating the lesion in the conducting mechanism alone, but should conclude that the receptive apparatus was affected as well. Especially would such a conclusion be warranted if, in addition to the above, bone-conduction for the fork C^2 was appreciably reduced below the normal standard of bone-conduction, or if the fork C^3 was not heard at all by bone-conduction, or if the fork C^4 was perceived by neither bone- nor air-conduction. In such a case the chances would be that the receptive apparatus had become involved secondarily, and that although an operation might successfully relieve the tension in the transmitting mechanism, this relief might not greatly improve the hearing on account of the condition of the deeper parts, which would be unaffected by operation.

In applying these tests certain facts must be remembered. Thus, the age of the patient plays an important part in the determination of this question. Bone-conduction in individuals past middle life is relatively reduced as compared with this power in youth and early adult life. This has been demonstrated by Urbantschitsch[2] as due to senile torpidity of the auditory nerve, and can be confirmed by any one who makes use of the tuning-fork in a large number of cases. It is also to be remembered that secondary involvement of the receptive apparatus is less likely to have occurred when the cause of the impaired hearing or tinnitus has been a suppurative otitis, than when the tympanic affection has been of the sclerotic form. The duration of the malady is also to be taken into consideration; but as operative measures would only be adopted after all other plans had failed to give relief, this need scarcely be mentioned.

The above tests may be applied equally well to cases in which the membrana tympani has been partially or almost completely destroyed, or when it is intact. Moreover they are not based upon theory, but are deduced from the comparison of the results, after operations, by the author, in a number of cases in which the tests have been made. Almost without exception success or failure could be predicted by a careful study of the results of the tuning-fork examination, and the cases where these tests indicated a probable unfavorable result were subjected to operation only at their own request, that they might be allowed to have every possible chance for improvement, however slight this might be.

Preparations Preliminary to Middle-ear Operations.—While the remarks included under this heading may be, to a certain extent, superfluous, I have resolved to enter into detail, for the reason that I believe the suggestions may be of value to some whose experience in this branch of otology has been limited.

Instruments.—Most of the instrument-makers are pre-

pared to furnish instruments designed for this special work; many of the instruments are designed for the purpose of performing one particular operation, and usually have been modelled according to the idea of some one individual operator, and represent his personal preferences. It should be remembered, however, in this branch, as in general surgery, that individual preference for any one instrument does not of necessity indicate that it alone is adapted to the special procedure; but simply that in the hands of one familiar with its use it

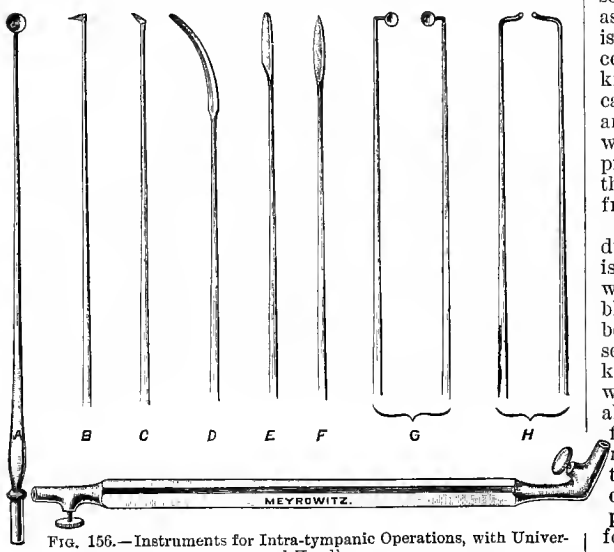


Fig. 156.—Instruments for Intra-tympanic Operations, with Universal Handle.

has served a good purpose. Every operator will, from habit, develop a preference for a special device, and in his hands it undoubtedly is more serviceable than any other, but the aural surgeon upon entering the operative field should first obtain a clear idea of what is to be accomplished, and then choose those instruments which seem to him best adapted to carry out the procedure. In a general way, then, the armamentarium should include in addition to the ordinary instruments used in diagnosis and treatment, delicate knives, both sharp- and probe-pointed, and both curved and straight; knives curved on the flat, angular knives, the blade making an obtuse angle with the shaft, or a right angle, according

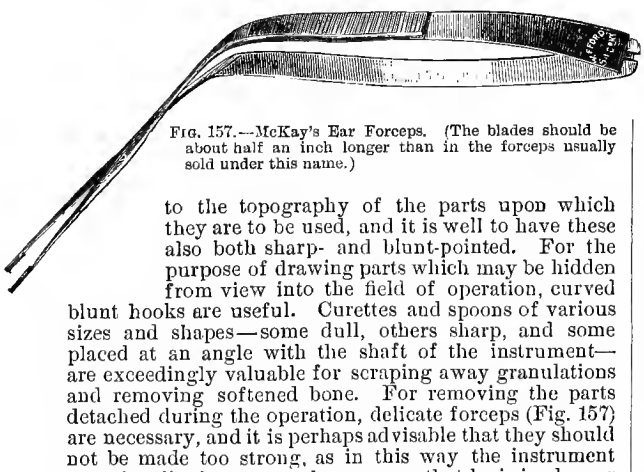


Fig. 157.—McKay's Ear Forceps. (The blades should be about half an inch longer than in the forceps usually sold under this name.)

to the topography of the parts upon which they are to be used, and it is well to have these also both sharp- and blunt-pointed. For the purpose of drawing parts which may be hidden from view into the field of operation, curved blunt hooks are useful. Curettes and spoons of various sizes and shapes—some dull, others sharp, and some placed at an angle with the shaft of the instrument—are exceedingly valuable for scraping away granulations and removing softened bone. For removing the parts detached during the operation, delicate forceps (Fig. 157) are necessary, and it is perhaps advisable that they should not be made too strong, as in this way the instrument may, by slipping, warn the surgeon that he is in danger of using too much violence. A good aural snare is also a convenient instrument to have at hand. As to whether the instruments should be mounted upon straight or angular handles is again a matter of personal preference. For my own use I prefer to have most of the instruments so modelled that the shaft forms an angle of 30 to 45 degrees with the handle; but as it is sometimes more convenient to use a straight instrument, it is well, in case the universal handle is to be used, to have one extremity adapted to receive the instrument at an angle, while by fitting the knife into the other end of the handle a straight instrument is obtained (see Fig. 156). For rapid operative work it is better to have each instrument in a separate handle, but as this increases the bulk of the case, as well as the cost of the instruments, the universal handle is often used. Of late I have made use of the excellent suggestion of Prout,[3] that the shank of the knife be left untempered, and in this manner its shape can be changed at will. Knives made in this way, and provided with simple octagonal metal handles, into which the shaft screws, can be obtained at a much less price than those of a more elaborate design, and as from their extreme delicacy instruments of this kind must be frequently replaced, this form certainly commends itself.

At any operation all cutting instruments should be duplicated, and even a greater number of each variety is an advantage, as they soon become too dull for delicate work. It is important that in all knives the back of the blade should be of sufficient thickness to permit of its being honed to a very fine edge; it being impossible to secure a keen cutting edge in a very thin knife. All knives should be as sharp as skill can make them, and when even slightly dull should be laid aside. It seems absurd to state this, but I have frequently had great difficulty in impressing its importance upon instrument-makers, and consider it a point of the greatest importance. The structures to be divided are extremely delicate, and unless the blade be very keen, may often be pushed aside by the knife, instead of divided, or undue force may be necessary in order to effect section, and important structures may thus be damaged. Again, the field of operation being small, any failure to expose the parts as fully as possible, or the production of hemorrhage by harsh manipulation, seriously hampers the operator.

Immediately before the operation all instruments to be used should be sterilized by submersion in boiling water or exposure to steam for about ten minutes.

Preparation of the Field of Operation.—In order to diminish the probabilities of suppuration, and reduce the reaction to a minimum, the field of operation should be rendered as aseptic as possible. In cases where there is no discharge from the ear, and the canal is clean, there is very little danger of infection from this source. It is safer, however, to order that the ear be syringed with a solution of bichloride of mercury, 1 to 5,000, twice daily for several days before the operation, and that after each syringing the canal be closed by a pledget of aseptic cotton. Of course, any cerumen or dead epithelium which may have collected in the canal must be thoroughly removed before the syringing is done. Upon the day of the operation the ear is not to be syringed, owing to the congestion which it causes; Blake[4] suggests that it may be wiped out by means of a pledget of cotton saturated with the antiseptic solution.

In cases where there is discharge, the previous cleansing of the ear is of great importance, especially if there is to be any interference with the stapes, since infection of the labyrinth is among the possibilities. In all cases, therefore, where there is a purulent discharge, provided any operation is to be done beyond the simple division of adhesions, the ear should be syringed several times daily with an antiseptic solution in the manner already described. It is true that in many cases no harm comes from operating without carrying out these measures, but it is only our duty to protect the patient in every possible way.

When the middle ear has been the seat of a long-continued suppurative process, we usually find considerable granulation tissue within the tympanum, or, if this is not the case, the remnants of the drum membrane, as a result of chronic myringitis, are much thickened, and richly

supplied with blood-vessels, bleeding freely upon the slightest violence. It is often advisable in such cases to employ a certain amount of local treatment before the operation, in order to reduce the turgescence and render the operation more simple.

Anæsthesia.—As to the question of anæsthesia only general rules can be given. In general it may be stated that as these operations require exceedingly nice manipulation for their performance, and it is necessary for the patient to remain absolutely quiet, general anæsthesia is in most cases preferable, and in many absolutely necessary.

For the division of adhesions in old purulent cases, in which there is a large exposure of the tympanic cavity, the introduction of a few drops of a strong solution of cocaine will usually render the operation endurable in patients who have a fair command of themselves. In these cases it is often necessary to do repeated operations on successive days, each one occupying but a few seconds, and in such cases general anæsthesia would cause the patient more annoyance than the procedure itself.

Usually where the membrana tympani is present and we wish to enter the tympanic cavity for purposes of thorough exploration and subsequent operation, a general anæsthetic must be administered. If possible, however, it is advantageous to make the exploratory incision by means of local anæsthesia, as we can then determine the effect upon the hearing, and subsequently induce general anæsthesia for the purpose of conducting any further procedures which may be necessary. For the production of local anæsthesia I have used a ten per cent. ointment of cocaine and lanolin. A small quantity is smeared on a pledget of cotton, placed in contact with the membrana tympani and allowed to remain for about ten or fifteen minutes. A certain amount of anæsthesia is gained in this way. After the membrana tympani has been incised, a drop of a ten per cent. solution of cocaine in the tympanic cavity will produce a very decided anæsthesia.

Miot[5] claims that he has been able to carry on very extensive manipulation of the intra-tympanic structures by instillation of cocaine after incising the membrana tympani. Although the actual pain of these procedures is not great, the tax upon the nerves of the patient is severe, and much will depend upon the self-control of the individual. I have found the anæsthesia following the use of the lanolin and cocaine ointment, and the instillation of an aqueous solution of cocaine after the first incision, amply sufficient to remove the cicatricial membrana tympani which often forms after excision of the membrana, malleus, and incus. As all the cases operated upon by this method have been delicate females, I am inclined to think that the procedure has not been attended with much pain, as they scarcely complained.

Cholewa[6] has obtained excellent results from the use of strong solutions of aluminium aceto-tartrate as a local anæsthetic in this region, but I have no personal experience with the method. In general, I should restrict local anæsthesia to the division of adhesions in cases where the tympanum is freely exposed as the result of a previous purulent inflammation, or when the parts are covered by a thin cicatricial membrane only, or where they are endowed with slight sensibility; to partial myringectomy by chemical agents; and to exploratory myringotomy. In all other cases I decidedly prefer general anæsthesia, and in my own hands ether has been the agent employed exclusively. If the ordinary rules for preparing a patient for ether, such as attention to the food taken upon the day of operation, the condition of the bowels, etc., are attended to, the unpleasant effect of the drug is in a large measure avoided, and is rarely very disagreeable.

Position of the Patient.—As we habitually inspect the ear with the patient in the upright or semi-recumbent position, the operator is placed at a decided disadvantage if the horizontal position is employed at the time of operation. Another disadvantage of this position is that with the head low, or only slightly elevated, hemorrhage is much more profuse, and the field of operation more obscured, especially that portion of the field in which lie the structures of the greatest importance, the upper and posterior part, the blood collecting in this situation in obedience to the laws of gravity. A still further objection lies in the fact that if the ossicles are to be removed, the horizontal position favors the dislocation of the incus toward the mastoid antrum. For the comfort of the surgeon the head should be in such a position that it can be easily turned in all directions without the operator's manipulations being in the least interfered with. For all of these reasons I now always operate with the patient in the semi-recumbent position. This is easily secured by means of the head-and-shoulder rest shown in Fig. 158. This device is clamped to any convenient table, or to a bed, the head-rest is removed, the shoulder-frame let down, and the patient is anæsthetized in the horizontal position, care being taken that the shoulders are well up on the frame. When complete anæsthesia has supervened, the shoulder-rest is elevated to the required height and held in place by the ratchet, as seen in the figure. The head-rest is placed in position and supports the occiput. As the head-piece is supplied with a ball-and-socket joint, the head can be placed in any desired position, and maintained by turning a screw which renders the joint immovable. Straps passed under the arms prevent the body from sliding downward; elevating the foot of the table or couch also serves the same purpose. By this simple device the head is as completely

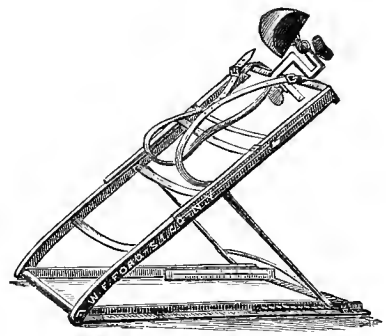


FIG. 158.—Head-and-shoulder Rest.

under the control of the operator as when the patient is conscious, and the surgeon can manipulate from all sides, his movements not being interfered with by the patient's shoulders, the edge of the table or other obstacles. Anæsthesia is maintained in this posture with no more difficulty than with the patient in the ordinary position.

Illumination.—Many prefer daylight for all work upon the middle ear, and there can be no doubt that a perfect north light affords an ideal source of illumination. The great objection to natural light is its uncertainty. For this reason I have never used it extensively, even in the examination of patients, and have become accustomed to make use of the ordinary argand gas-burner. The slight yellow tinge of the gas-flame modifies the appearance somewhat, but if used to the exclusion of other sources of illumination, of course does not mislead. When general anæsthesia is resorted to, the gas-flame becomes objectionable on account of the danger of igniting the ether, and if it is removed to such a distance that there is no danger, its rays, reflected from the surface of the head-mirror, are scarcely powerful enough for fine operative work. If great care is used the gas-burner may be brought near enough to furnish sufficient light; it should never be less than five feet away from the inhaler, and at a somewhat higher level. As an additional precaution, the face of the patient, and the inhaler also, should be covered with a wet towel. Since the use of storage batteries has become general, the incandescent electric lamp has been much used, and undoubtedly affords the most convenient source of illumination. The lamp is usually placed in a cylinder, one end of which is provided with a double convex lens for rendering the rays convergent, while behind the lamp is placed a metal

reflector, which serves to direct all the rays through the lens. The apparatus may be worn upon the head by means of the ordinary head-band, or may be mounted upon a standard, and the head-mirror used in the usual way to illuminate the field of operation. If the first method is adopted the lens should have such a curvature as to bring the rays to a focus at a point about six or seven inches in front of the apparatus, while if the head-mirror is used the rays should simply be rendered parallel. As I habitually make use of the perforation in the head-mirror, I prefer to use the latter method; this is simply a matter of personal preference, however. The use of the electric lamp does away with all fear of accident from ignition of the ether, and permits the surgeon to give his entire attention to the operation.

Classification of Operations.—The various operations which have from time to time been suggested and performed upon the middle ear are quite numerous. While I do not propose to give a full history of all of these surgical procedures, it may be wise to mention them briefly, dwelling at length only upon those which seem to be of undoubted value. We may classify these measures as follows:

1. Operations involving the membrana tympani alone, under which are to be considered:

(*a*) Perforation of the membrana (myringotomy).

(*b*) Excision or destruction of a portion of the membrana for the purpose of establishing a permanent opening (partial myringectomy).

(*c*) Single or multiple incisions through the membrana for correction of anomalies in tension. (Under this head we include division of the posterior fold, or plicotomy.)

2. Operations involving the soft parts within the tympanum, under which we include:

(*a*) Tenotomy of the tensor tympani muscle.

(*b*) Tenotomy of the stapedius muscle.

(*c*) Section of the anterior ligament of the malleus.

(*d*) The division of adhesions, the result of suppurative or non-suppurative inflammation.

3. Operations involving the ossicular chain, comprising:

(*a*) Excision of a portion of the malleus.

(*b*) Disarticulation of the incudo-stapedial articulation, or division of the long arm of the incus and mobilization of the stapes.

(*c*) Plastic operations for the purpose of uniting either the incus or stapes with the membrana tympani.

(*d*) Removal of the ossicular chain in its entirety, or the excision of individual ossicles.

1. *Operations Involving the Membrana Tympani Alone.*

(*a*) *Myringotomy.*—Puncture of the tympanic membrane became a recognized surgical procedure chiefly through the investigations of Sir Astley Cooper.[7] Performed primarily for the improvement of hearing, it was found that it was of permanent benefit only in those cases in which the hearing had been impaired by collections of fluid within the tympanum. Its efficacy in such cases has been already discussed in the portion of this work devoted to otitis media, and need not be commented upon here. Under other conditions, closure of the opening by cicatrization reduced the hearing to its former condition.

To us incision of the membrana tympani is of use not only for the evacuation of fluids, but as affording us a means of exploring the tympanic cavity, and determining the mobility of the stapes in cases where adhesions have formed within the middle ear.

Schwartze[8] recommended the excision of a portion of the membrane for the purpose of determining the mobility of the stapes, while De Rossi[9] advises the formation of a flap from the membrana tympani, and after turning it aside to fully test the mobility of the ossicles.

It should be remembered that an operation through the membrana enables us not only to test the mobility of the ossicular chain by means of a probe, but if the operation is performed without the use of a general anæsthetic, and this is often possible, we are able to observe the effect of the artificial opening upon the hearing. In cases of thickening of the membrana tympani itself, or when it has become much relaxed, and by its own weight acts as a load to the conducting mechanism, the hearing will improve after the perforation. It also gives us some information as to the condition of the membrane covering the round window, since the artificial opening allows the sound-waves to impinge directly upon this part. Exploratory incision, then, is, in certain cases, of aid in informing us how much of the impairment in hearing is due to the presence of the membrana tympani and also the extent of the rigidity of the stapes. It is of special diagnostic value in cases of tympanic sclerosis, resulting from non-purulent inflammation, in which the receptive apparatus is involved secondarily. In such a case the probable outcome of surgical interference can sometimes be determined by exploratory myringotomy, since if the stapes were found movable, and the hearing is not improved by the artificial opening, very little could be expected from further operative procedures. In a case of this kind, in which this opinion had been arrived at by means of the tuning-fork tests, an exploratory incision enabled me to confirm the diagnosis, and advise against further operative interference.

Steps of the Operation.—In the cases in which such an incision is likely to be required, the membrana tympani, as the result of the preceding inflammation, has usually lost much of its normal sensibility; but if the impact of a probe causes pain it is well to place a pledget of cotton saturated with a ten per cent. cocaine lanolin ointment against it for a few minutes before operating. With a sharp knife a curved incision is to be made from the lower border of the membrana flaccida downward, directly over the incudo-stapedial articulation if this is in view, otherwise the incision is to be made close to the posterior margin of the tympanic ring. The incision is to be parallel to the periphery of the membrana tympani, and should extend downward nearly to the level of the tip of the long process of the malleus. Usually the edges of the wound retract enough to permit the articulation to be seen, and the mobility of the parts to be tested by means of a probe; if not, a second incision may be made from the upper extremity of the first, and carried toward the short process of the malleus, until a sufficiently large flap is formed to permit of the exposure of the articulation. The upper incision should lie just below the border of the membrana flaccida; should this membrane be incised, the resulting hemorrhage might obscure the field of operation, while if the section is made as directed above, and care is taken not to wound the inner wall of the tympanum, no blood will be lost and the exposed parts will be clearly seen. The mobility of the stapes can now be tested by means of a fine probe passed through this opening. Any effect upon the hearing should also be noted. If further operative steps are deemed unadvisable, the edges of the incision should be approximated with the cotton-tipped probe, and a pledget of sterilized cotton adjusted against the membrane. In case of a simple incision the insufflation of a little boric acid is usually all that is necessary.

(*b*) *Partial Myringectomy.*—For the purpose of establishing a permanent opening in the membrana tympani various methods have been resorted to, such as excision of a portion of the membrane as advised by Gruber,[10] destruction of the membrane over a limited area by means of the actual cautery, as advocated by Voltolini,[11] or by a chemical caustic, as practised by Simrock.[12] Schermunsky[13] advises that a crucial incision be made in the membrane at the desired location, and that the edges of the wound be then cauterized with chromic acid. According to this author, a permanent opening will be left upon the separation of the eschar caused by the chromic acid.

In my own hands this method has proved as useless as the others, and it has been the experience of all otologists who have attempted this procedure, that in most instances the opening closes, though in some cases the interval is very long. To maintain a permanent opening, Politzer[14] advised the insertion of a vulcanite eyelet into the perforation made either with the galvano-cautery or

with the knife. Experience has proved that even this method is ineffectual, and it has fallen into disuse.

The only cases in which I can conceive of partial myringectomy as being advisable are those in which further operative measures are to be employed, in case an opening in the membrane improves the hearing. Here I believe that all the indications are better met by the exploratory myringotomy already described. In one case in which I attempted to establish a permanent opening in the membrane, the method of Simrock was employed, and as this seems to be rather simpler than the other procedures I will describe it in detail.

A minute drop of concentrated sulphuric acid is carried into the canal on a cotton-tipped probe, and held against the membrane at the point where the perforation is to be made, care being taken not to touch the canal at any point. The acid at once destroys the membrane over the area touched, and perforation is readily effected by means of a blunt probe. In my own case very little reaction followed, and I am inclined to believe that the method accomplishes the purpose quite as well as the more complicated procedures. After the perforation has been made, the parts should be kept clean, either with the cotton pledget, or, in case a profuse discharge supervenes, the syringe may be used, although the less the parts are manipulated the longer the perforation remains, as a rule.

(*c*) *Multiple Incision of the Membrana Tympani.*—This operation has been advocated both by Politzer[15] and by Gruber,[16] but, curiously enough, for exactly opposite conditions. Politzer recommends the procedure in cases when the membrana tympani is much relaxed, the result of the cicatrization of a large perforation, believing that the contraction following the healing of the incisions will correct the relaxation. In his hands the operation has met with a certain amount of success. On the other hand, Gruber finds that when the membrane has become tense or rigid from a chronic inflammatory process that several incisions made through it will, upon healing, relax the abnormal tension, and permit the parts to perform their functions more properly. Gruber advises that the incisions be made from the centre toward the periphery, through the dense portions of the membrane, the adjacent lines of section being connected by transverse incisions, somewhat in the form of the letter H.

I have had no experience with this procedure, and should be inclined to believe that when the operation was performed for relaxation the improvement would be at the most but temporary. The method of performing the operation must of course vary in each individual case; care should be taken that the inner wall of the tympanum is not wounded by the point of the knife, as any bleeding would obscure the subsequent steps. Cicatrices of the membrane are only slightly sensitive, and the incision of a membrane thickened by a chronic myringitis is also usually much less painful than when the membrane is normal; hence in an intelligent patient general anæsthesia is seldom necessary, although it would be advisable to employ it if the patient is nervous.

Plicotomy.—Division of the posterior fold of the membrana tympani was proposed by Politzer[17] and by Lucae[18] at about the same time. This measure was recommended when the membrana tympani was much retracted, the short process and posterior fold being very prominent. In such cases the contraction of the fibres of connective tissue forming the posterior fold increases the tension of the conducting apparatus, and interference with function is the result.

The operation consists in the division of this fold by an incision midway between the short process and the peripheral extremity of the fold and perpendicular to the direction of the fold. Either the sharp-pointed knife may be used, or, as Politzer advises, the extremity of the instrument may be rounded, so as to diminish the danger of dividing the deeper structures. The same author advises that the incision be made from above downward. Gruber[19] has found better results from incising the fold longitudinally. In either case, if the operation has the desired effect, the manubrium will assume a less horizontal position, showing that the tension has been relieved. The immediate effect seems to have been to diminish the subjective noises, and in some cases to improve the hearing, but the improvement has almost always been temporary. My own experience has been limited to but one case, and here no improvement resulted. The operation is devoid of danger; if the chorda tympani is wounded the effect upon the sense of taste will be but transitory, and with proper care suppuration should not follow the operation. It is well to allow the wound to heal slowly, and for this purpose daily inflations for a few days after the section has been made may be practised. Locally, the insufflation of a minute quantity of boric acid is probably the best treatment for the wound. The operation is so uncertain in its results that it cannot be strongly advocated, since it will be the exception to find the increase in tension limited to the posterior fold. Usually the presence of similar constricting bands in other parts of the tympanum render the outcome of the procedure unsatisfactory.

The next group in our classification comprises:

2. *Operations in which Various Muscular or Fibrous Structures within the Tympanum are Divided.*

(*a*) *Tenotomy of the Tensor Tympani Muscle.*—This operation was proposed by Hyrtl,[20] but was first performed upon the living subject as a therapeutic measure by F. E. Weber.[21] The indications for performing this operation have never been definitely given, as it is manifestly impossible to be certain that in a given case the increased tension of the conducting apparatus depends entirely upon a shortening of the tensor tympani muscle. The most prominent indication for its performance seems to be a temporary improvement of the hearing or relief of tinnitus immediately after inflation, the symptoms soon reappearing, however, as the membrane becomes depressed. It is argued that in such cases the muscle has become permanently shortened, either by participation in the tympanic inflammation or from the fact that, on account of Eustachian obstruction of long duration, the aeration of the tympanum has been imperfect and the membrane sinks inward upon the promontory. The function of the tensor is thus ablated, and the muscle soon becomes atrophied from disuse and is converted into a tense fibrous band which prevents the membrane from resuming a permanent normal position, even when the patency of the tube is restored. In addition to this, it is supposed that by the tension of the muscle the manubrium is pressed upon the inner wall of the tympanum with considerable force, thus mechanically adding to the inflammatory process already present in the middle ear. It will be seen that if such is really the case a division of the tendon of the muscle would remove one of the causes of the tympanic inflammation. Since the operation was first proposed valuable contributions to the subject have been made by Green,[22] Pomeroy,[23] Hartmann,[24] Schwartze,[25] Cholewa,[26] and Müller.[27] It is hardly necessary to say that in addition to the objective signs already given, as indicating the advisability of the operation, the result of the tuning-fork tests should also be considered and should indicate unquestionably a lesion of the conducting apparatus as the prominent pathological condition. Cholewa states that the forks C and C^1 should be heard at least eight seconds by bone-conduction, and that the air-conduction for the forks C^1, C^2, C^3, C^4, should not fall much below one-fourth the normal duration of air-conduction for these tones.

Steps of the Operation.—Most authors agree that general anæsthesia is seldom necessary, and Cholewa states that in many of these cases the sensibility of the membrana tympani is much diminished. The same author advocates the induction of local anæsthesia by strong solutions of aluminium aceto-tartrate or by ether, a pledget of cotton saturated with the agent being placed in contact with the membrane and the fluid allowed to evaporate. The ointment of cocaine and lanolin may also be used in the same manner. In the very few cases in which I have resorted to this measure it was rather difficult to control the patient as perfectly as might have been desired, and I believe

that a general anæsthetic will add much to the completeness of the operation.

With reference to the method of dividing the tendon there is considerable difference of opinion. Weber-Liel and Cholewa have advised that it be accomplished by the introduction of the knife in front of the short process of the malleus. Both of these operators have devised special instruments for the purpose, differing from each other only in the shape of the blade. These instruments were constructed in such a way that the hook-shaped knife could be rotated upon the long axis of its shaft by sliding a button upon the handle. The technique with an instrument of this kind is as follows: The membrana tympani is incised just in front of the processus brevis, the hook-knife introduced into the tympanic cavity, and by depressing the handle of the instrument and carrying it somewhat forward the blade is made to press upon and partially encircle the tendon; by sliding the button upon the handle downward the hook-blade is rotated, thus dividing the tendon; by again manipulating the slide the blade assumes its original position and the instrument is carefully withdrawn from the tympanic cavity; a forcible inflation and the insufflation of a little boric acid to cover the wound complete the procedure.

Much simpler are the methods of Schwartze, Hartmann, Gruber, Pomeroy, Green, and Urbantschitsch, who divide the tendon without the aid of the complicated instrument above described. With the exception of Gruber,[28] all of the above writers prefer entering the tympanic cavity behind the malleus handle, and Gruber states that in some cases, where the anterior segment is very small, this may be advisable. Almost every operator has devised a special instrument which, in his hands, has appeared more satisfactory than any other, from which we may infer that, bearing in mind the anatomy of the parts, almost any instrument with the blade curved on the flat may be used for the purpose. Schwartze, Pomeroy, and Green prefer a blunt knife, curved on the flat, similar to that represented in Fig. 156, *D*, with the exception that the curve should be a little sharper than represented. Gruber's knife is less curved and is pointed. Hartmann's knife is pointed, and, in addition to the curve on the flat, the sharp point is curved upward, so that when the knife is inserted the point passes well up into the tympanic cavity. Urbantschitsch[29] uses a knife with a double cutting edge, the blade being short and making an obtuse angle with the shaft; an instrument similar to that shown in Fig. 1, *C*, with the exception that it is blunt instead of sharp.

The position of the puncture and the manipulation of the instrument after the blade has entered the tympanic cavity will vary according as the tendon is to be divided from above downward, or from below upward; and here again I believe the operator should be allowed a certain amount of latitude, depending upon the conformation of the parts in each special case. If the division is to be made from above downward, as advised by Schwartze and Urbantschitsch, the membrana tympani is punctured immediately behind the short process, and the curved or angular blade of the knife is carried high up into the tympanic cavity by depressing the proximal end of the instrument, which at the same time should be carried a little backward, thus causing the blade to apply itself closely to the malleus. The blade is then rotated forward and downward through an angle of 90°, the tendon being severed by a slight sawing motion, and by pressing the knife downward, at the same time withdrawing it. As the tendon is divided the operator feels the resistance which it offered suddenly overcome, and frequently a sharp snap is heard at the moment of division.

Hartmann and Pomeroy divide the tendon from below upward. Hartmann advises that the membrane be incised just below and behind the short process; upon entering the tympanic cavity the knife is advanced forward, inward, and slightly downward, the shaft remaining almost horizontal and the flat surface of the blade being close to the handle of the malleus until the blade has nearly traversed the breadth of the tympanic cavity, when the handle is depressed, thus carrying the curved point of the knife high up in the tympanum; the instrument is then withdrawn, upward pressure being continually exerted, and the tendon is divided from below upward. Just before the tip of the knife emerges from the tympanum, the handle is elevated to avoid injury to the parts in the region of the posterior fold. Pomeroy[30] first punctures the membrane behind the manubrium and near its tip, and then introduces a blunt curved knife, with its concave side looking forward and being closely applied to the handle of the malleus. The tendon is divided by depressing the handle of the knife and extending the incision upward to the short process.

Green[31] enters the tympanic cavity with a myringotome, behind and below the short process of the malleus, and extends the incision upward to the margin of the ring. Through this incision the curved blunt knife is introduced and the tendon located; it is divided either from above downward, or in the opposite direction, according to its attachment in each individual case.

When it seems desirable to divide the tendon by an incision through the anterior segment of the membrana tympani, the curved knife is to be carried through the membrane somewhat below the short process, the concavity of the knife looking backward. On entering the cavity the instrument is advanced upward and backward, keeping the blade closely applied to the malleus handle. The tendon is thus divided from below upward. Whatever method is used to effect a division of the tendon, the after-treatment consists in a forcible inflation by means of the catheter or Politzer's method, after which the incision is covered with a little boric acid and the wound allowed to heal.

Results.—The immediate effect of the operation is usually to diminish the subjective noises, and in some cases the hearing improves. It has been the experience of many observers, however, that the good results have been but temporary, and that after an interval the symptoms have reappeared. This may be explained by the reunion of the cut ends of the tendon, or by the invasion of other parts of the conducting apparatus by the pathological process. My own experience with the operation has been limited to a few cases, in which the tendon was divided for the relief of tinnitus. In one case there was considerable improvement; in the others the final result is not known, but immediately after the operation there was no improvement. In making the section I ordinarily use the curved knife (Fig. 156, *D*), the membrane being first incised with a pointed knife, either in front or behind the manubrium, according to the shape of the canal and the amount of retraction present.

I am not enthusiastic over the operation, for the reason that it is absolutely impossible in any given case to be certain that the tensor tendon is the only intra-tympanic structure affected. While our methods of determining that a lesion is located in the conducting apparatus are fairly perfect, we have no means as yet of assuring ourselves that the increased tension is due to a shortening of the tensor tympani tendon alone. My own choice, when operative measures are necessary, is usually for a procedure which corrects the increased tension, no matter in what portion of the mechanism it is located. Of late the operation has been again brought to the notice of the profession by Cholewa[32] and Müller.[33] Cholewa strongly advises its performance in the cases variously called sclerotic, proliferative, or insidious, not only from the effect upon the ear operated upon, but also for the improvement which he claims often results in the opposite ear. The poorer ear is always the one operated upon first, and even when its condition is not much improved, this author has found in many cases a remarkable improvement in function upon the opposite side. I shall allude to this later, in describing my own experience in cases of ossiculectomy.

Müller advocates the operation in cases of purulent inflammation, in which the discharge continues in spite of careful cleansing and local applications. He believes that the contracted tendon, by crowding the articular surfaces of the ossicles together and binding them to the tympanic wall, is a prominent factor in keeping up the inflammation.

He reports a number of cases in which tenotomy was followed by a rapid cessation of the discharge. The effect upon the function of the organ and upon subjective noises was also satisfactory.

(*b*) *Tenotomy of the Stapedius.*—Division of the stapedius tendon alone scarcely deserves a place among the operations, since when this muscle needs to be divided the section of its tendon is only one step in operative procedures to free the stapes. With the other portions of the conducting mechanism normal, I can conceive of no condition which would indicate tenotomy of this muscle. Accordingly the description of the procedure will be given under those operations of which it really forms a part.

(*c*) *Division of the Anterior Ligament of the Malleus.*—This measure was advised by Politzer [34] in cases of marked retraction of the membrana tympani. It was found that, even after section of the tendon of the tensor tympani, the membrane in some cases would not retain its normal position upon inflation. If, however, the ligamentous structures of the anterior fold were divided the membrane could be made to resume its normal position. The operation consists in puncturing the membrane just in front of the short process with a short curved knife, carrying it nearly to the inner wall of the tympanum; the handle is then depressed and the knife withdrawn, thus dividing the tissues in the anterior fold. In the cases in which this operation was performed by Politzer there was considerable relief to tinnitus, and the hearing was somewhat improved. The objection to the operation is the same as that mentioned in tenotomy of the tensor tympani, viz., that we are never certain that the increased tension is entirely dependent upon the anterior ligament. The procedure may, however, be made use of in cases of tinnitus, with but slight impairment of the hearing, in which more radical measures might be considered a menace to the auditory function.

(*d*) *The Division of Adhesions, the Result of Suppurative or Non-suppurative Inflammation.*—Under this general head we include a large number of procedures, differing from each other according to the precise local condition met with in the individual case. As the stapes is the part of the ossicular chain whose motion is a necessity to useful audition, the ultimate aim of all our efforts is to render motion of this ossicle possible. We have then two classes of cases:

1. Those in which the rigidity depends upon adhesions about the stapes itself.

2. Cases in which the rigidity is caused by adhesion of the malleus or incus to the inner tympanic wall, or by tense bands immobilizing the entire ossicular chain, the articulations between the various ossicles being intact.

Naturally these conditions are more pronounced in cases of old purulent inflammation, although the same condition may obtain in cases of non-purulent otitis. It scarcely need be stated here that a diagnosis is much more simple in cases arising from a purulent inflammation, as the result of which the membrana tympani is largely wanting, enabling the surgeon to see the location of the constricting bands, and to manipulate the parts with the probe, than in those cases in which the deeper parts must be viewed through the membrane, or if this is too opaque, through an artificial opening made for this purpose. It follows that operative measures of this character are much more successful in purulent cases than in the other variety.

When the rigidity depends upon adhesions about the stapes itself, as a result of a purulent otitis, the incudo-stapedial articulation having been destroyed, we find the region of the oval window occupied by a mass of dense tissue, which frequently completely changes the appearance of the parts. Not infrequently the head of the bone is so buried as to be distinguishable only as a slight elevation upon the surface of the mass. Close inspection may reveal a preponderance of the newly formed tissue toward the posterior aspect of the region of the window. This is ordinarily due to the deposit about the stapedius tendon which sometimes can be seen as a bright line running through this mass. To free the stapes (or what is left of this ossicle) in such a case I usually first incise directly downward close to the tympanic ring, so as to divide any bands which tend to pull the stapes out of the field of vision. In making this incision it is important that the knife be carried inward until the inner tympanic wall is encountered, and that in the downward stroke all the tissues be completely severed throughout their entire depth, otherwise some fibres of the stapedius may remain undivided, and pull the stapes out of view. The knife is next carried entirely around the area believed to be occupied by the stapes, thus freeing it from adhesions above, below, and anteriorly. When the knife is carried inward until the bony wall of the tympanum is encountered, care must be taken not to insert it so deeply that, in case the entire stapes has come away, the labyrinth will be wounded. Taking the region of the oval window as a centre, several short radiating incisions are next made to permit the tissues to retract from the oval window; the local depletion thus obtained is also an advantage, as it favors the rapid formation of a thin cicatricial membrane in place of a thick one. After the operation a little boric acid may be insufflated, and syringing should be avoided if possible, as moisture is objectionable.

Frequently this procedure has to be repeated several times, for the process of cicatrization may partially reproduce the old condition, but by repeated incision, dividing the parts most tense, favorable results usually follow in a large proportion of cases. Of course here, as in other conditions, the tuning-forks should be used to locate the seat of the lesion in the conducting apparatus.

In the second class of cases, where the motion of the stapes is impeded by pressure from other parts of the conducting apparatus, which are bound down by adhesions, relaxation of the tension of these parts frequently effects an improvement. Thus we frequently meet with cases in which there is a large perforation, involving the inferior half of the membrane; the edges of the membrane may adhere to the promontory throughout their extent, or the adhesion may be confined to the region of the manubrium. In this latter instance I usually separate the structures with the flat curved knife (Fig. 156, *D*), although Politzer [36] prefers to make vertical incisions through the cicatrix. In either case adhesions reform, but the tension is lessened, and improvement usually results. It is in such cases that Müller [36] advises division of the tensor tympani muscle.

In still another class of cases, with considerable destruction of the membrana tympani, the remnant of membrane in the upper and posterior quadrant will be found thickened and tense, its lower border forming a dense fibrous band, which binds the underlying structures firmly together, and may partially or completely hide the stapes or incudo-stapedial articulation from view. Dividing this band by an incision upward will frequently improve the hearing, or in exposing the stapes may reveal a condition here amenable to operation.

Examples of all of these different conditions have come under my own observation, and the results have always been gratifying. A few of these cases were reported some time since,[37] and subsequently I have met with many more cases in which the results have been gratifying.

When adhesive processes are the result of the so-called otitis media insidiosa, the division of adhesions is not followed by such good results, for the simple reason that when divided through an artificial opening in the membrana tympani, any bands which reform during the process of healing can only be attacked by reopening the tympanic cavity, in fact, by repeating the original operation. While in the class already considered the operative field is always open to inspection, and the operative interference may be undertaken at intervals, according to indication, in the cases we are now considering, the ultimate success or failure depends entirely upon the single operation, and the result of faulty cicatrization cannot be corrected. Still in certain instances the division of adhesions has been of benefit in this class of cases. Thus De Rossi [38] reports a case in which, after turning

down a flap from the membrana tympani, a fibrous band between the malleus and incus was divided. The flap was replaced and held in position by means of a cotton pledget. The patient was much improved by the operation. Prout [39] operated upon a case in which the membrana tympani about the tip of the malleus was adherent to the inner tympanic wall. The instrument used resembled the knife shown in Fig. 1, *C*. By this means the adhesion was divided, that portion of the membrana which was adherent being cut away and either removed or left adherent to the inner tympanic wall. A permanent perforation resulted and the hearing was permanently improved.

While I am heartily in favor of these procedures in cases dependent upon suppuration, I believe that they are to be advised only in special instances where there has been no suppuration. When upon an exploratory myringotomy a condition is found, as in De Rossi's case, which is sufficient to explain all the symptoms, and in which a single operation promises every prospect of success, the simple division of the existing adhesion is all that is indicated. Most frequently, however, we find that the rigidity does not depend upon such a cause, but that the ossicular chain can be rendered normally movable only by the division of adhesions in several localities, especially about the stapes, and so located that subsequent cicatrization is almost certain to result in a return, to a certain extent, of the former local condition. In such cases I prefer to remove the membrana tympani, malleus, and incus at once, the field of operation being then accessible for further measures in case of necessity. My reason for this is that when the membrana is intact, a prolonged intra-tympanic operation necessitates general anæsthesia in most cases, and this cannot be resorted to again and again on account of the discomfort to the patient which it entails. With the tympanic cavity open, as in purulent cases, or after removal of the membrane, malleus, and incus, local anæsthesia by means of a solution of cocaine suffices for all operative procedures of this kind. Hence in any non-suppurative case where general anæsthesia is to be resorted to for the purpose of an exploratory myringotomy and the division of adhesions, the patient's consent for myringecto-ossiculectomy should be obtained, in case the condition revealed by exploration should render this advisable.

3. *Operations involving the Ossicular Chain.*—(*a*) *Excision of a portion of the manubrium mallei* and a large part of the membrana was proposed by Wreden [40] in cases where it was deemed desirable to maintain a permanent opening in the membrane. The procedure has fallen into disuse, and it is probable that it would not accomplish the end aimed at.

(*b*) *Disarticulation of the Incudo-stapedial Joint, or Division of the Long Arm of the Incus, with Mobilization of the Stapes.*—This measure is one of the most satisfactory operative procedures which fall to the lot of the otologist. It is of especial value when there has been previously a suppurative inflammation with destruction of the membrana tympani in the upper and posterior quadrant, or when the articulation is covered by a thin cicatrix only, through which the parts can be easily seen. It is of less value in cases of otitis media insidiosa, since the closure of the opening made for the performance of the operation renders it impossible for the surgeon to relieve by secondary operations any unfavorable results attending cicatrization.

In cases where both the long arm of the incus and the posterior crus of the stapes are in view and uncovered, the joint may be divided by inserting the angular knife (Fig. 1, *C*) behind the long arm of the incus and cutting downward through the joint; any portions of the capsule undivided may be severed by inserting the point of the knife into the joint below and cutting upward, and also by hooking the instrument around the anterior aspect of the long arm of the incus and cutting downward. It is usually advised that the knife be hooked around the posterior aspect of the long arm of the incus and the joint opened from above, downward and forward, the resistance offered by the stapedius muscle rendering this the simplest procedure for disarticulating at the joint. This is theoretically correct, but is open to several objections. In the first place, the long arm of the incus frequently lies so near the margin of the tympanic ring that the knife can only be inserted in this locality by the use of considerable force; again, if the joint is divided before section of the stapedius tendon has been done, the pull of the stapedius muscle may so displace the stapes as to render its subsequent mobilization impossible. My own method of procedure is therefore to thoroughly divide the stapedius tendon and the adjacent adhesions as the initial step of the operation. This is done in the manner already described, by inserting the sharp straight knife behind and above the head of the stapes, between it and the tympanic ring, carrying it inward until the point touches the inner tympanic wall and then cutting directly downward. By this procedure the stapes, and hence the articulation, is released, and by the action of the tensor tympani and the elasticity of cicatricial bands located anteriorly the articulation is brought more clearly into view. The anterior aspect of the descending crus of the incus is in such a position that by applying the angular knife to this, and cutting downward, the joint is easily divided, or it may be more convenient to enter the joint from below with the point of the knife, and cut upward, sweeping the blade anteriorly and posteriorly as a final step. If the knife is sharp no violence will be done, although the resistance afforded by the stapedius has been ablated.

After the joint has been divided the long arm of the incus is pushed upward and forward, so that it cannot reunite with the stapes. Attention is next given to the condition of the stapes, and if this is not freely movable it is to be freed by passing the pointed knife about the foot-plate, dividing all bands which may be found in the manner already described in treating of adhesions about the stapes. If the ossicle remains firmly fixed after these incisions have been made, it may be mobilized by pressing upon it with a cotton-tipped probe, the pressure being applied successively from below, from above, and upon the anterior and posterior crura. Care must be taken not to rupture the crura by this manipulation.

I have in quite a number of cases obtained a marked improvement in hearing and a diminution in the tinnitus by the division of the incudo-stapedial articulation and of the stapedius muscle, together with fibrous bands about the stapes, and this is, I believe, the experience of all otologists who have made use of the method. In a certain number of cases we find that the incudo-stapedial articulation has become ossified and division with the knife is impossible. In such an event Politzer [41] divides the long arm of the incus with stout scissors and separates the fragments so that reunion is impossible.

As before stated, mobilization of the stapes by division of the incudo-stapedial articulation and of adhesions about the ossicle is mostly of service in cases dependent upon a previous suppuration. In cases of otitis media insidiosa the mobilization of the stapes has been attempted, notably by Miot, [42] who enters the tympanum by an extensive incision along the posterior margin of the membrana tympani, and by means of a delicate instrument, the distal extremity of which is flattened into a small plate, mobilizes the stapes by pressure applied from below upward, from above downward, and upon the anterior crura backward. In certain cases also traction is made upon the long arm of the incus, to aid in the mobilization. The stapedius muscle and the incudo-stapedial articulation are left intact, unless the latter is ossified, when the long arm of the incus is divided. If adhesions exist between the incus, malleus, and the tympanic wall they are divided. The author claims that by frequent inflation by Valsalva's method the wound in the membrane can be kept open long enough to admit of several attempts at mobilization upon successive days, if the first does not afford the improvement hoped for. General anæsthesia is not considered necessary, as after the first incision through the membrane the introduction of a solution of cocaine into the tympanic cavity produces sufficient anæsthesia. In cases following a purulent inflammation the same general plan is followed, the author preferring to over-

come the rigidity by stretching the adhesions rather than by dividing them, although in certain cases he uses the knife. I have never attempted this method of procedure, but in one case of otitis media insidiosa I entered the tympanic cavity, and after dividing the incudo-stapedial articulation severed the stapedius muscle, as well as all adhesions about the base of the stapes. There was a moderate amount of reaction, and after the closure of the opening in the membrane the hearing remained the same as before operation, although the tinnitus was somewhat improved.

Although the method of Miot is certainly unique, and his results seem to have been good, yet I can scarcely believe that the operation will ever come into general use. There can, it seems to me, be no advantage in leaving in the tympanic cavity structures whose function has been so impaired by the inflammatory process that they are of little use, while by their presence they afford an additional opportunity for the recurrence of the condition for which operative measures have been instituted. Stretching of the adhesions may give temporary relief, but the method which, theoretically at least, would be the best, would be the one which prevented all possibility of their reformation. This indication, in my opinion, is better met by the free use of the knife, and the removal of all parts not absolutely necessary to the function of audition.

(*c*) *Plastic Operations for the Purpose of Uniting the Incus or Stapes with the Membrana Tympani.*—By means of the above procedure vibrations falling upon the membrana would be transmitted directly to the stapes; in cases, therefore, in which extensive adhesions existed, limiting the mobility of the malleus or incus, or both, or when, as the result of relaxation, the membrana tympani and one or both of the two larger ossicles by their own weight acted as a load to the conducting mechanism, this procedure, theoretically at least, should be beneficial. Blake[43] has performed operations of this character, but at present, in similar cases, he prefers stapedectomy. So far as I know, Dr. Blake has never published an account of these operations but refers to them incidentally in the above communication; he was also kind enough to explain the method to the writer three years since.

Operation.—A triangular flap from the posterior-superior quadrant of the membrane is turned aside, exposing the incudo-stapedial articulation; by means of the probe the mobility of the incus and stapes is determined; all tension due to adhesions about the stapes or to contraction of the stapedius muscle is relieved by incision. If, now, the incus and stapes move freely, the triangular flap is pressed against the long arm of the incus, and held in place by a pledget of cotton. If the incus is not freely movable, disarticulation at the stapedio-incudal articulation is performed, and the flap applied to the head of the stapes instead of to the long arm of the incus.

(*d*) *Removal of the Ossicular Chain in its Entirety or the Excision of Individual Ossicles.*—We come now to operations in which either the entire ossicular chain or individual ossicles are removed. These operations have either been done for the purpose of improving the hearing or relieving tinnitus, or, in cases where the function of the auditory apparatus was not sufficiently impaired to necessitate interference of any kind, they have been called into requisition for the arrest of long-continued suppuration which had resisted all other forms of treatment. It is evident at once that as one or all of these conditions may be present in any given case, it may often happen that the decision for or against operation becomes an exceedingly delicate matter. Given a case in which the hearing is good enough to allow the patient to carry on his vocation in life without the least annoyance, and yet with a chronic discharge from the ear, which has failed to yield to skilful treatment, we must be certain that any operative interference which may be advised for the cure of the otorrhœa will not impair the function of the organ. In another case, in which impairment of the hearing or severe tinnitus has resulted from a chronic non-suppurative inflammation of the tympanum, or has been produced by a previous suppurative process, the ear at the time advice is sought having been dry for a long period, no measures for relief can be strongly advised which may result in long-continued suppuration. The surgeon must, therefore, not only be able to hold out a fair prospect of success for the operation, in accomplishing the purpose for which it is to be performed, but must also be able to assert that no disagreeable consequences are likely to follow its performance.

The history of operations upon the ossicular chain is interesting, from the fact that it shows how the earlier operators hesitated to interfere with the parts intimately connected with the labyrinthine structures, and that it was only after a considerable period that it became a recognized fact that the labyrinth might remain uninjured in spite of considerable traumatism inflicted upon the ossicular chain, or even its complete loss.

As early as 1873 Schwartze[44] advised the removal of the malleus and incus for caries, but stated that removal of even a portion of the stapes should be avoided for fear of a purulent infection of the labyrinth. He also states[45] that as early as 1873 he practised removal of the malleus and membrana tympani and disarticulation of the incudo-stapedial articulation in cases of chronic non-suppurative inflammation. In this condition he apparently did not remove the incus, but simply disarticulated it from the stapes.

In 1876 Kessel,[46] having several years before proved that the removal of the columella in birds was not attended by severe consequences, effected mobilization of the stapes in a patient in whom the malleus and incus had been destroyed by suppuration. The operation consisted in tenotomy of the stapedius muscle, and the division of adhesions binding the foot-plate in the oval window. From the reading of this report there can be but little doubt that the membrane covering the oval window was punctured and a certain amount of perilymph allowed to escape. There was some improvement in the hearing and a diminution of the tinnitus, but more important than this, no severe symptoms followed. The same author,[47] at a later date, excised the membrana tympani, malleus, and incus, and mobilized the stapes in a case of complete closure of the Eustachian tube. While it had been demonstrated quite early that removal of the two larger ossicles was not a dangerous or difficult operation, but one which was frequently indicated in caries, and followed by good results, even when no suppuration had been present, yet it was not until several years later that these measures were practised to any extent. In 1885 Lucae[48] published an account of fifty-three operations in cases of sclerosis, and called attention to the necessity of excluding serious labyrinthine involvement by means of testing the hearing with a series of tuning-forks before holding out a hope of improvement from operative procedures. While Lucae's published results are not as favorable as might be wished, they certainly demonstrate the fact that in certain cases such operative procedures are in the highest degree beneficial, and warrant placing them among the legitimate means for improving otherwise hopeless cases.

In 1888 Sexton[49] reported a number of cases of chronic non-suppurative otitis media, in which excision of the membrana tympani, malleus, and incus had been beneficial.

The removal of the ossicles for the relief of chronic suppuration has been continually gaining ground, and thanks to the contributions of Kretschmann,[50] Stacke,[51] Ludewig,[52] Grunert,[53] and others, it is now looked upon as a recognized surgical procedure. All writers upon the subject of intra-tympanic operations, involving the removal of the ossicles, have until quite recently avoided interfering with the stapes, or at the most have recommended the division of adhesions about the ossicle, and subsequent mobilization by *brisement forcé*. Jack[54] and Blake[55] have, during the last year, demonstrated that the entire stapes may be removed without danger, and in many cases the result has been a decided improvement in the hearing. Both of these surgeons, as the outcome of experience, advocate the removal of the stapes for the improvement of the hearing in cases where the impair-

ment depends upon some lesion of the conducting mechanism, resulting from either suppurative or non-suppurative inflammation; the other ossicles are left *in situ*, unless carious. We have then to consider the following operative measures:

1. Removal of the malleus and incus.
2. Removal of the malleus, incus, and stapes.
3. Removal of the stapes (stapedectomy).

If the membrana tympani is present, this is also removed as completely as possible in performing the first two operations above enumerated, while in stapedectomy the membrane is left.

In cases where long-continued and uncontrollable suppuration exists, or is the sole cause for operative interference, the two larger ossicles will certainly require removal; the advisability of removing the stapes will depend upon conditions which will vary with the individual cases. If carious, the affected bone should certainly be removed; if healthy, the question of its removal will depend upon the condition of the hearing before the operation, and the probabilities of improving it by the excision of this ossicle, as indicated by the careful functional examination of the ear before the operation, and the amount of rigidity of the stapes, as determined by manipulation after the two larger ossicles have been removed.

When removal of any or all of the ossicles is to be practised for the improvement of the hearing,—the process which has given rise to the impairment having been either non-suppurative inflammation or a purulent inflammation which has ceased either spontaneously or as the result of treatment, leaving a rigidity of the conducting mechanism,—advice as to the propriety of operative interference is a matter of no little moment. In the first place the lesion must be located in the conducting apparatus by the tuning-fork tests already alluded to. It is not enough that the inspection of the ear reveals a pathological condition of the conducting mechanism. It must be proved that this is at present the cause of the defective audition, since secondary changes may have taken place in the labyrinth which place the case beyond all hope of improvement by any operation upon the conducting mechanism. Evidence of such involvement of the labyrinth can only be excluded by a careful functional examination, and the method which has served me the best purpose has already been given in the early part of this paper. Both Lucae and Kessel have called attention to the necessity of such an examination before undertaking operative interference for the purpose of improving audition, and the tests used by these observers are in the same line as those already described.

As to the choice of operation, much is to be said. In all the operative procedures previously described, the object has been to reduce weight or tension in the conducting apparatus, by the division of muscles, adhesions, ligaments, folds of the membrana tympani, etc., or to establish a communication with the middle ear by a permanent opening in the membrana tympani, thus admitting sound to the oval window more directly, this end being still further carried out, in certain cases, by disarticulation at the incudo-stapedial articulation. Each individual procedure has, in certain cases, been of undoubted benefit, and the lack of enthusiasm with which they have been viewed has been due to the fact that it has been impossible to declare positively that the rigidity was the result of a limited lesion, such as contraction of the tensor tympani, tension of the posterior fold or similar localized conditions, and experience has shown that the same pathological process which has caused any of these conditions, in the large majority of cases, has effected changes in other parts of the conducting apparatus as well, which would be uninfluenced by operations affecting one portion only of this mechanism. In other words, we can be pretty certain of rigidity of the conducting mechanism as a whole, but as yet cannot define the exact limits of the lesion. It seems rational, therefore, that removal of the membrana, malleus, and incus, by affording direct access of the sound waves to the oval window or head of the stapes, should meet the indication better, or that the evulsion of the stapes itself, by removing the effect of increased tension of the labyrinth caused by the binding down of the other structures within the tympanum, should be a rational method of procedure in cases demanding operative interference. When the two larger ossicula are excised, the operator usually endeavors to maintain a permanent opening into the tympanic cavity, while when the stapes alone is removed, this end is not aimed at; but if the membrana tympani is present every attempt should be made to restore it to its integrity after the operation.

While I do not favor criticism unsupported by personal experience, I cannot help feeling that the removal of the stapes alone, in cases where the membrana tympani is intact, the wound made by the operation being closed as quickly as possible, is not a commendable procedure. The two larger ossicles certainly perform no function, after removal of the stapes, while they certainly increase the probability of serious reaction following the procedure, since they aid in shutting off the atrium from the fornix tympani not only by their own presence but also by the preservation of the numerous folds of mucous membrane found in this region, which reduplications are obliterated by the removal of the two larger ossicula. Again, the presence of the membrana tympani itself must present a certain amount of obstruction to the entrance of waves of sound, while if the membrane, malleus, and incus are taken away, it will be possible, certainly in most if not all cases, to maintain a permanent opening into the tympanum. Still further, cases are met with in which complete anchylosis of the foot-plate of the stapes renders removal of the ossicle inadvisable or impossible, and the surgeon can only divide all adhesions about the foot-plate, in the hope of securing a slight amount of motion. In such an event it would certainly be of advantage to be able to divide, subsequently, any adhesions which might form during cicatrization, after the first operation. If the membrane and the two larger ossicles have been removed, access can be easily gained to the stapes without resort to general anæsthesia, even if the membrane has reformed, as the resulting cicatricial membrane is only slightly sensitive, and may be easily removed under local anæsthesia. More than this, by the obliteration of the folds of the mucous membrane lining the vault of the tympanum, no reaction follows repeated operative interference in these cases, and as these folds must, on account of their density, tend to reduce the amplitude of sonorous vibrations, their preservation cannot be urged for the purpose of improving the function of audition. The desirability of leaving the membrana tympani for the purpose of protecting the tympanum is not clearly proved, since the mucous lining of the middle ear, after exposure to the air for a short time, ceases to be sensitive, and secretes almost no fluid. If, however, the protecting influence of the membrana tympani is deemed important, this can be secured, even though the malleus and incus have been removed; for a large portion of the membrane may be left intact and made to adhere to the inner tympanic wall, thus affording a cutaneous covering, while at the same time access can be easily had to the oval window. That the operation of removing all of the ossicula is more prone to be followed by serious reaction than removal of the stapes alone, I am not prepared to admit. Certainly my experience has been that the reaction following the removal of the malleus and incus has been practically nothing. Stapedectomy, then, would be the operation of election in a case in which the stapes was easily accessible, but was bound so firmly by adhesions (due to a former otitis media purulenta) that disarticulation from the incus and the division of adhesions would produce no permanent effect, while at the same time the region of the stapes had been shut off from the other parts of the tympanic cavity by the previous inflammation. In such a case, removal of all of the ossicles would hardly be called for, while removal of the stapes would be simple, and the thin cicatrix would afford easy access to the region for the purpose of further operative procedures. In non-suppurative inflammation, if the portion of the drum membrane covering the stapes were very thin,

making it probable that, after removal of the ossicle, the flap of the membrane would fall inward and adhere to the tissues over the oval window, thus affording no barrier to the entrance of sound, here again stapedectomy might be chosen; it is also applicable to certain cases in which, for any reason, general anæsthesia is objectionable, the patient possessing sufficient self-control to permit of the operation being done under local anæsthesia. As before stated, the membrana tympani is often partially or completely anæsthetic, and, after an opening has been made into the middle ear, perfect local anæsthesia can be obtained by the introduction of a ten per cent. solution of cocaine. Much will here depend upon the command which the patient has over himself, and the operator is certainly working at a disadvantage, but special circumstances may make the trial advisable, the possibility of failure having been explained to the patient before the attempt is made. In all other cases, however, I believe it is much simpler to clear away the other structures first, and then to decide whether the stapes should be removed or left *in situ*.

The technique for the removal of the membrana tympani, malleus, and incus is the same whether the stapes is to be removed or left in position; hence, to describe both operations separately, would be but a repetition. I shall give, therefore, the steps for the removal of all the ossicula, the reader understanding that, in case the stapes is to remain, the steps to be carried out up to this point are exactly the same. The method of operating differs somewhat, in cases where the membrana tympani is intact, from that employed when it is partially or almost completely destroyed, and the technique in each will be given.

Technique of the Removal of the Membrana Tympani and the Ossicles when the Membrana Tympani is Intact.—With the sharp knife (Fig. 156, *F*) an incision is made through the membrana tympani in the upper and posterior quadrant, commencing just below the point where the posterior fold meets the tympanic ring, and, following this curve, is carried downward to about the middle of the posterior border of the ring. This incision is made close to the insertion of the membrana, but should lie entirely in the clear membrane, for the reason that if this is done no hemorrhage results. For the same reason care must be taken not to wound the inner wall of the tympanum with the point of the knife, as any bleeding greatly obscures the field of operation, and renders the succeeding steps more difficult. The edges of the incision are now separated, and the incudo-stapedial articulation is usually clearly and easily exposed. If sufficient space is not gained, a horizontal incision may be made from the upper extremity of the first, forward toward the short process of the malleus, the section following the course of the posterior fold, and lying just below it, thus avoiding the more vascular tissues. In this way a flap is formed, which, on being turned downward, enables the operator to see the incudo-stapedial articulation clearly. The next step is the division of the stapedius tendon; this may sometimes be seen, running from the neck of the stapes backward, disappearing behind the tympanic ring; frequently, however, the head of the stapes lies so close to this structure that the tendon cannot be seen; in such a case the pointed knife used in dividing the membrana tympani is inserted close to the head of the stapes, and slightly above it, and carried inward until the inner wall of the tympanum is reached; a short cut downward is then made, carrying the knife between the head of the stapes and the tympanic ring, while the point is still firmly pressed upon the inner wall of the tympanum. In this way the muscle is thoroughly divided. When the tendon can be seen, its division is perhaps more simple, but in either instance the point of the knife should be firmly pressed against the inner wall of the tympanum, in order that the tendon and any adhesions about it may be thoroughly and completely severed.

As soon as this has been done, the action of the tensor tympani will bring the incudo-stapedial articulation and the stapes more clearly into view. The next step is the division of the incudo-stapedial articulation, which is effected with the angular knife (Fig. 156, *C*). The knife, inserted into the handle in such a way that the point is directed backward, is carried into the tympanic cavity in front of the long arm of the incus, and the blade passed to the inner side of this process; by slight traction outward and pressure backward the instrument is made to hug the descending process of the incus, while, at the same time, the articulation is divided with a downward stroke. Any fibres of the capsular ligament which may have escaped division may be severed by inserting the point of the knife into the articulation from below, and sweeping the blade backward and forward. If fibres still remain undivided posteriorly, the angular knife is to be turned in an opposite direction, the point directed forward, when by passing it behind the long process of the incus, a downward stroke will complete the division.

If these steps have been carried out as indicated, it will be the exception if more than a drop of blood has been lost.

Next, with the pointed knife, a short, horizontal incision is made through the membrana tympani at its most dependent part, close to the insertion into the annulus tympanicus; the pointed knife is quickly laid aside and the probe-pointed knife (Fig. 156, *E*) is inserted, and the membrane is divided along its posterior periphery from below upward, until the exploratory incision is encountered. In the same manner the anterior segment of the membrane is divided from below upward with the probe-pointed knife, the incision extending as far as, but not into, Shrapnell's membrane. Up to this point no blood has been lost and the field of operation is as clear as when we started. There remains to be divided the membrana flaccida and the ligaments which bind the malleus externally, in front, and behind. The pointed knife is again used for this section, which should be made rapidly; the knife is held so that the flat surface of the blade looks toward the roof of the canal, the cutting edge being directed backward; the point of the knife is entered just above the short process of the malleus and is pushed inward and upward, the handle being depressed so that the shaft often touches the margin of the speculum. In this manner the knife is made to enter the fornix tympani; it is now made to cut its way out, downward and backward, thus severing the external and posterior ligaments of the malleus and dividing the membrana flaccida posteriorly. The knife is then quickly turned and made to cut in the opposite direction, being carried forward over the short process, dividing the anterior segment of the membrana flaccida, some fibres of the external ligament, and the strong anterior ligament of the malleus. The malleus is now held only by the superior ligament and the tendon of the tensor tympani, neither of which is strong. The hemorrhage from the last incision may be free, and may obscure the field, but, usually, owing to the elevated position of the head, the upper part of the field is not obscured, and the short process of the malleus can be distinctly seen. The ossicle is quickly grasped, just below the short process, with the forceps (Fig. 157), and by pressure inward to dislodge the neck of the bone from the projection on which it rests, followed by traction downward and then outward, the ossicle is extracted; no force is required to rupture the tendon of the tensor tympani or the superior ligament, as they offer very little resistance.

It will be necessary now to wipe out the blood which has followed the removal of the malleus, but in most cases a single pledget of cotton will dry the cavity completely. The incus is next sought for, and, if in sight, is grasped with the forceps and removed, traction being exerted at first downward and then outward. Most frequently when the incus is in view, the long process will be seen, not in the normal location but lower down, and lying close to the border of the tympanic ring, so close, frequently, that it is easily overlooked, apparently constituting a part of the ring. Manipulation by means of a probe reveals its identity, and the ossicle can be extracted in the manner already described. This displacement of the incus downward and backward is due to the fact that in the removal of the malleus the capsu-

lar ligament binding the two ossicles together must be ruptured. The incus itself is attached to the tympanic wall simply by means of a single ligament running from the short process of the incus to the wall of the fornix tympani. Traction downward on the malleus displaces the incus downward and also revolves it backward, the short process being the fixed point. Thus, frequently, after the malleus has been removed, careful inspection of the field of operation fails to reveal any trace of the incus, it having been rotated entirely out of sight behind the tympanic ring. To effect its extraction is not always easy, and yet in cases where there has been no suppuration it will rarely happen that the ossicle will escape. When not in sight, the long process of the incus can be easily brought into view by means of the incus hooks (Fig. 156, *H*). These hooks are curved in opposite directions for the right and left ear, the concavity of the curve looking anteriorly in each case when the instrument is inserted into the handle with its angular extremity directed upward. The incus hook is passed into the tympanic cavity, and the angular portion passed behind the tympanic ring close to the floor of the canal, the hook being inserted in such a way that the concavity of the hook looks upward. When the angular portion of the instrument has entirely disappeared behind the ring, the instrument is drawn outward until it is felt to press closely upon the inner surface of the tympanic ring, when it is rotated forward, at the same time being carried a little upward. Usually this manipulation swings the long arm of the incus into view. The difficulty sometimes met with in securing the incus usually lies in the fact that the operator is inclined to search for the ossicle too high up in the tympanum and to forget that the long process lies close to the margin of the ring; the hook is, therefore, frequently carried too deeply into the tympanic cavity and fails to engage the long process. This manœuvre is to be repeated several times in case the first effort is not successful. If no free body is felt with the hook posteriorly, it is then inserted into the tympanum, at the anterior inferior portion, with the curve of the hook directed posteriorly; the hook is now rotated, sweeping the extremity which hugs the tympanic ring closely, backward, and at the same time carrying the instrument somewhat upward. This manipulation will bring the incus into view in case the posterior ligament of the incus was ruptured during the removal of the malleus, allowing the ossicle to fall into the lower part of the tympanic cavity, an event which may sometimes happen.

If the ossicle is not found in either of these situations the hook should be swept upward and forward through the postero-superior and superior portions of the tympanic cavity, keeping it still pressed firmly against the internal margin of the ring. Care is to be taken in this manipulation that the hook does not pass between the crura of the stapes or fracture them as it is carried forward. If the ossicle still remains hidden, the hook having the opposite curve should now be used, being carried into the fornix tympani, with the concavity directed backward, the angular portion of the instrument being hooked behind the inner extremity of the superior wall of the meatus; the instrument is now rotated backward, and at the same time is carried downward, rotation being continued through an angle of 180°. The object of this manipulation is to dislodge the incus, in cases where its posterior ligament is very strong, or where the long process has been rotated far backward out of reach of the hook. After this downward sweep it is well to repeat all of the steps for dislodging the incus in the order named, as this last manipulation may displace the ossicle downward, although it may still remain hidden from view. The objection to beginning the search in the manner last mentioned lies in the fact that if the ossicle is already free, or nearly so, the manipulation is apt to displace it so far toward the mastoid antrum as to render it entirely inaccessible. I have written upon the method of extracting this ossicle somewhat at length, because I believe it to be extremely important to remove it if this be possible, and I feel certain that the advantages gained in its extraction are more than enough to warrant prolonging the operation for this purpose.

After the incus has been removed the cavity is thoroughly dried, and the region of the round window inspected. Any thickening in this situation should be overcome by cutting away the hypertrophied tissue, if present in sufficient amount to permit of this. Usually, however, we find simply a thickening of the mucous membrane about the fenestra. Stellate incision of this thickened tissue, by means of the angular knife (Fig. 156, *B*), most frequently relieves the tension.

The stapes is next inspected and its mobility tested. If rigid, all adhesions about it should be divided; if its motion is now free, the operation may be considered completed. If, on the other hand, the motion of the stapes is still impeded, or if the adhesions have been found so extensive that, after these have been divided, cicatrization will probably render the ossicle rigid again, the stapes should be removed. All soft tissues binding it down should be carefully severed with the sharp knife passed around the foot-plate, after which a delicate hook is passed between the crura and the ossicle is removed by traction. It is often more easy to grasp the head of the bone with the forceps, and remove it in this way than by making use of the hook.

In cases where difficulty is experienced in finding the incus, and it is deemed necessary to remove the stapes, this ossicle being easily seen, it is often wise not to delay the removal of the stapes until the incus is found, since in the manipulations necessary to displace the incus the crura of the stapes might be accidentally broken, or the head of the bone be so displaced as not to be easily seen. Hence, if the incus is not readily found, the stapes may be removed as the second step of the operation, and the incus subsequently searched for. If the stapes is removed at this stage of the procedure, care must be taken in searching for the incus that the incus hook is not passed through the oval window, thus injuring the labyrinth. This may seem a needless precaution, but any one who has studied the parts upon the cadaver will appreciate how easily the incus hook could be passed through the thin membrane covering the fenestra ovalis. The reason of this lies in the fact that the plane of the oval window is not vertical, but inclined downward and outward. When this opening is situated high up, and is almost hidden by the tympanic ring, the incus hook may be easily carried under its upper margin and through the membrane covering the opening, the operator mistaking the resistance offered for that of the tympanic ring. If the posterior wall of the canal is closely followed, and the incus hook made to enter the tympanum low down, and it is made afterward to hug the tympanic ring closely, this accident cannot occur.

In some instances the margin of the tympanic ring hides the stapes so completely that this ossicle can hardly be seen, and it is impossible to form an intelligent opinion as to its condition, or to effect its removal. In such an event the margins of the ring in this situation may be cut away by means of the forceps shown in Fig. 159. These forceps are so constructed that when open the distal extremity of the lower blade can be passed up behind the tympanic ring. Upon closing the instrument the chisel blade cuts away a small chip from the overhanging wall. By repeating this procedure, enough space can be gained to permit of access to the stapes and oval window.

Occasionally the foot-plate of the stapes will be found to be so firmly fixed in the oval window that it cannot be loosened, and that after dividing all adhesions its removal is impossible, the crura sometimes being broken in the attempt at extraction. In such an event the operator should proceed with the greatest caution. All the soft tissues should be carefully removed from the oval niche by means of the short angular knife (Fig. 156, *B*) and a delicate curette. If the outline of the foot-plate can now be made out, a pointed knife should be carried around its periphery, in the hope of making an opening at some point where the union is less firm; through such

an opening a delicate hook can be introduced and a part at least of the foot-plate brought away. If complete ossification has taken place, I should advise the cautious use of a small guarded drill, which might be made to perforate the foot-plate at its centre, after which portions might be removed with the hook. I have never had occasion to do this upon the living subject, but should not hesitate to do so, using, of course, great care; it would be possible to carry out this step without evacuating the perilymph, but even if a small quantity of the fluid should be lost, Kessel's [66] observations have proved that no harm results.

After all the operative steps deemed necessary have been carried out, the cavity is to be dried with pledgets of cotton, and a tampon of iodoform gauze introduced. This is packed rather firmly into the tympanum, while the canal is but loosely filled. The object of the gauze is to check any oozing which may occur, and prevent the formation of a blood-clot within the middle ear, for if this is allowed to form it may give rise to considerable pain, by preventing the escape of secretion during the first days after the operation, at which time its removal is apt to be somewhat painful. A few hours after the operation, this tampon is removed, and the ear douched with a warm weak antiseptic solution, such as a saturated solution of boric acid, or a solution of bichloride of mercury, 1 to 8,000, after which the tampon is reinserted. When the odor of iodoform is objectionable, sterilized or borated gauze

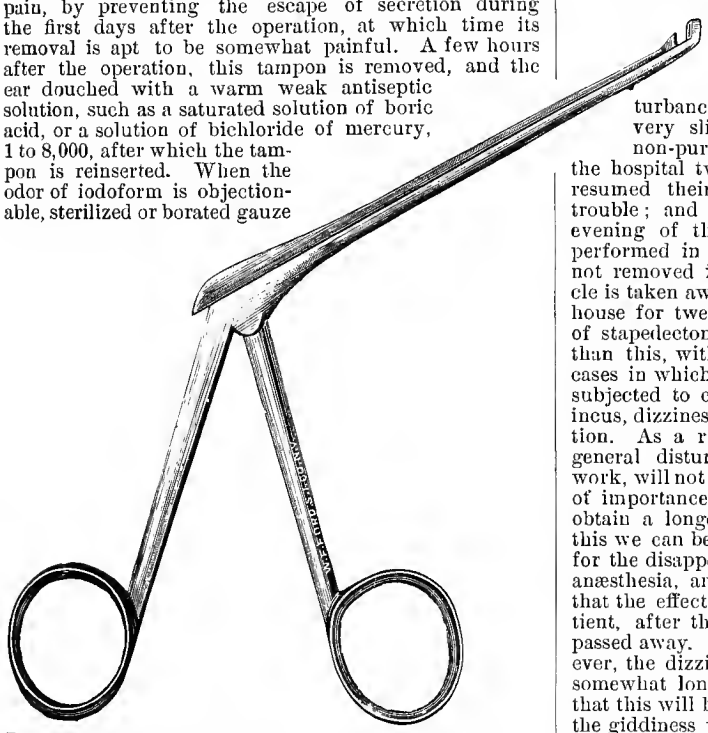


Fig. 159.—Cutting Forceps for the Removal of a Portion of the Inner Extremity of the External Auditory Canal.

may be used. This second tampon is allowed to remain for from twelve to twenty-four hours. The subsequent treatment depends upon the amount of local reaction following the procedure. If there is but little discharge, the cleansing of the ear once daily by the surgeon, followed by the insufflation of boric acid, dermatol, or some kindred powder, will be all that is necessary. If the patient cannot be seen daily, as is usually the case in dispensary practice, gentle syringing of the ear once or twice daily, according to the amount of discharge, is all that will be required, and I have never thought it wise to trust the insufflation of any powder to the patient. When the discharge is only slight, even the syringing is objectionable, and an intelligent patient may be allowed to cleanse the ear, by simply wiping it out with a pledget of cotton wound upon an appropriate cotton-holder. On the other hand, if at the end of a week there is still considerable secretion, the patient is directed to instil a few drops of a solution of boric acid in alcohol, of a strength of twenty grains to the ounce, after each syringing. The amount of discharge after the operation will depend upon the habit of the patient, and also upon the condition of the mucous membrane of the tympanum. In cases of advanced sclerosis, the amount is frequently insignificant, especially if the patient is not of a full habit. On the other hand, when the tympanic cavity or the fornix tympani has been full of connective tissue rich in blood-vessels, the discharge following the operation will be more profuse. It is probable, also, that prolonged manipulation within the cavity at the time of the operation, favors a more profuse discharge, although this is certainly not so in all cases, and should not deter the operator from doing a deliberate and thorough operation.

I have written somewhat at length about the management of the cases after operation, because I consider this an important point. In a general way, the less that is done after the operation, the more likely we are to obtain a permanent opening into the tympanic cavity, a condition always to be desired. Hence, the aim should be to keep the ear clean with as little manipulation as possible, and to avoid the use of astringents or caustics to stop the discharge, since they will certainly promote the reformation of the tympanic membrane.

With reference to the amount of disturbance caused by the above procedure, this is very slight. In forty cases, both purulent and non-purulent, all, with the exception of five, left the hospital twenty-four hours after the operation, and resumed their regular daily work without the least trouble; and quite a number returned home upon the evening of the same day, the operation having been performed in the afternoon. Of course the stapes was not removed in all of these cases, and when the ossicle is taken away, I prefer to confine the patients to the house for twenty-four hours at least; yet in three cases of stapedectomy the patients returned home in less time than this, without any unpleasant effects, while in two cases in which this ossicle was left *in situ*, but had been subjected to considerable manipulation in securing the incus, dizziness persisted for several days after the operation. As a rule, the patient can be assured that any general disturbance, sufficient to incapacitate him for work, will not last more than twenty-four hours, an item of importance among those who find it impossible to obtain a longer respite from their daily vocation. Of this we can be as certain as in allotting the same period for the disappearance of the unpleasant effect of general anæsthesia, and the surgeon is justified in promising that the effects of the operation will not detain the patient, after the disturbance due to the anæsthetic has passed away. When the stapes is to be removed, however, the dizziness may make locomotion difficult for a somewhat longer period, and if there is a probability that this will be necessary, it is not wise to promise that the giddiness will not interfere with locomotion for several days, although in quite as many cases the reverse has been true. If the malleus and incus alone are removed it will be decidedly rare for any such disturbance to follow.

Pain or severe local inflammation I have never met with as the result of these operations, for the reason, I believe, that such perfect drainage exists that no retention of secretion is possible. In this respect I feel certain that the complete removal of the ossicles and membrane commends itself, when compared with some of the intratympanic operations, in which less apparent violence is done, but in which free drainage is not secured.

As regards the partial or complete reproduction of the membrana tympani, my experience has been that, as a rule, the membrane will reform, although this is not always the case. For dealing with this result the removal of the two larger ossicles is of great advantage. The membrane which reforms is usually thin, and not as sensitive as the normal membrane, and its removal is but a trivial matter, both for the patient and surgeon. Again, its reproduction does not always impair the result of the operation. In cases, however, in which, after the membrane has been reproduced, the hearing becomes

worse than while a perforation was present, it should be removed. General anæsthesia, in my experience, has never been necessary; a pledget of cotton smeared with a ten per cent. ointment of cocaine in lanolin, renders the membrane sufficiently anæsthetic for incision; after which a drop of a ten per cent. aqueous solution of cocaine, introduced into the tympanic cavity, renders the remainder of the operation painless. The operation is best performed by passing the straight knife (Fig. 156, *F*) through the membrane close to the tympanic ring and just above the head of the stapes, and dividing the posterior attachment of the membrane close to the ring for a short distance, great care being taken not to wound the mucous membrane of the tympanum. The probe-pointed knife should then be substituted, and the attachment followed downward to its lowest point. It will then be found that the tissue is so relaxed that division of the anterior attachment is difficult; to overcome this, the sharp knife is again passed through the membrane at its upper part, just in front of the original puncture. A little pain is usually experienced from the incision, but it is only momentary. The anterior attachment is now divided downward with the blunt knife, until the incision meets that which severed the posterior attachment. Usually the relaxation interferes with the complete section. The membrane is now held by a thin strip of tissue above and below. A touch with the sharp knife severs these attachments, or weakens them to such an extent that the entire membrane can be easily removed with the forceps. The procedure is so simple that if attention is given to the aseptic condition of instruments and field of operation, no reaction results. The operation may be performed safely at the office of the physician, and the patient at once allowed to resume his usual duties. It is well to protect the ear by the insertion of a cotton pledget, which need not be worn for more than twenty-four hours after the removal of the new membrane. The patient should be cautioned to guard against taking cold, but, further than this, no special precautions are necessary. The procedure is not likely to be followed by any discharge, and all syringing of the ear is to be avoided, unless pain or profuse discharge supervene, as disturbing the parts in any way may excite enough reaction to cause a reproduction of the membrane.

One point is worthy of special attention, and that is, that the removal of a membrane which has formed after operation should not be undertaken until all traces of inflammation have disappeared. The surgeon must wait until the newly formed tissue is pearly white and glistening, and until the mucous lining of the tympanum has also assumed its normal condition, as evidenced by the absence of redness, engorgement of its vessels being easily made out through the thin cicatricial membrane. If this rule is not observed the operation will be more painful, and reproduction is almost certain. If the membrane reform again, a second or third removal is still more simple, as the density of the tissue is less each time that it is reproduced. In one case this was so marked that after the first incision the edges of the wound retracted so widely that it was possible to remove only a minute portion of the new-formed tissue, and yet the tympanum was freely exposed, and no reproduction has followed at the end of several months.

In plethoric individuals a persistent reproduction of the membrana tympani after excision can be prevented by a restriction of the diet for a few weeks previous to and following the secondary removal of the structure. This is suggested by Sexton,* and I have proved its efficacy.

In certain instances it may be found that the new membrane has become adherent to the inner wall of the tympanum, thus rendering its complete removal difficult. In one such case, in which the stapes had been left *in situ*, the hearing remaining impaired, apparently on account of the stapes being bound down by the newly formed membrane, this structure was divided first behind the head of the stapes and the incision carried downward close to the tympanic ring for a distance equal to about one-third its posterior margin. The stapes then lay free while in front there was a flap, attached by adhesions to the inner tympanic wall; this flap was turned forward and the underlying wall of the tympanum was scarified, after which the flap was replaced and pushed down upon the wall of the middle ear, care being taken that the free margin lay below the tympanic ring. Adhesion at once resulted, leaving the stapes projecting into the canal, while the tympanic cavity was largely obliterated from the adhesion of the membrana to its inner wall. Thus the middle ear was thoroughly protected by a cutaneous covering, while the parts essential to audition remained accessible for further operative procedure. The patient, though better, is still under treatment, and I hope for still further improvement following the division of remaining bands which bind the stapes. It may be advisable in certain cases to preserve the anterior portion of the membrana tympani in removing the malleus and incus, and, after scarification of the inner wall of the tympanum, to attempt to secure adhesion of the anterior segment of the membrana to this. In this manner we might shut off the anterior part of the tympanic cavity from the posterior portion, which contains the structures concerned in audition. The posterior portion would in this manner become covered by epithelium from the surface of the membrana tympani, and the objection of having an exposed mucous surface would be avoided. In this manner we could by care secure a thin epithelial covering for the round and oval windows, the stapes being removed, or not, according to indications. I have never performed the operation with this object in view, but from the fact that nature occasionally succeeds in doing this unaided, it may not be out of place to suggest it here as worthy of trial.

Technique of Operation where the Membrane is Partially or Almost Completely Destroyed.—When a purulent inflammation has resulted in the destruction of a considerable portion of the membrana tympani, the method of procedure must be to a certain extent modified. In some of these cases we shall find the lower portion of the membrana wanting, the membrana flaccida thickened and highly vascular, binding the ossicles down and concealing them more or less completely; we may be able to recognize by inspection only the prominent short process of the malleus and a portion of the manubrium, the latter lying almost horizontal, its tip bound firmly to the upper part of the inner tympanic wall. Behind the short process examination with the probe reveals the incus and stapes as present, but whether in their entirety or not cannot be determined. In other cases, while there may have been extensive destruction of the membrana tympani, the posterior superior segment is covered with a thin cicatricial membrane through which the incudo-stapedial articulation is plainly seen, or this joint may be completely exposed, no covering being present. My rule has been in all cases where the incudo-stapedial articulation is visible, or where this region is covered by a non-vascular membrane whose division will not lead to annoying hemorrhage, to first divide the stapedius muscle and then the incudo-stapedial articulation, in the manner described when considering the method of operation in cases in which the membrana tympani is intact. When, however, it is evident that an incision in this region will be followed by hemorrhage, such a step only serves to complicate the operation, as the bleeding will render it impossible to see the incudo-stapedial articulation and divide it with certainty, and will frequently completely obscure the field of operation and hide even that most prominent and important landmark, the short process of the malleus, and considerable difficulty may be experienced in removing this ossicle even. Experience shows us that when this condition exists there is very little hemorrhage after the membrana flaccida has been completely freed from its attachments and removed, together with the malleus. Our first step, then, must be to insert the straight pointed knife above the short process, pushing it inward and

* The Ear and Its Diseases, New York, 1889, p. 392.

Ear Operations.

upward until the inner wall of the tympanum is encountered, where it is made to divide rapidly the attachments of the remnant of membrane to the tympanic ring by directing its edge backward and incising close to the margin of the ring, and then, without removing it from the wound, to turn the edge in the opposite direction and divide the anterior attachments. In cutting backward the operator must bear in mind that the incudo-stapedial articulation has not been severed, and in this region as little force as possible should be used; for this reason also the posterior incision should be first made as above directed. Almost immediately the fundus of the canal fills with blood, but for a few seconds at least the short process is plainly visible, and if examination has shown us that the manubrium is not firmly bound to the promontory, the malleus is at once seized with the forceps just below the short process and removed in the manner already described. If, however, firm adhesions are known to exist, or if the malleus is found to be firmly fixed upon grasping it with the forceps, no force should be used to effect its removal, but the canal should at once be tamponed firmly with cotton by carrying an elongated plug to the tympanic cavity with the forceps and pressing it firmly upon the tympanic wall, the remainder of the plug being then forced inward. Upon this tampon a second and third are crowded until there is no bleeding about the plugs. If held in position for a few moments and then removed with the forceps, the field of operation will be found to be dry, the bleeding having been entirely checked. Any given area can be more completely cleansed by touching it with a small pledget wound upon a cotton-holder. The adhesions binding the malleus to the promontory can now be divided with the blunt knife curved on the flat (Fig. 156, *D*), after which the ossicle is removed by means of the forceps. If the malleus is still firmly fixed, manipulation by means of the probe will determine the situation of the undivided attachments, and their section can be effected.

When it has been possible to divide the incudo-stapedial articulation as the initial step, I frequently remove the malleus in the manner above described as the second step of the operation, in place of first freeing the remnant of the membrane from its peripheral attachments below, anteriorly, and posteriorly; this, of course, applies to cases in which the greater portion of the tympanic membrane has been destroyed. When only a comparatively small portion of the membrana vibrans is wanting and excision is deemed proper, it may be well, after dividing the incudo-stapedial articulation, to sever the peripheral attachments of the membrane from below upward, by means of a blunt knife introduced through the perforation. As a rule, however, so many adhesions exist between the inner tympanic wall and the lower portion of the membrana that such a procedure is unadvisable; moreover, the parts are frequently so vascular that the attendant bleeding may complicate the more important part of the procedure—the division of the superior attachments and the removal of the malleus. It is usually wiser, in these cases, to divide the upper segment first, the knife being carried into the perforation in terminating the posterior and anterior incisions.

It may seem hazardous to subject the stapes to the possibilities of violence attendant upon removal of the malleus before the incudo-stapedial articulation has been divided. A moment's reflection will convince one, however, that the increased formation of connective tissue which renders the procedure necessary also fixes the stapes so firmly that intelligent manipulation can scarcely displace it, while the danger of inflicting such an injury is much greater if an attempt is made to divide the articulation with the field of operation partially obscured by blood. Again, it frequently happens that the long process of the incus has become necrotic, and the articulation destroyed, so that no connection between the two ossicula exists.

After the malleus has been removed, the stapedius muscle and incudo-stapedial articulation should be sought for and divided, unless this step has already been performed, after which the incus is sought for in the manner already fully described. It should be remembered that as caries more frequently attacks the incus than any other ossicle, it may be partially or completely destroyed. In the former case its removal is often difficult, while it is important to determine with certainty the latter condition, to avoid overlooking it if present, or a prolonged search if it is absent. It should also be borne in mind that the pathological process may have resulted in a bony union between the incus and malleus, and that both ossicles may be extracted together. In case both ossicles were intact, the operator could not overlook such an occurrence, but when one or both have been partially destroyed, careful inspection of the portions removed may be necessary, to determine simultaneous removal of the malleus and incus. The operator should then, upon extracting what he supposes to be the malleus, carefully examine it, in order to assure himself that the body of the incus is not attached thereto. If nothing but the malleus is found, the field of operation should be dried and inspected carefully. If no portion of the ossicle is seen, special attention should next be given to the posterior-superior segment of the field. It sometimes happens that the incision has not been close to the tympanic ring in this region, a circumstance not easily recognized unless the parts are touched with the probe, when it will be found that a small curtain, or flap, of tissue remains undivided. A destruction of a small part of the ring at this point, as the result of caries, also gives rise to a similar appearance. It quite frequently happens that the incus is adherent to this flap, or completely concealed by it; division of the soft parts close to the bony margin will, in such a case, bring the incus into view. If not found in this situation, the ossicle must be searched for with the incus-hook, in the manner already described while considering cases with intact membrana tympani. If all of these manipulations fail to bring the incus into view, or if it has not been felt, and the incus-hook can be carried freely, from behind forward, through the vault of the tympanum, the operator may decide that the ossicle has been destroyed by caries, or that it has suffered partial destruction, and the remaining portion has become amalgamated with the tympanic roof. If, however, it has been seen or felt at any time, its subsequent loss will mean dislocation into the mastoid antrum.

The management of the stapes and the region of the round window is conducted in the manner already described.

Any parts of the membrana tympani which may remain in the lower portion of the fundus are to be removed with the knife and forceps if they are the seat of an hypertrophic process, as evidenced by considerable thickening and increased vascularity, as they may conceal areas of bony necrosis. If, however, the appearance of the lower portion of the membrane is healthy, we may feel certain that the bony structures are unaffected, and that there is no indication for the removal of the lower portion of the membrane; in fact, its presence will hasten cicatrization.

After drying the tympanum thoroughly we should next search for softened bone, both by inspection, which will often reveal here and there unhealthy granulation tissue indicative of the presence of dead bone, and with the probe, which should be made to explore thoroughly the entire inner wall of the tympanum, and should also be bent at a right angle at the tip, to enable the surgeon to thoroughly explore the tympanic vault. The curette should then be freely used, and all granulation tissue and softened bone should be removed. For the atrium, the straight curette (Fig. 156, *A*) will be found serviceable, but for the vault the sharp spoons, bent at a right angle (Fig. 156, *G*), must be called into requisition. This procedure of thoroughly removing and curetting the entire cavity is of the greatest importance, and should be conducted with special care, as the ultimate success of the operation often depends quite as much upon this step as upon the removal of the ossicles. An area of softened bone in the vault of the tympanum will keep up the discharge for a long time, and render the result of the opera-

tion far from satisfactory. Hence quite as much attention should be given to this procedure as to the removal of the ossicula. After the bony walls of the tympanum have been thoroughly curetted, the margins of the tympanic ring should receive attention. It frequently happens, when long-continued suppuration has existed, that the margin of the ring becomes involved. This is particularly true of the superior and postero-superior margin, on account of its intimate relation to the ossicula, and because it is the floor of a portion of the vault of the tympanum. Any roughness or softening in this region should be dealt with in the same manner as in the case of a similar condition in other portions of the tympanum ; all diseased areas should be removed with the curette, and a portion of the margin may be excised with the cutting forceps if necessary.

After all these steps have been carried out, the treatment of the case for the first few days does not differ from the after-treatment of cases in which the membrana tympani was originally intact. The subsequent treatment, however, must vary with each individual case. While the discharge continues profuse, the ear must be cleansed with the syringe and mild antiseptic solution in the hands of the patient twice daily, or more frequently if this is necessary to keep the parts clean. At the end of a week, if there is considerable discharge, I recommend the instillation of the solution of boric acid in alcohol twice daily, after thorough cleansing. Any granulation tissue must be destroyed as it appears, by means of chromic acid, silver nitrate, the actual cautery, or any other destructive agent. If it is found that all carious bone has not been removed, lactic acid, applied by means of a cotton-tipped probe to the affected areas, is frequently sufficient to determine the formation of healthy granulation tissue, and effect complete cicatrization. The concentrated acid should be used, and should be thoroughly rubbed into the tissues. As the discharge becomes almost *nil*, the syringe may be dispensed with, and the patient allowed to cleanse the ear by means of pledgets of cotton wound upon any convenient probe, while the surgeon may once or twice weekly insufflate a small quantity of boric acid, dermatol, or other mild antiseptic or stimulating powders, until all discharge ceases. It has been my good fortune, in all such cases, to either stop the discharge completely or to diminish it so much that it has ceased to be a source of annoyance. The length of time which must elapse after the operation, before the discharge will completely cease, must vary with each case, depending upon the extent of the original involvement. In general, from six to eight weeks will probably be the average time ; in some cases cicatrization may be perfect at the end of two or three weeks, while in others the same number of months must elapse.

The technique given above varies in some particulars from that advocated by other operators.

In the division of the incudo-stapedial articulation the ordinary direction is to enter the knife behind the long arm of the incus and divide the articulation by cutting downward and forward. Those who advocate this plan of procedure say that the pressure of the instrument is then opposed by the action of the stapedius muscle, and danger of injury to the stapes is avoided, while at the same time the resistance of the stapedius renders the division more easy. My own preference is to completely sever the stapedius tendon before attempting to disarticulate, as by this means the articulation is brought more perfectly into view by the action of the tensor tympani and tense ligamentous bands located anteriorly. If the stapedius muscle is not completely divided as the initial step, the stapes, after disarticulation, is frequently pulled out of sight behind the margin of the tympanic ring. After division of the stapedius, disarticulation by the above method may dislocate the stapes, although this is not likely to occur. It is often difficult, however, to insert the knife between the tympanic ring and the long arm of the incus, and for this reason I prefer the method given in my description of the technique of the procedure—that is, to pass the angular knife in front of the long arm of the incus, and open the articulation by cutting downward and backward against the pull of the tensor tympani ; or to open the joint at its lower aspect, and then to sweep the knife through it by carrying it backward and forward. By either of these methods the joint is more easily opened than when an attempt is made to carry the angular blade behind the long process of the incus, which frequently lies so close to the tympanic margin that considerable violence must be used in introducing the knife.

In removing the incus Kretschmann,[57] who was the first to formulate the procedure for removing this ossicle, made use of a hook which, in addition to the curve shown in Fig. 156, *H*, was bent outward at the distal extremity, so that when the instrument was in position, the tip rested upon that small shelf-like structure of the superior wall of the canal which affords lodgement for the incus. He introduced the instrument with the concavity directed backward and brought the incus into view by rotation backward and traction downward. While this manipulation is no doubt of great value in certain cases, the backward rotation seems more likely to carry the ossicle far out of reach toward the mastoid antrum, in case it is not secured at once, and the manipulation of attempting to bring the long process into view by passing a hook behind it and rotating forward, has in my hands proved very satisfactory, while it certainly lessens the danger of displacing the ossicle far backward.

The teaching that it is not advisable to make a prolonged search for the incus, seems to me to be unwise. In non-suppurative cases careful manipulation will render failure to secure it exceedingly rare. If it has not been displaced, it must occupy its original position, and failure to bring the long process into the field of vision will render it impossible for the operator to be certain of a complete division of the incudo-stapedial articulation ; or if the head of the stapes is seen lying free in the field it is certain that the incus has been displaced, and, by acting as a foreign body, may give rise to trouble if allowed to remain. If the long process is in view there is no difficulty in removing the ossicle.

In purulent cases it is still more important that the ossicle should be removed. Ludewig[58] found the incus carious in eighty-five per cent. of the cases upon which he operated ; in my own twenty-nine cases of purulent otitis, the ossicle was carious in nineteen, while in eight it had been completely destroyed. Prolonged manipulation in searching for the ossicle has not, in my hands, in any way added to the reaction following the procedure, nor has it interfered with the results. I should therefore earnestly advise prolonging the operation for the purpose of securing the incus rather than to perform a rapid operation and fail in its removal.

Among the complications which may interfere with the operation, hemorrhage is the one upon which especial emphasis is laid. Since I have operated with the patient in the semi-recumbent position, rather than with the head low, annoying hemorrhage has been the exception, rather than the rule. If it is sufficient in amount to interfere with the manipulation, it can always be checked by tamponing the canal firmly with cotton pledgets. It is important, in executing this manœuvre, that the first pledget of cotton should be carried well into the tympanic cavity, and also that the individual pledgets should not be too large, as upon withdrawing a large tampon, the force necessary for its removal is likely to lead to a recurrence of the hemorrhage. This objection is overcome if a number of small plugs are used instead of a few larger ones. It may be necessary to repeat the tamponing several times, but it will certainly effect its purpose if a little patience is exercised. A ten per cent. solution of cocaine is said to be useful in checking a slight oozing, but I have never had occasion to use it. Schmiegelow[59] has reported one case in which the hemorrhage following an attempt to excise the malleus was so severe that he was obliged to discontinue the attempt.

My own experience with intra-tympanic operations, more especially the particular class now under discussion, has led me to consider them remarkably free from risk. It is possible, however, for unpleasant sequelæ to

follow such procedures. Among these the most important are injury to the facial nerve, deafness due to impaction of the stapes into the oval window, injury to the labyrinth from accidental removal of the stapes, either by direct traumatism, or by infection, etc., and inflammation of the mastoid process.

The facial nerve is occasionally injured by the incus-hook. The cause of this accident is to be found either in a congenital defect in the Fallopian canal, or in the partial or complete destruction of its wall as the result of disease. With the exercise of a little care in manipulating the incus-hook, bearing in mind that great force is not necessary to displace the ossicle, the accident can usually be avoided. If the facial nerve is touched by the instrument, the twitching of the face immediately warns the operator of what has occurred, and subsequent caution will prevent serious injury. In one of my own cases, twitching of the face was noticed while attempting to locate the incus, and upon recovery from anæsthesia there was marked paresis of the corresponding side of the face; the facial nerve had been slightly involved before the operation, but after this the signs were much more pronounced. Daily faradization for about ten days was followed by complete recovery. Facial paralysis consecutive to a similar operation also occurred in a case reported by Ludewig.[60]

Complete loss of hearing following removal of the ossicles has occasionally occurred. In a case reported by Buck[61] the operator believed that the stapes had been impacted in the oval window during the operation. In one of Ludewig's[62] cases the stapes was accidentally removed and the hearing was entirely lost, while Wurdemann[63] reports a case of excision of the mallens in a patient about sixty years of age, in whom total deafness followed the procedure. The stapes was not interfered with in this case, and as there was persistent vomiting upon recovery from the anæsthetic, it is supposed that this led to a labyrinthine hemorrhage causing a complete loss of the power of audition. It seems manifestly unfair to record this as due to the operation, as the same accident might happen after anæsthesia for any other purpose. As far as accidental removal of the stapes is concerned, I cannot understand how it could have resulted in the total loss of the power of audition in Ludewig's case. The author expressly states that there was no evidence of purulent inflammation of the labyrinth from infection, and if this can be excluded, the only other event possible would have been direct injury of the labyrinth after the removal of the ossicle, which at the hand of so experienced an operator as Ludewig cannot be thought of. We know, furthermore, that the removal of the stapes alone is not followed by impairment of the hearing, even if considerable perilymph is lost. I am induced to class this case as one in which the result can hardly be attributed to the operation.

I have twice removed the stapes unintentionally: once, when there was ossification of the incudo-stapedial joint, the incus-hook removed the stapes, the incus being subsequently secured; in a second case, no force being used, the incus-hook, swept upward and forward, brought away the stapes, which upon examination proved to be necrotic. As no force was used here, I believe that the stapes had already been detached from the fenestra ovalis by long-continued suppuration. In both the above cases the hearing was not impaired, and in one it was improved.

With reference to severe mastoid inflammation as a sequel to the operation, Randall[64] reports a case in which this occurred; the observer remarks that the mastoid empyema may have been the result of an attack of influenza, which was almost epidemic at the time, but is inclined to believe that as the incus was not found during the operation it had been displaced toward the mastoid antrum, and by obstructing the escape of secretion gave rise to the mischief. That such accidents must occasionally happen no one can deny, but that they are very rare, so rare in fact that they can almost be looked upon as curiosities, is also true. This case also adds weight to the opinion already expressed as to the importance of removing the incus. Among my own cases there has not been a single instance in which unpleasant symptoms have followed the operation, with the single exception of giddiness, and this has been severe in five cases only.

My own operations of excision of the ossicles now number forty. In eleven cases the membrana tympani was intact, and of these two had previously suffered from purulent inflammation of the middle ear, ending in complete recovery. In ten instances the operation was done for the improvement of the hearing, being performed once for the relief of tinnitus, although the hearing was considerably impaired. In ten of these cases the mallens and incus were removed and all adhesions divided. In one case the incus was not found. Of this number great improvement followed in six cases, moderate improvement in four cases, while in the case in which the operation was performed for the relief of tinnitus, the hearing was not improved and the tinnitus was not relieved.

Of the cases much improved, in three a permanent perforation remained as the ultimate result of operation, although in two it was necessary to perform secondary operations under cocaine anæsthesia to secure this. In two the membrana tympani reformed completely, but the hearing remained so good that secondary removal was not required. In the remaining case the hearing was much improved so long as an opening remained in the membrana tympani, but returned to its original condition when this became obliterated. The patient passed from observation, as she resided in a distant city, and I have been informed that the physician in attendance has not been able to secure a permanent opening. In this case the incus could not be found, but the mastoid had been chiselled for an empyema one year before, and, as the ossicle was not seen during the operation, I am inclined to believe that it had been displaced during the treatment of the previous suppurative inflammation. In most of these cases an interval of many months has elapsed since the removal of the ossicles, and the improvement continues. It is only fair to say, however, that even when a permanent opening has been secured the hearing is not as good after the cavity has become completely dry, as immediately after the operation when the parts are moist. In those cases where the improvement continues, notwithstanding the complete reproduction of the membrana tympani, the hearing distance has remained as good as before the complete closure of the opening, and hence there has been no indication for further interference.

Of the cases slightly improved, in one the receptive apparatus was known to be involved before the operation, and only slight improvement was hoped for. In the second the stapes was anchylosed, and could not be mobilized (in a similar case I should now remove it completely); in the third, the operative treatment was resorted to at the request of a colleague, and the exact condition of the receptive apparatus was not known. In the fourth case, although the hearing was only slightly improved, tinnitus, which had been present, disappeared, and the hearing upon the opposite side became very much better. To this last fact I wish to call special attention, as it confirms the observations of Cholewa, already alluded to in considering tenotomy of the tensor tympani muscle. I have found this true in more than this one case, and on one occasion, after subjecting the opposite ear to operative treatment, this improvement disappeared. Since this time I have exercised great care in advising the employment of surgical measures upon the better ear, when this has improved after an operation upon its fellow. Whether the phenomenon is to be explained upon the theory advanced by Gellé,[65] to account for the modification of the hearing upon one side, when the air in the external meatus of the opposite side is compressed, or whether it depends upon the fact already proven by Edinger,[66] that the auditory nerve of one side receives fibres from the nucleus of the opposite side, I am not prepared to state. The influence which a pathological process in one ear exerts upon the functions of the other has long been recognized, and it is strange that more attention has not been given to this point, in the hope that one ear at least may remain useful as the result of

the early treatment of the affection upon the opposite side. The observations of Wharton-Jones,[67] Politzer,[68] Urbantschitsch[69] and others prove conclusively that this "crossed action" exists, and it certainly deserves more consideration than it has received. It carries with it the suggestion, however, that in cases where the conducting apparatus of both ears is affected, the receptive apparatus remaining intact or nearly so, surgical interference shall be first tried upon the poorer ear, and the effect be noted not only upon the ear operated upon, but also on the opposite side. From certain facts, I am inclined to believe that the rule is also applicable to cases in which the impairment upon the more affected side, or upon both sides, is the result of a chronic purulent otitis. Certainly I grow more and more cautious in advising operation upon the better ear, until considerable time has elapsed after the operation upon its fellow.

The above results, while not as gratifying as might be desired, still place the operation among the means which it is the duty of every otologist to advise when other measures fail. In this line Lucae[70] has probably operated upon more cases of chronic proliferative otitis media than any other single surgeon. It should be mentioned, however, that although he selected his cases with great care, and only operated when careful tests with the tuning-forks indicated a lesion of the conducting apparatus, he was content in the large majority of cases to leave the incus. As already stated, I believe that the removal of the incus is very important. Lucae reports 53 operations, with the following results: In 9 there was marked improvement; in 19 slight improvement; in 18 no improvement; while in 7 the hearing was impaired by the operation. Of the 9 cases in which the improvement was marked, the membrana was completely reproduced in 3, while a permanent opening remained in 14 of the cases in which there was only slight improvement. In these 53 operations the incus was removed in but 6 cases.

In cases where the membrana tympani has been partially destroyed, most of my own operations have been performed primarily for the relief of the purulent discharge, the hearing in a large number not being so seriously impaired that operative interference was sought for this cause alone. In cases of this character, then, our report must show the effect upon the suppurative process and also upon the function of the organ. When the operation is undertaken for the improvement of the hearing, an opinion as to the probable result should be based upon the result of an examination with the tuning-forks, according to the suggestions already given. It should be remembered, however, that the general results of operative procedures are better in such cases than when the inflammatory condition has been of the proliferative variety. Another fact which it is important to consider is, that when the hearing is good, surgical interference for the relief of purulency is not likely to impair the function of the organ. Thus in 29 cases of this character operated upon by the writer, in but one case has the hearing been impaired, and from a knowledge of the patient, and careful examinations, it is more than probable that this impairment is simulated.

Of these 29 operations, in 18 cases the hearing improved, and in 10 cases it remained the same as before operation. In but two of these last cases was the operation performed for the sole purpose of improving the hearing, and in one an unfavorable prognosis was given, and surgical treatment was resorted to only at the earnest solicitation of the patient. No improvement followed in this case, confirming in every way the opinion based upon the functional examination. On the contrary, in the other case the examination indicated that the removal of the obstructing conducting apparatus should improve the hearing. In this instance removal of the malleus, incus, and stapes, and the section of dense adhesions over the round window improved the bearing in the ear operated upon to such an extent that with the opposite ear tightly closed, conversation could be understood, this being impossible before the operation. The hearing in the opposite ear improved at the same time, but as other factors may have influenced this, it cannot be certainly credited to the operation upon the other side.

Of the 29 cases the discharge stopped completely in 15; it was greatly reduced in quantity in 9, while 5 cases are still under treatment.

In 14 cases the malleus and incus were removed, and in 4 the malleus, incus, and stapes. In 2 cases the ossicles had been completely destroyed by caries and the tympanic cavity was thoroughly curetted. In a single case the stapes alone was present, and as the head was carious this was removed, the foot-plate being left in position. In another case the malleus and incus were firmly adherent to the walls of the tympanum and could not be removed, but by the aid of the curette the carious areas were scraped away and the case was completely cured. In 7 cases the malleus alone was removed; in 5 of these the incus had undoubtedly been completely destroyed by caries; in 1 case it was overlooked during the operation, and subsequently found but not removed, while in the other case I may have displaced it into the mastoid antrum, as I felt certain of its presence early in the operation, but finally failed to secure it.

Ludewig[71] reports the results of removal of the malleus and incus in 75 cases, in 42 of which the discharge was cured as the result of the operative interference, while in 16 it continued after the operation. In 9 cases the patients were still under treatment at the time the report was written. In 5 cases no report was obtainable as to the result of the operation. Death occurred in 3 cases, but in no instance could it be traced to the operation.

Grunert,[72] in 28 cases operated upon, reports 13 cured. In 13 the discharge continued, and 2 cases were still under treatment at the time of writing. When it is remembered that the cases above reported represent those which have resisted all other means of treatment, there can be no question as to the advisability of undertaking the operation. The great danger is that the surgeon may mislead the patient as to the probable result of the procedure. It is seldom possible, in a given case, to assert positively that suppuration will cease completely after the operation. If the ossicles alone are carious, then their removal will put an end to the affection, but when the condition has existed for a long time it is quite possible that the adjacent tympanic walls have become involved, possibly in such remote situations as to be inaccessible to instruments. In such an event the procedure is advisable, but a complete cure cannot be promised. The indication for operation in such an instance lies in the fact that by the complete removal of the contents of the vault of the tympanum free drainage is afforded, and the danger of pus becoming confined in this space is reduced to a minimum. For this reason particularly, I insist upon the removal of the incus, as its presence interferes with drainage, and moreover it is the ossicle most frequently affected. Of the 75 cases of purulent otitis operated upon by Ludewig this ossicle was found carious in eighty-five per cent. Among my own cases I can remember no instance in which a healthy incus was removed. The probe sometimes enables us to determine the extent of the caries, but more frequently we are obliged to be satisfied with the simple fact of the presence of softened bone, without being able to define the extent of the area involved.

As to the question of impairment of the hearing when the procedure is adopted for the relief of suppuration, the hearing remaining fair, the results given above indicate that in very few instances has the hearing been rendered poorer by the operation. Out of Ludewig's 75 cases this occurred 6 times.

In view of the fact that all portions of the tympanic cavity are not accessible through the canal, and in order that the procedure may be more directly under the eye of the operator, Stacke[73] prefers to expose the parts by external incision. His method is as follows: An incision is made down to the bone, just behind the attachment of the auricle, and, following this in direction, from the tip of the mastoid process to a point just above the tragus. With a small elevator the cartilaginous meatus, and as much as possible of the periosteum of the osseous

canal are separated from the bony parts. In this manner the superior, posterior, and inferior aspects of the margin of the bony meatus are exposed, the soft parts being held only anteriorly. The soft parts are now divided transversely downward and forward, as deeply in the canal as possible, and by traction upon the auricle the funnel-like mass is pulled out of the bony meatus. The periosteum of the anterior wall is next divided, when the entire cartilaginous meatus and a part of the thin cutaneous lining of the osseous canal can, by traction forward, be so displaced as to leave the margin of the bony meatus entirely free. The tympanic structures can then be seen by direct light and all affected parts removed. By means of the gouge, the superior and posterior margins of the inner extremity of the bony meatus can now be removed, and the stapes being protected by a proper instrument, the curette can be freely used in the vault of the tympanum, the manipulations being under ocular inspection. In this manner the entire cavity can be completely cleared of necrotic tissue, and the mastoid antrum even may be exposed. In case there is evidence of serious mastoid involvement the original incision is made a little farther back than directed, and the antrum entered in the ordinary way, after which the tympanic cavity is exposed and treated in the manner above described, and finally the canal and the artificial opening into the antrum are thrown into one. In this way the middle ear, mastoid cells, and canal are converted into a single cavity, all parts of which are easily accessible through the external meatus.

After the operation the cartilaginous canal is replaced, and a drainage-tube, completely filling its lumen, is passed into the bony meatus, thus preventing displacement. The external incision is sutured, all drainage being through the meatus. In cases where the mastoid antrum has been freely exposed, it is usual to incise the soft parts of the canal longitudinally along the posterior aspect, and press the flaps thus formed backward into the cavity, holding them in position with tampons of iodoform gauze. In this manner a cutaneous lining for the mastoid antrum is secured. The same result is attained by cutting a quadrilateral flap from the cutaneous canal and carrying it into the antrum.

Stacke seems enthusiastic over this method of operation in cases of caries of the tympanum, but my own experience would lead me to employ it only in the most unpromising cases, and I should then be induced to first try the effect of excision of the ossicles in the ordinary manner. If there is mastoid involvement there can be no question as to the efficacy of the procedure. It should be borne in mind that the amount of space gained by exposure of the bony meatus is not as great as might be supposed, and unless the caries is extensive enough to make a thorough opening of the mastoid antrum desirable, a surgeon accustomed to operating through the canal will do quite as well by employing this method as the one above described.

Stapedectomy.—Accidental removal of the stapes has already been referred to as having occurred during the removal of the malleus and incus at the hands of different operators. Kessel [74] partially detached the foot-plate from the oval window in one of his cases. A quantity of perilymph was lost, but no serious consequences followed. Later, the experiments of Botey [75] proved that stapedectomy was not a serious operation, and might be beneficial in certain cases. It remained, however, for Jack [76] and Blake [77] to establish the removal of this ossicle as a distinct surgical procedure. The results reported by Dr. Jack are certainly very promising, and it is to be hoped that subsequent observations may demonstrate its utility beyond a shadow of a doubt. I have already given my own views upon the question of removal of the stapes alone, having clearly stated that they are not based upon any extended personal experience with the operation. On theoretical grounds, it seems that perhaps the removal of the entire ossicular chain might be preferable, but experience alone can determine this fact.

The procedure would be applicable to cases in which the hearing was impaired as the result either of non-suppurative inflammation, or of a suppurative inflammation which had been cured, leaving the stapes in an accessible position. If suppuration is present, then removal of all the ossicles would be the proper operation.

Steps of the Operation. (*a*) *When the membrana tympani is intact*, the incudo-stapedial articulation is exposed either by a curved incision in the postero-superior quadrant, close to the attachment of the membrane to the tympanic ring, or by a triangular incision in this situation, or by the incisions already described in the operation of exploratory myringotomy. After the incudo-stapedial articulation is brought into view the stapedius muscle should be completely divided; the incudo-stapedial articulation is then severed, and the long arm of the incus pushed forward so as not to interfere with the subsequent steps. If the presence of the incus still interferes with the separation of the stapes the long process may be seized with the forceps, and the ossicle removed. The stapes is then freed from adhesions binding it to the oval niche by means of the sharp straight knife, and is removed by gentle traction with the forceps, or by a hook passed between the crura. It is important to sever the stapedius muscle completely before disarticulation, as otherwise, after disarticulation, the stapes may be pulled out of view. If the foot-plate is found anchylosed, this condition may be treated in the manner already suggested; although in such a case, as the parts would be subjected to more violence, it is probable that removal of the malleus, incus, and membrana tympani would diminish the chances of reaction after the operation.

Blake [78] has advocated the performance of this operation under cocaine anæsthesia, a ten per cent. solution being first introduced into the tympanum, through the catheter. After the first incision through the membrana tympani, the direct application of the cocaine solution to the middle ear, by means of a cotton-tipped probe, renders the subsequent steps painless. In three cases of this kind I have been able to clear the oval niche in the above manner, no pain being experienced after the first incision. I am inclined to think that the introduction of cocaine through the Eustachian tube has very little effect in mitigating the pain of the first incision, and if a very sharp knife is used this is never severe. After this no pain need be felt if the cocaine is carefully applied. My results have been very satisfactory, but I am inclined, at present, to employ this method more as an exploratory than as a therapeutic procedure, for the purpose of determining how much improvement can be hoped for by any operation upon the conducting mechanism. When, for any reason, general anæsthesia is objected to—unless great improvement can be assured,—the measure above detailed is of great value in deciding this point; but under general anæsthesia, much more exact work can be done if the membrana and two larger ossicles are first removed.

After the removal of the stapes the flap is replaced and the meatus is occluded by a plug of antiseptic cotton, which is left in position for several days unless inflammatory symptoms supervene. The wound usually heals in a few days, and in no case has the reaction been severe.

(*b*) *When the membrane is partially destroyed*, the stapes or the incudo-stapedial articulation may be already in view; but if they be not visible, the appropriate incision for the exposure of these parts will vary in each case, after which the technique given above is to be carried out. In two cases operated upon under local anæsthesia, the stapes being clearly in view, extraction was easily accomplished and the results were flattering, in one instance the hearing for a low whisper increasing from seven to thirty feet; here the entire stapes was removed intact. In the second case only a portion of the ossicle was secured, yet the improvement was considerable. It is well to bear in mind that even slight hemorrhage will render the removal of the stapes difficult, and when this region is covered by dense structures which bleed freely when incised, it may be necessary to remove the malleus and incus and remains of the membrane to secure a suitable field for the performance of stapedectomy.

The after-treatment may be the same as in the preceding class of cases. It is well, however, to inspect the

ear at the end of twenty-four hours, and if signs of inflammation are present, to cleanse it frequently with a mild antiseptic solution. If, however, the parts are perfectly dry, they should not be disturbed, for fear of interfering with the healing process.

Edward Bradford Dench.

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EASTBOURNE. One of the most popular seaside resorts in England. It is situated on the Sussex coast, between Brighton and Hastings. Eastbourne is only sixty-five miles from London. Dr. Yeo ("Climate and Health Resorts") speaks as follows concerning the merits of this place:

"The roads and streets have been skilfully planned and laid out on a uniform system, so as to secure abundance of space, free ventilation, and the picturesque planting of trees throughout the streets of the town. Moreover, the streets and other residential parts of the town are not all huddled together close to the shore as in some resorts, but spread out over a considerable tract of land extending toward the magnificent downs behind the town, for three-quarters of a mile or more from the sea-shore. This is a great advantage, for it enables the physician to make use of Eastbourne for many patients who are not comfortable when close to the sea, and for others to whom the exciting effect of strong sea-air might prove injurious, while the pure, bracing air of the downs, which are so readily accessible from the inland part of the town, might be advantageous.

"The sanitary arrangements are as complete as they can well be made, and an abundant supply of pure, soft water is obtained from wells sunk through chalk into the green sandstone. Every house has a constant supply. The sewers are freely ventilated, and the sewage flows into the sea at a point three miles away to the east, where the tides carry it away without the chance of its returning to the bay. The death-rate is low, the annual average for the last three years being 14.18 per 1,000."

The same author also states that during the summer he has known phthisical patients to do extremely well at Eastbourne, especially if they begin their stay by living away from the sea. Cases of torpid scrofula, of slow convalescence from surgical operations or injuries, cases of anæmia and general want of tone, cases of depressed function, nervous or digestive, are all suited to this place. In houses built to the west of the town, and with rising ground between them and the east, the winter temperature is not unpleasantly low, and there is more than the average amount of sunshine. But those parts of the town which are unprotected from the east suffer much from the prevailing winds in spring.

The country surrounding Eastbourne is attractive, and the place undoubtedly deserves the growing favor with which it is regarded in England. The accommodation offered in numerous hotels and lodging-houses is fairly satisfactory. *Edmund C. Wendt.*

ELECTRO-THERAPEUTICS. The advances in electro-therapeutics since the first issue of this work have been important. In no department, perhaps, has there been more activity than in the relation of electricity to the diseases of women. The most extravagant statements have been made by extreme partisans as to the extraordinary efficacy of the new methods in dissipating fibroid tumors, and in curing almost every variety of uterine disorder. There is a large class, however, who are extremely pessimistic in their views as to the therapeutic properties of electricity, and who deny that it possesses any considerable value in gynecology.

When, however, a man possessed of the experience of Keith, of Edinburgh, can say that many are prejudiced against electricity because they consider it quackery and know nothing about it, that his confidence in its power to relieve disturbing symptoms of uterine fibroids and to cure many chronic inflammatory conditions of the pelvis continues to increase, and that he has no fear for the future of electricity, we have testimony that must greatly outweigh assertions and opinions that are purely negative.

In a recent and animated discussion of the subject at the Société de Chirurgie of Paris, equally favorable opinions were advocated by the majority of those engaged in the debate; and the strength of these opinions was accentuated by the fact that the majority of those who hold them are signally distinguished as laparotomists.

A word in regard to the faradic current in its relation to diseases of the uterus. Its effects are mainly mechanical, and according to the construction of the helix and the length and thickness of the wire do we measure its action on the muscular tissues of the uterus. Applied directly to the uterus of animals in physiological experiments, the organ visibly contracts, although not to

such an extent as the intestines, which, on application of the electrodes, can be seen to draw up gradually, very much after the manner of a woman's work-bag. Its action on the smooth muscular fibres of the human uterus, when applied therapeutically, is analogous to that of ergot, although manifestly more prompt and energetic, especially under the influence of the positive pole, which possesses a much greater power over the involuntary muscles than the negative. It is a current of alternation, of constant closing and breaking; hence it produces a sort of interstitial massage, heightening the activity of the circulation, accelerating absorptive processes, and influencing favorably the nutrition of parts.

Faradization, by its power over muscular contractions, sensibly increases temperature. According to the chemistry of the development of heat during muscular contractions, muscular work is the result of the decomposition of nitrogenous substances, and the muscles grow at the same time that they work and develop heat. That the value of the faradic current is more limited than the galvanic in the treatment of uterine disease must be immediately manifest to all who appreciate the difference between them; but in some conditions which come within the range of its physical and physiological activities, the faradic current may exceed in efficiency the galvanic. By its direct excitation of the smooth muscular fibres of the uterus we are enabled to combat that stasis of the circulation which is the beginning of uterine inflammation.

By this method we obtain a veritable interstitial massage, that is potent in overcoming the primary inertia of the organ and in preventing an arrest of retrograde metamorphosis, through which comes sub-involution with its inevitable and persistent sequelæ. In its purely local influence, then, faradization would seem to be preventive rather than curative, so far as it relates to uterine disease; or rather it is preventive, so far as concerns the latter conditions of uterine engorgement, and curative only in its initial stage. When the processes that go to make up the graver and more chronic diseases of the uterine parenchyma and its lining membrane have continued a long time, as is usually the case when medical interference is sought, the simple mechanical effects of the faradic current would be altogether misdirected.

Here we resort to the electrolytic influence of the galvanic current, or rather to what may be more fitly termed its galvano-chemical cauterizing effects through which are destroyed the granulations and fungoid growths of the diseased mucous membrane. By the interpolar influence of the current we correct a languid nutrition and hasten the absorption of exudations.

Just as the positive pole of the faradic current has an action of its own, superior in effect to the negative in causing uterine contractions, so the positive pole of the galvanic current has an action peculiar to itself. Here oxygen is generated and acids accumulate which render this pole directly hæmostatic. It is, therefore, indicated in all hemorrhagic conditions, as well as where there exists an excess of the natural secretions. Owing, also, to the greater retractibility of cicatrices following positive galvano-cauterization, the results are more lasting in the treatment of fungoid growths, or vegetations, than could possibly be the case with the negative pole.

At the negative pole, on the contrary, the alkalies precipitate, imparting caustic properties and causing effects fluidifying rather than hæmostatic. The absorptive process is undoubtedly more active under this pole than under the positive, and is especially indicated in indurated chronic metritis and for the resolution of fibroids.

That the galvanic current often completely dissipates fibroid tumors of the uterus few will, I believe, affirm. In the treatment of scores of fibroids on the external surface of the body, I have never yet seen a single instance where one of them completely disappeared. As a rule, the reduction is comparatively slight, unless suppuration is excited, which may be easily done. External fibroids are simply unsightly, and for this reason we desire to be rid of them; and as it is not possible to obtain more than a reduction in size, the knife is to be preferred, and electrolysis has fallen into disuse. We treat uterine fibroids, on the contrary, not because they are unsightly, but because associated with them are a train of symptoms sometimes of the most distressing character. These symptoms can, it is believed, be relieved to a greater or less extent by electrolysis, and sometimes so completely relieved as to lead to the belief, so far as the patient is concerned, that the tumor has entirely disappeared. In the great majority of cases, however, it is simply a symptomatic cure. The tumor is still there, but reduced in size, and so far as pressure upon surrounding parts is concerned, or any hemorrhagic tendency, it is entirely harmless. I am a firm believer in the great utility of the galvanic current in the thickenings and infiltrations resulting from inflammation of the pelvic cellular tissue. For the absorption of old exudations in other parts of the body, this treatment has long been used with excellent results, and in pelvic exudations the results are even better. I have seen the treatment, persistently carried out, result not only in the absorption of large pelvic deposits, but in the cure of the most obstinate and severe sciatica, and in the restoration of power to partially paralyzed limbs. In such cases, both sciatica and paralysis are caused, undoubtedly, by pressure upon the pelvic floor, and can be relieved only through the dissipation of the morbid products.

There are two methods of action through which we obtain results from electrolysis. The first and most apparent is the absolute destruction of tissue which takes place at the time of treatment. Some suppuration may follow, and thus, by actual loss of substance apparent to the sight, the tumor decreases in size. If, however, these were the only active forces in the electrolytic process, the method would lose much of its effectiveness.

If this be not so, how can we account for the many well-attested cases where morbid growths have entirely disappeared under simple external applications? Herein is the difference between the electrolysis of organic and that of inorganic substances. In the electrolysis of inorganic substances the effects cease as soon as the current ceases, the substances remaining in the condition in which the current left them. The electrolysis of organic substances, on the contrary, starts a process that continues long after the current ceases to flow. Besides this subsequent effect, the current penetrates the tissue and induces various important changes beyond and beneath the eschar, and these combined agencies do far more, in many cases, to diminish the size of morbid growths and prevent further development than an actual destruction of a limited area.

Hitherto one important defect in the treatment of various uterine diseases, and especially morbid growths, has been the use of too weak currents. This has been due partially perhaps to a commendable caution in dealing with an agent so potent as electricity, but more to our lack of definite knowledge of the amount of current strength needed to accomplish certain ends, and our inability to readily command more than a certain limited working power from the apparatus in ordinary use. A third obstacle was the absence of any instrument by which the current could be accurately measured. The improved milliamperemeter has overcome this difficulty, and is indispensable in all electro-surgical operations, besides being a vast aid in all electro-medical applications. Instead of a strength of current equal to only ten to thirty milliampères, which was commonly used, and which indeed was all that could be obtained from the appliances in use, it is now no uncommon thing to use currents of even several hundred degrees of strength.

For this purpose the external electrode must not only be material of the best conduction possible, but of suitable size and sufficiently flexible to be perfectly adjusted to every inequality of surface which it covers. The strength of current from a given number of cells is in proportion to the size of the electrodes, and therefore, when from a certain number of cells it is desired to get the greatest strength possible, the electrodes should be of the largest size convenient for our purpose. As to the quality of the electrodes, sponges are too bulky and offer too great resistance when our object is strength of cur-

rent. As a substitute Apostoli suggested sculptors' clay held in place by gauze.

This material holds moisture fairly well, can be adapted closely to the skin, and is undoubtedly an admirable electrode. An electrode that answers well, however, for the ordinary purposes of local application consists of layers of absorbent cotton, spread smoothly over flexible metal backs of varying size.

The material is easily obtained, and is so inexpensive as to warrant a fresh supply for every patient.

In all this, reference is of course made to the external electrode, which, in the treatment of the uterus and its appendages, is usually placed upon the abdomen. The internal electrodes consist mainly of a small metal bulb attached to a long insulated stem, for applications to such portions of the uterus as can be reached per vaginam; of metal probe electrodes, for intra-uterine applications; and of needles of varying size, for electro-puncture. It should ever be borne in mind that when the positive pole is applied to the interior of the uterus, the metal should be of some non-oxidizable metal, as platinum. In the electrolytic treatment of fibroids a good milliamperemeter is a necessity. The external electrode, whether of sculptor's clay or other material, is first placed upon the abdomen, and may be pressed upon and kept in position by the hands of the patient herself.

An insulated needle is now introduced into the tumor either through the vagina or through the abdominal walls, and the current gradually increased without interruption until the required strength is obtained, which may vary from one to two or three hundred milliampères. The duration of the séance may be from five to ten minutes, and even longer if the patient bears the operation well. Too much stress cannot be laid upon the necessity of an entire absence of any interruption of the current during the treatment. In trivial operations, where the tension is slight, this is not of such vital importance, but in the treatment of conditions where a very great strength of current is necessary, a shock would decidedly disturb a patient of even strong nerve, and inflict serious damage on many. No one would willingly do this, but there are so many possible disturbing factors to the steady working of the current, that from my personal knowledge of the condition in which physicians too frequently keep their electrical apparatus and appliances, these interruptions are liable to occur at any moment and when least expected or desired. It is to be doubted whether many patients would submit to a second trial after having received a shock from a current strength of two hundred milliampères.

While the treatment of fibroid tumors by electro-puncture is liable to be attended with more unpleasant results, it is no more efficient in many cases of uterine myomata than the more simple method of intra-uterine applications; and in our opinion the latter method should, as a rule, be attempted before resorting to puncture.

If, however, in any case of fibroid it is impossible to enter the cavity with our electrode, or when a sub-peritoneal tumor is so situated as to be beyond the effects of intra-uterine applications, in these emergencies puncture is of course the only choice. Punctures may be made either through the vagina or through the abdomen. The former method is generally preferred.

In the intra-uterine treatment of fibroids the strength of the current that may be used varies from 30 to 150 milliampères, and the negative pole, because of its superior absorptive properties, is to be preferred. In hemorrhagic cases the positive pole is indicated, and it cannot be too often repeated that, with this pole, platinum or some other non-oxidizable metal should always be used. In chronic cases the idea is, according to Apostoli, to destroy the mucous membrane and produce a healthy derivation.

The faradic current, which is so valuable in simple uterine engorgements following abortions, and perhaps in the earliest stages of metritis, becomes useless in the presence of parenchymatous metritis.

The chemical action of the galvanic current is alone serviceable in these cases. As in the treatment of fibroids, powerful currents are demanded, varying in strength from 50 to 150 milliampères. Some good form of rheostat should be used, and as the current is gradually increased and decreased the utmost care should be exercised to avoid shocks. The operation is not electrolysis proper, but more correctly a chemical galvano-cauterization. The choice of the intra-uterine pole will be determined by the symptoms in each individual case.

At the positive pole the acids and oxygen accumulate. This pole is therefore coagulating and hæmostatic, and is indicated in all forms of hemorrhages and abnormal discharges. Another advantage possessed by this pole in hemorrhagic conditions is due to the greater retractibility of the positive cicatrices, which tend to prevent a return of hemorrhages. At the negative pole alkalies accumulate, producing some of the effects of caustic potash. It is sometimes called the fluidifying pole, and is more especially indicated in the non-hemorrhagic forms of metritis.

It is especially valuable in old, atrophic, or indurated forms of chronic metritis, where the connective tissue has become hard, fibrous, and devoid of blood. Far more effectually than the positive pole, it excites the languid or perverted uterine circulation and restores the menstrual flow. The caution never to use with the positive pole, in intra-uterine applications, any steel or other oxidizable electrode, cannot be too strongly emphasized.

Platinum is to be preferred, and, although it is expensive, it never wears out. A cheaper form of electrode is made of carbon so thoroughly polished as to render it non-irritant, or of steel subjected to certain processes by hydrogen which render it non-oxidizable.

In time, however, both of these materials become roughened through the constant action of liberated oxygen.

Peri-uterine hæmatocele, uterine hyperplasia, and stenosis of the uterine canal, have also been successfully treated by the newer methods. Even salpingitis, through the depletion and drainage secured by electricity, has been decidedly benefited.

Cataphoresis.—By this is meant the introduction of medical substances into the body by means of the galvanic current. It is a method that has long been known, but it is only within the last few years that it has been largely attempted. Its application is exceeding simple. In using cocaine, for example, for local anæsthesia, it is only necessary to place upon the absorbent covering of the positive pole a five to ten per cent. solution, and, after the current has passed for a few moments, marked anæsthetic effects will be observed.

In order to secure exact dosage it is convenient to have a flat metallic electrode, preferably of platinum, upon which is fitted a piece of tissue paper or some other compact absorbent material. Upon this is placed drop by drop the solution of any drug to be used, and the electrode is then applied to the skin.

In this way the exact quantity of the drug is known. It is hardly necessary to exactly measure the strength of the current.

As a rule a sufficient guide is to use the current only up to the point of easy endurance. Other remedies that have been used in this way with more or less success are aconitia, strychnia, and helleborin.

The author has known cocaine to afford marked temporary relief in some cases of neuralgia, and in epilation it has enabled him to operate with little if any pain to the patient; but that there may be danger attending the use of the remedy in this way, admits of little doubt. A one per cent. solution of helleborin has been said to act even more satisfactorily than cocaine, producing deeper and more lasting, and accompanied by no constitutional, effects. The salts of lithium have been used for rheumatic and gouty swellings, and among mercurial remedies the imidosuccinate and bichloride of mercury are suggested. Before applying the medicated electrode to the skin it is a good plan to dissolve the oil-globules upon the surface by the application of ether. It is believed

that the "effects of the galvanic current upon nutrition are in part due to the cataphoric transfer of molecules of protoplasm and liquid from one cell to another, or from a cell to a capillary vessel in the path of the anodal stream; and since the diffusion takes place more readily and more quickly in direct proportion to the current strength, it behooves us to employ as many milliampères as feasible in our galvanization of the atrophied and paralyzed extremities of poliomyelitis, chronic neuritis, and peripheral nerve-trauma. Moreover, there would seem to be a possible advantage in the use of nutritive emollients in conjunction with the labile application of the anode to the atrophied member, just as they have been combined from time immemorial in the exercise of the aliptic art (massage)."

The use of iodine by cataphoresis has been attempted in cases of goitre, and good results have been claimed for it.

Bipolar Faradization.—By bipolar faradization is meant the localization of the faradic current by means of a single electrode, and the method is confined, for the most part, to the treatment of internal organs, such as the vagina, the uterus, the rectum, and the bladder.

Bipolar faradization, more perhaps than any other form of electrical treatment, necessitates a knowledge of the varied physiological and therapeutical properties of the induced currents of electricity. A current from a short, thick coil of wire (No. 21, say, in size, and but two or three hundred feet in length) will be of comparatively slight tension, but of so-called large quantity; while the current yielded by a long and thin coil is of little quantity but high tension, overcoming the greatest resistances with the utmost ease. When, therefore, it is desired to produce powerful mechanical effects in the external faradization of the body, a current of tension from a long and thin coil is needed; while to obtain these powerful effects in the faradization of internal organs, where the resistance is slight, a current of quantity from a short and thick coil is necessary. Let one become but once convinced by personal experience of the striking difference in the action of induced currents of quantity and tension on nerve and muscle, and he will hardly need the demonstration of clinical experience to convince him of their different therapeutical properties. The short, thick coil offers very little resistance to the passage of electricity, and so gives forth a current of little tension but large quantity.

When applied externally its appreciable influence is very slight. Its tension is so low that it overcomes with exceeding difficulty the resistance of the skin that must be encountered in all external applications.

The important practical point in connection with this current is the extraordinary increase in energy that is manifested when it is applied to parts within the body. When applied to the rectum, the vagina, or the uterus, not only are the contractions pronounced, in response to a current which is not strong enough to produce any observable effect when applied exterually, but they may easily become exceedingly painful. When applied, indeed, to these internal organs by the bipolar method, its extraordinary action on motor and sensory parts will hardly be credited without actual demonstration. It is the easiest thing in the world to demonstrate this fact unwittingly, to the injury of the patient and to the operator's mortification. This is what may very readily occur:—An intravaginal or intra-uterine application is being made with the current of tension. The patient complains of an uncomfortable sensation, which may or may not be due to the action of the current, and you exchange the current of great for one of lesser tension, which, according to all the experiences of external application, is infinitely weaker. Instantly a shock is occasioned, associated with the acutest pain and the most rigid contractions, that astonishes yourself and terrifies your patient.

The advantages of the induced current of quantity from the short, thick coil of wire, over the current of tension from the long, thin coil, lie almost wholly in the effects of their internal application, and especially by the bipolar method. This current is capable of exciting contractions of the involuntary muscular fibres of the uterus, of every degree of severity.

For this reason it is invaluable in cases of post-partum hemorrhage, and must, it seems to me, prove far superior to ergot for its suppression, since it acts instantaneously and with a force just sufficient to accomplish the object desired. Currents of tension, however, from very long and thin coils, while they overcome with great readiness the enormous resistance of the skin and produce effects of a most pronounced character, exert by no means the same influence over the contractions and sensibility of the vagina, uterus, rectum, or bladder. So tolerant, indeed, are the internal muscular organs of the body to the induced currents of tension, that it is frequently a question of how to obtain a current of sufficient power from the batteries in ordinary use. Batteries that have been long in use, and that are allowed to get out of order, while perhaps yielding a current of sufficient strength for localized applications externally, are insufficient for bipolar applications.

Even if at first the current is appreciably felt in the uterus, the sensitiveness soon subsides, although its strength may have been very much increased; and both physician and patient may be in doubt as to whether the current is being received at all. This phenomenon becomes promineutly apparent in hysterical cases with which is associated excessive hyperæsthesia of the abdomen, and it has been no uncommon thing in my observation to treat women with the current of tension for the relief of the most acute surface abdominal hyperæsthesia, and at the close of a single séance to find the abdomen insusceptible to any ordinary manipulation.

Far different is it with the current of quantity. Tolerance is not established, and what is painful in the beginning continues more or less painful throughout the treatment, and it frequently becomes necessary to decrease rather than increase the strength of the current. A No. 21 wire, with a length of five or six hundred feet, constitutes a satisfactory coil for currents of quantity; while No. 36 wire, with a length of three thousand feet and more, is necessary to obtain the best effects of current tension. Among comparatively new devices and suggestions connected with electrical apparatus and methods of application, may be mentioned the franklinic interrupted current, electrodes for eliminating polar effects, and the various arrangements which enable us to directly utilize the current from the street. The static induction current is obtained from any machine that generates static electricity. The static discharge in the form of sparks becomes dynamic, and closely allied, in the effect that it produces, to the ordinary induced or faradic currents of electricity.

The spark no longer directly affects the body of the patient, but occurs in some distant part of the circuit, thus obviating the shocks which are to some so disagreeable. There are two methods by which we obtain the static induction current: 1st, with the electrodes attached to the prime conductors either without or with the condensers; 2d, with the electrodes directly connected with the condensers. On account of its high electro-motive force, and the readiness with which it overcomes the resistance of the skin, this current is often of great value in alleviating pain. It seems to me, however, to be inferior to the galvanic current in this respect, and yet it does relieve, as does the faradic, in some cases where the galvanic has failed. The differential indications for the use of currents of quantity and tension are, however, too wide a subject to be discussed here. I will only say that I have not infrequently found that the static induction current has proven more efficacious for the relief of pain than the ordinary faradic current.

It is well known that what is called the faradic current of tension is far more efficacious in relieving pelvic pain than currents of quantity; and the static induction current is a current of but little quantity but enormous tension.

When we consider that its voltage runs up into the thousands, it is not difficult to accord to it, despite its lack of quantity, special physiological and therapeutical

properties. In the remarkable rapidity of its interruptions and alternations, also, the static or franklinic interrupted current is unique. While the average induction coil gives but a few hundred vibrations per second, it is claimed by physicists that the oscillations of each spark of the static current amount to many millions per second, and that these sparks follow each other at the rate of two hundred per second. The superiority, then, of the static induced current over the ordinary faradic in relieving pain is undoubtedly to be ascribed, first, to its superior tension; second, to the inconceivable rapidity of each spark-oscillation, amounting to many millions per second. It should, however, be borne in mind that the vastly improved coils now obtainable have greatly increased the anæsthetieal properties of the faradic current, and for the relief of uterine and ovarian pain these high-tension inductive currents are unsurpassed.

A. D. Rockwell.

EMBRYOS, HUMAN. AGE.—It has been quite generally accepted that the age of an embryo must be determined by the time of a certain cohabitation. In many cases it was attempted to locate the day exactly. After it had been shown that the ovum is extruded from the ovary at or before menstruation, it was then generally admitted that the egg could be fertilized at any point between the ovary and the uterus. The time required for the ovum to pass through the Fallopian tube was considered the time in which it was capable of being fertilized. According to the above, these conclusions are not based on a sound footing, because of the difficulty in obtaining accurate observations, and also because they do not agree with the results obtained from the lower animals. Both Coste and His have shown that the eggs of the hen are fertilized ten or more days after copulation, and the former has shown that the egg is no longer capable of fertilization after it has passed through the after-portion of the oviduct.

Impregnation is nearly always marked by a cessation of menstruation, and it now remains to be shown whether the fertilization takes place during the last menstrual period, or at the time of the first cessation; for it is known from post-mortem examinations that ovulation comes just before menstruation. Since it seems to be necessary to fertilize the egg just as it leaves the ovary, it is probable that impregnation takes place just before the menstrual period. To locate the menstrual period, from which to compute the age of an embryo, we must consult the following table, which is in great part copied from His.

Number.	Observer.	Length of embryo in millimetres.	Beginning of last period.	Last possible cohabitation.	Time of first lapsed period.	Day of abortion.	Time between Abortion and		Probable age of embryo.
							Last period.	First lapsed period.	
							Days.	Days.	Days.
1	Graf Spee	1.54	.....	.....	.....	.....	35	.....	7 (?)
2	Riechert	.....	October 10.	Early November.	November 7.	November 21.	42	14	14
3	Breuss	.....	×	.....	× + 28.	× + 38.	38	10	10
4	Thomson	2.1	♡	.....	× + 28.	× + 42.	42	14	14
5	Thomson	2.5	May 24.	.....	.....	June 1.	8	.....	8 (?)
6	His (S. R.)	2.2	August 15. (?)	.....	End of September.	October 14–15.	60 (?)	14 (?)	14 (?)
7	His (Lg.)	2.15	September 10.	.....	October 8.	October 20.	40	12	12
8	Janošik	3.0	June 1.	.....	June 28.	July 13.	43	15	15
9	His (BB.)	3.2	March 26.	April 4.†	April 23.	May 13–16.	48	20	20
10	Stubenrauch *	4.3	April 10.	.....	May 28.	June 1.	53	52	22
11	Wagner	4.5	×	.....	.....	× + 20.	20	.....	20
12	His (a)	4.0	October 4.	.....	November 1.	November 24.	51	23	23
13	His (W.)	5.0	March 5.	.....	.....	March 26.	21	.....	21
14	Hensen	4.5	×	.....	.....	× + 21.	21	.....	21
15	Stubenrauch *	6.0	July 1.	July 8.	July 28.	August 14.	45	17	17
16	Stubenrauch *	7.0	April 1.	April 14.	April 28.	May 20.	51	22	22
17	Mall	7.0	October 6.	.....	November 3.	November 27.	52	24	24
18	His (SH.)	7.75	July 5–8.	July 20.†	August 2–5.	September 1–3.	57	29	29
19	Ecker	10.0	April 4.	April 15.	May 2.	June 3.	60	32	32
21	His (Br_1)	11.0	April 24.	.....	May 22.	June 24.	61	33	33
22	His (Br_2)	15.6	October 20.	End of October.†	November 17.	December 22.	63	35	35
23	His (M_2)	13.0	August 7.	.....	September 4.	October 10.	64	36	36
24	Stubenrauch *	22.0	May 16.	.....	June 12.	July 16.	62	34	34

* I have not full confidence in Stubenrauch's data. Some very apparent errors have been corrected. † Earliest cohabitation.

From a comparative standpoint we can easily determine the age of human embryos within four weeks. Counting from the last menstrual period, it is quite easy to see by the size of the embryo whether or not it is, say three or seven weeks old. The table shows that, by counting in this way, embryos of the same size may have a difference of four weeks in age (see Nos. 5, 11, 13, and 14). In these cases the age corresponds to the other cases, if from their time twenty-eight days are subtracted. This already indicates that, as a rule, fertilization of the ovum takes place during the ovulation which precedes the first menstruation which has lapsed. After Reichert had shown that menstruation is only a method of clearing out the uterus after an ovulation, and after Leopold had shown that the mucous membrane of the uterus undergoes histological changes before ovulation, it is fair to assume that the latter changes are only preparatory to the reception of the ovum, and that when the unfertilized ovum reaches the uterus, menstruation is only a method of reducing the uterus to its former condition.

Only in four of the cases is it necessary to compute the age of the embryo from the last menstrual period, and it is not fair to assume that just these four embryos have grown too rapidly. All the rest must have twenty-eight days subtracted from the time in order to make them correspond with the above four. These are the main reasons for assuming that the fertilization of the egg takes place just before the first menstrual period which lapsed. It may be that a great many fertilizations take place during the last menstrual period, but that when menstruation has once begun, the activity of the uterus destroys the ovum, and that, as a rule, only those are preserved in which menstruation does not follow the last ovulation. At least the embryological evidence speaks for this, and at present embryologists make their specimens correspond to one another when they reckon their ages from the last menstrual period, minus twenty-eight days.

The table shows, in addition, that in certain pregnancies the first cohabitation followed the last menstrual period. It cannot be that in these cases the ovum of the last period could have been fertilized, for it is quite certain the ovum loses its power of being fertilized shortly after it leaves the Graafian follicle. In case No. 9 (B B), the first cohabitation of a newly married woman took place on April 4th, say about five days after the last menstrual period; and the woman ceased menstruating at once, probably on account of the fertilization of the ovum of the following ovulation. If all the cases of

newly married women in which there was an early pregnancy were collected, it would, no doubt, be shown that in many of the cases the women did not menstruate at all after marriage. At present, although not being a practitioner, I know of four such cases. His has tabulated cases given by Harter, in which the first copulation, the last menstrual period, and the date of birth of the child are given. In all of these cases the age of the fœtus is from two hundred and seventy to two hundred and eighty days, if the beginning of pregnancy is reckoned from the beginning of the first period which has lapsed. If the beginning of pregnancy is placed at the first cohabitation, the age of the fœtuses varies fully a month according to the time of the cohabitation; if the time which has elapsed between the cohabitation and the first menstruation which lapsed is subtracted from the duration of the pregnancy, then the lengths of the pregnancies are practically alike. Assuming that the lengths of pregnancies should be about the same, it makes it highly probable that fertilization takes place at the time of the first menstrual period which has lapsed rather than at the time of cohabitation.

In several of the cases given in the table, the last cohabitation took place several weeks before the cessation of menstruation, showing that the vitality of the spermatozoa within the female organs lasts for at least a few weeks. It is probable, however, that the spermatozoa cannot live in the Fallopian tubes or uterus for over a month, because authentic posthumous births always take place within two hundred and eighty days after the husband's death.

The general conclusions formulated by Professor His, and accepted by embryologists, are as follows:

1. The beginning of development is the time of impregnation, *i.e.*, at that moment when the spermatozoon enters the ovum.

2. The time the egg leaves the ovary is marked by menstruation, but it is not necessary for the Graafian vesicle to rupture during menstruation; it may take place two or three days before or even during the hemorrhage.

3. The egg is not capable of being fertilized at any point from the ovary to the uterus, but only shortly after it has left the ovary; as a rule, as it is entering the Fallopian tube.

4. The spermatozoa which have entered the female sexual organs must await the ovum in the upper part of the Fallopian tube, and can retain their vitality here several days, or possibly several weeks. The time of cohabitation is, therefore, not directly related to the age of the embryo.

5. The age of the embryo is to be counted from the beginning of the first menstrual period which has lapsed, although it is possible to have a menstruation after fertilization of the ovum.

6. The age of an embryo can be expressed by the following formula: $A = M + X - 28 \times 3$, in which M is the beginning of the last period, X the time which has elapsed before the abortion, and the 3 the time between ovulation and menstruation.

There is no reason why the gynecologist should not add his share in determining the age of embryos. Any physician would add greatly to the subject if he would tabulate all cases in his practice after the plan of the above table. It would not be necessary to confine himself to young embryos alone, but he might include children at full term; especially those of newly married women would be valuable. Moreover, if the young specimens were carefully preserved, he could do a great work hand in hand with the embryologist.

Preservation.—The human embryos which come into the hands of the embryologists are nearly altogether worthless for careful study, due to careless preservation. Of fifty embryos less than six weeks old, which have come into the writer's hands during the last few years, only four have proved to be valuable, and these came from two physicians. The main reason why specimens are destroyed, in nearly all cases, is that the ovum is placed in very dilute alcohol, and in so doing it is also handled very roughly. Yet poor specimens are better than none at all, and in all cases all ova should be preserved, even if there is but little hope for a good specimen. *The best and most convenient method of preserving young embryos is to place the unopened ovum, with the least possible handling, in a large quantity of very strong alcohol.* The alcohol of druggists is in no case too strong, and, according to my experience, is as a rule too weak. Often the ovum is wrapped in a towel and then placed in a small quantity of alcohol and water. This may be a method of preserving museum specimens, but it practically ruins every embryo which is preserved in this way. When an ovum is placed in, say four ounces of strong alcohol, the water of the ovum dilutes the alcohol to a proper strength.

Those physicians who have the proper opportunities should place the specimen as soon as possible, and without opening the ovum, in seventy per cent. alcohol, *i.e.*, absolute alcohol reduced by volume to seventy per cent. At the end of a day or two it should be placed in fresh alcohol of the same strength.

A second convenient method is to place a specimen in quite a large quantity of Müller's fluid, to be changed once or twice during the first few days, after which it may be preserved in the same fluid indefinitely. The embryo is fully hardened in about a month, and then it can be washed in water for a day or two, after which it is to be preserved in seventy per cent. alcohol.

Ten per cent. nitric acid is a convenient and a most excellent method. The ovum is to be placed in four or six ounces of a ten per cent. solution and opened while in the fluid, care being taken not to injure the embryo. According to its size (if not over an inch long), it should remain in the acid for from thirty minutes to two hours. At the end of this time it is to be placed in seventy per cent. alcohol.

Another excellent method is to employ saturated aqueous corrosive sublimate. The specimen is to be treated as in the ten per cent. HNO_3, only it is to remain in the sublimate longer. These specimens are then to be preserved in seventy per cent. alcohol.

There are many other methods, but if any of the above are employed there will be a sufficient supply of material to aid the study of human embryology. It is really wonderful to see what progress has been made in this study when we consider how difficult it is to obtain good material. Some of the most important discoveries have been made in the careful study of a few well-preserved human embryos, as a glance at the many papers of His and at the excellent text-book of Minot will show.

A great work is done when the specimens are once obtained, but in order to make it complete they must be placed in the hands of a specialist, who can devote all his energies as well as all the additional necessary expense to these—the most precious of embryological specimens.

Franklin P. Mall.

EMOTIONS, THE PHYSIOLOGICAL AND PSYCHO-PHYSICAL BASIS OF THE. The practitioner of medicine is not universally expected to command a minute or special knowledge of psychology, but he may, and should be, familiar with certain intimate anastomoses of this subject and physiology. At a time when so-called psychological healing offers active competition to medicine in certain quarters, it behooves the physician to understand and to be able, if need arises, to formulate the conditions of psychical influence upon the body. On the other hand, men who are daily brought face to face with abnormalities of psychical function in connection with diseased bodies, and whose attitude is essentially critical and practical, might exercise a most wholesome influence upon the development of that new psychology which lays claims to recognition as a natural science.

The scholastic and convenient tradition which divides psychical manifestations into cognitions, volitions, and feeling, permits us to single out a class of so-called mental manifestations, which are conceived to be determined by a form of the receptivities of mind known as the susceptibilities. The most careful writers have discovered

in this group of "faculties" a perennial source of dispute and ambiguity.

Older psychologists conceived of feeling as obscure or implicate thought, or as impotent or unexpressed impulse or will.

Hoeffding defines feeling as "that in our inward states which cannot by any possibility become an element of a percept or an image;" as "an inner illumination which falls on the stream of sensations and ideas." Both these expressions indicate the difficulty involved in isolating feelings, the one being negative, the other an illustration. Sibbern notices that feelings and will have this in common, that in both "the ideas involved have a personal hold and effect, so that we yield ourselves up to them and are incited to act and strive for their realization." Recognizing the futility of the distinctions usually made, James has boldly used feeling as synonymous with the word psychosis or subjective state, and made no attempt to distinguish it from thought. The emotions (German *Effecte*) are described as a bubbling up of feeling which may greatly influence the course of cognitions and volitions, or temporarily inhibit or stimulate them. If emotions be strictly limited to feelings with psychical (cognitive) occasion or accompaniment, much ambiguity may be avoided, but it would still be necessary to insist on the essential similarity of these feelings to others with simple sensational basis. The following classification may prove convenient:

I. *Feelings.*	Sensations.	Sense gratification and pain.	General or total feelings.
II. *Occasions.*	Normal (moderate) sensory stimuli.	Super-normal stimuli, with tendency to irradiate.	Diffuse (somatic, especially "total") stimuli.

Emotions.	Impulses.	Sentiment.	Disposition.
Somatic changes occasioned or accompanied by cortical activity.	Reflexes excited by somatic and cortical activity.	Persistent cortical changes.	Reactions of cortical residua on new data of consciousness.

This series of subjective states is not to be regarded as arbitrary, but capable of the most far-reaching interpenetrations. Of course it may be claimed that there is a great gap between sensation, or even bodily pain and pleasure, and the emotions which depend chiefly upon data of a higher intellectual character. Between these two groups is another, which seems, in part at least, to bridge over the interval, the total or general feelings.

Sensations, as the most direct responses of the consciousness to external irritations in which the bodily participation is more direct than in the subsequent processes (perception, etc.), afford the simplest data of consciousness. Even in this case, however, the nature of the response varies with the organ in respect to the amount of subjective participation. Thus, sensations are excentrically projected or externalized; the former in the case of tactile, gustatory, thermic, and algesic senses; the latter in the case of special senses—visual, auditory, and olfactory.

That this is not a primitive difference, but is developed through associations of several senses, is proven by such facts as that when a blind person is suddenly given sight, the external world seems to touch the eye, *i.e.*, is excentrically projected rather than externalized. That externalization is possible to the tactile sense or "muscular sense" is shown by hyperexcentric reference of sensations of double contact, as when the blind man seems to feel an object at the end of his cane, or the surgeon's sensation is transferred to the end of his probe. We may dismiss, as beyond our limits, the three sciences —optics, acoustics, haptics (the skin and muscular sensations)—and there still remains a set of sensations which may be conveniently grouped as general sensations, which bring us into closest relations with the lower special senses, olfaction and taste, and the diffuse sensations on one hand, and subemotional processes, like elation, ennui, and depression, where total sensations and rudimentary feelings fuse.

It must not be forgotten that pain and sense gratification are strong elements in the emotions and require a careful examination. Hoeffding says "feeling stands out plainly, as an element different from the actual sensation, in certain experiences, which prove that the pain caused by an excitation takes longer to be produced than the actual sensation, and that sensation may arise without the corresponding feeling, and *vice versâ*." Richet says "pain without memory and without radiation would be no pain at all." Often an interval of one or two seconds may elapse after the sensation is perceived before pain appears. These cases, so often quoted as proving the distinct nature of pain, are in one respect fallacious. When a nerve-fibre is penetrated by a pin the pain is nearly, if not quite, as promptly felt as the touch. When the finger is struck by a hammer the pain is frequently long delayed. But the acme of pain in that case is due to a reactionary process in the tissues, notably the vascular contractions, etc. There may be several oscillations of pain and a set of summations of a curious character. It is even possible, by bringing to bear counter-irritants, to preclude these after-effects and mitigate the pain, as by rubbing or pinching the part.

In the case of a burn the conductivity of the tissues and vascular responses are even more evident, and such attempts to differentiate pain from sensation as a modality of feeling are futile. The fact that there may be analgesia without anæsthesia, and *vice versâ*, is tentatively explained by the recent suggestion, that thermic and painful sensations find their way to the cortex through the gray matter of the cord instead of the fibrous columns, and affords us added data for the generalization for which we are now ready, viz.: Feeling is always composed of two sets of factors; first, a sensational, and second, a cognitive or intuitional element. The sensations which directly participate in feeling are non-localized (general or total sensations), or are so acute as to irradiate, and thus ally themselves with total sensations. The cognitions or intuitions are primarily such as identify the subjective state with the empirical ego. The association of reflexes and instinctive responses converts the feeling into an impulse which is usually embodied in the so-called emotion.

James identifies instincts and emotions as two forms of impulse, in this usage betraying German influence. He says that the class of emotional is rather larger than that of instinctive impulses. Its stimuli are more numerous, and its expressions are more internal and delicate, and often less practical. The physiological plan and essence of the two classes of impulse is the same. This identification of the expression of the emotion with the psychical element (feeling) seems illogical, inexpedient. Instincts may have an emotional origin, or may be of the nature of impulse deprived of its psychical element; but pure instinct is not emotional, though emotions may be awakened by a resistance to the gratification of the instinct. An impulse stands on a present or historical basis.

With this difference in distribution, the theory of emotions proposed by Professors Lange and James goes far to place the emotions on a plane of scientific research. As expressed by the last named, this theory is about as follows: Bodily changes follow directly the perception of the exciting fact, and our feeling of the same changes as they occur is the emotion. Objects excite bodily changes by a pre-organized mechanism, and these changes are so indefinitely numerous and so subtle that the entire organism may be called a sounding-board, which every change of consciousness, however slight, may make reverberate. Everyone of the bodily changes is felt acutely or obscurely the moment it occurs.

James says: "If we fancy some strong emotion, and then try to abstract from our consciousness of it all the feelings of bodily symptoms, we find we have nothing

left," . . . "a cold and neutral state of intellectual perception is all that remains." "The more closely I scrutinize my states, the more persuaded I become that whatever moods, affections, and passions I have are in very truth constituted by, and made up of, those bodily changes which we ordinarily call their expression or consequence." These quotations serve at least to emphasize the importance of the corporeal element, however much they ignore the cognitive element. The natural and logical criticism is that the *effect on consciousness*, which is all we get out of feeling, is wellnigh overlooked.

Emotion consists (1) of general sensations of total, organic, or irradiating varieties which have in common a lack of localization and, as a result of associational laws, are amalgamated more or less closely with the empirical ego; (2) of more or less explicate or implicate cognitions (perceptions, intuitions) of the relation between the cause of the sensation and our well-being; (3) the emotion is more or less closely attached to various impulsive expressions which tend in various ways to intensify the two preceding. More in detail: The sensations are produced in most cases by vaso-motor changes which, in turn, produce "total sensations," usually entirely unlocalized and not necessarily distinguished apart from the feeling. Such sensations may be recognized, and to some extent analyzed, by practice. They precede the emotion proper and compose its sensational element. When one lies half asleep in the morning and a loud report startles him, the sudden surging of the blood to the periphery produces a familiar but indescribable sensation, which may include tingling at the finger-tips, a curious twinge in the axials, a suffocating sensation in the chest, as more specific accompaniments. Then a flash of fancy depicts the burglar in the kitchen and a scene of bloodshed, danger to self, and the like; now perhaps a strange "gone" feeling in the abdomen, and helpless atonic condition of muscles follow; then impulse dominates, and the tendency to spring to the defensive arises; all this before judgment announced that the cook has slammed the range door. Granting that the illustration has served to indicate the meaning of the statement above, it need require but brief experiment and self-observation to show that vaso-motor and organic changes always accompany and afford a sensational basis for feelings. A just analysis will not neglect the subjective processes in construing the physical. Stripped of the sensations above referred to, and the instincts and impulses associated with them, the residuum is still not to be passed over. "A feelingless cognition that certain circumstances are deplorable," or otherwise, may be, and generally is, but the first step in a series of judgments or representations out of which spring the involuntary acts which are the really important results of emotion. The sensational element is that which represents the general, though subtle, bodily effect of the stimulus (be it physical or psychical), while it serves to awaken within us the empirical ego (the sum of our purely subjective bodily reactions on consciousness), which gives point or poignancy to the following psychical processes and links self with phenomena, awakening the participation of the soul in the states of the body, or of other beings, which otherwise might concern us only as do phenomena in Mars. It is then no mere figure which localizes the emotions in the heart or bowels, but a statement of sober physiological truth. A heartless man is one whose intellectual appreciation of the results of an act does not awaken sympathetic thrills in his physical being adequate to quicken in him a participatory or sympathetic state. Such a condition may be acquired by habit or produced by heredity. Practically, we are first interested to study the physical substrata conditioning the emotional temperament and its expressions.

The sensational elements in emotion are, first, pains and sense gratifications; second, obscure organic and total sensations which are not usually perceived as such, but are interpreted as part of the feeling; third, reproduced pains or gratifications always followed or accompanied by total sensations; fourth, representations which awaken by association either reproduced pains and gratifications which, in turn, give rise to total sensations, or the latter without the former; fifth, instincts, which obey laws of association whose rational explanation lies in the development or phylogenetic history.

Pain and sense gratification are more difficult to construe, because more direct and simple than the others named. So long as pain, etc., were regarded as simply exaggerated forms of ordinary sensation the problem was insoluble. That this is not the case is suggested by the fact that they pursue other courses in the cord, and are associated more closely with thermic sensations. If a small area of the skin is isolated it is found that tickling with a feather is interpreted as warmth, and a thrust with a needle cannot be distinguished from heat. In other words, if the local signs by which position is recognized are excluded, the differences break down. It may be noted that general changes in temperature states are closely connected with the general feelings, as witness a shudder or the cold chills of fear, and the glow of pleasure. Briefly stated, the peculiarity of pain and intense gratification of sense which adapt them to become sources of feeling, is their diffusive (irradiative) character. If the current suggestion that algesic stimuli pass by conduction through the gray matter of the cord be substantiated, a much closer connection with the visceral centres than hitherto suggested may be postulated, and the thrill of pain can be readily interpreted as the sympathetic contraction wave passing throughout the vascular system. The evidence for the existence of adequate vaso-motor causes of the sensational element in emotion is largely subjective, but those familiar with nervous diseases will not lack for evidence that variations in circulation are powerful factors in emotional disturbance. Shame is an emotion quite independent at times from any judgment of adequate occasion for chagrin. It is very closely connected with peripheral vascular changes. In anæmic or neurotic persons the flush may come without any external exciting cause, and yet frequently produces all the subjective effects of shame. Not very infrequently this symptom becomes intolerable and almost alone drives one from society. Still more frequently psychical reflexes become associated with it and enhance its power. Fear, which originates in a shock or contraction wave of the vascular system, bringing a whole series of visceral and secretory changes in its wake, illustrates the possibility of separating the sensational from the cognitive element. Dreams often afford instances of all the physical manifestations of fear, with no adequate cognitive process. The writer has dreamed of being the actor in a play in which fear of impending danger entered, and, in his capacity as actor, felt fear (sensational); while in his capacity of critic he, at the same time, observed the entire inadequacy of the supposed occasions of fear.

Lange says: "No one has ever thought of separating the emotion produced by an unusually loud sound from the true inward affections. No one hesitates to call it a sort of fright, and it shows the ordinary signs of fright. And yet it is by no means combined with the idea of danger, or in any way occasioned by associations, memories, or other mental processes. The phenomena of fright follow the noise immediately, without a trace of spiritual fear. Many men can never grow used to standing near a cannon when it is fired off, although they perfectly know that there is danger neither for themselves nor for others—the bare sound is too much for them." One who has walked over a railroad trestle by night and narrowly escaped a fatal plunge by observing just in time the absence of a tie, will be able to recall the peculiar series of organic sensations involved. The thrill of vaso-motor disturbance pervading the body—the twitch of the radial artery—the pain in the sternal region—the suffocating sensation in the breast and lump in the throat—and, finally, the "gone" sensation in the abdomen somewhat resembling a sensation of cold, and due in all probability to vaso-constrictor reactions in the visceral vessels—these, and many more, illustrate the bodily effects which may wholly precede the apprehension of danger, and may be enhanced by a variety of imagination pictures, and may express themselves in impulsive gasps and gestures. It is not necessary to call attention to the fact that mental

images may be almost equally effective with the actual external irritations in producing the sensational responses of emotions. Before passing from the direct sensational elements, however, it may be noticed that those senses which externalize their data (vision, hearing, etc.) have special powers over the emotions which may in part be explained by a sort of central (bulbar ?) irradiation. Simple colors and musical sounds produce a vague and feeble pleasure unworthy to be called emotional, but similar to the normal subjectivity of nervous action ; but a symphony or aurora plays on the sensitive organism like a harp. The writer, without musical tastes or education, confesses to the tumult of indescribable sensations produced by Wagner or Beethoven. Flushes of cold and heat ; tinglings and palpitations local and general ; gusts and torrents in the blood ; creeping, swelling, scintillation of the skin ; giddiness and elation—these and indescribable "all-over" sensations are easily separable from intellectual appreciation, which may even be absent ; and one may be a wondering spectator observing the irrational gyrations of his own sense to tintinnabulating stimuli upon which judgment turns the cold shoulder. Another class afforded by the tickling and shuddering or irradiation sensations proper, further illustrate the necessity of diffusion in emotional sensation. The slight sensations of tickling, aided by subjective modifications, extend in most varied and irresistible sensations over the whole body. Its emotional character is almost wholly apart from the intellectual element. The shudder and chill which spring from a gritting sound or the velvety touch of a peach, imply in addition considerable instinctive elements.

The effect of instinct is powerful in the emotions generally. The faintness at sight of blood may be entirely apart from apprehension. The universal creepiness inspired by the approach of a harmless snake or the proximity to a precipice, are illustrations of a form of sensation obviously highly developed in animals (witness the rising hair of the new-born kitten at the odor of a dog). The sight of many small animals, pets, or children, produces a marked thrill in most children, often accompanied by curious sensations at the root of the teeth (analogous to the sensation sometimes felt with surcharged bladder), and accompanied by strong impulse to squeeze or hug the animal, to contract the muscles of the jaws, arms, etc.

These are often very powerful sensations, and productive of almost violent impulses. They are analogous to certain sexual instincts (perverted in gynophagia, etc.), but are quite distinct from them.

The impulses of emotion have received careful study, and only too often have been identified as part of the feeling. If it were desired to analyze emotion as of threefold character, thus : sensation, cognition, impulse, there could be no serious objection, except that impulse does not always require consciousness of its occasion as emotion must. Strong evidence as to the nature of emotion is afforded by the fact that imitation of the expressions of emotion reflexly awaken the emotion, while vigorous repression of these impulses quickly obliterate it. Distraction of the attention may check the tempest rising in a child's bosom which, once overflowing, could only find relief in exhaustion.

Many persons who are not suspected of neurotic disease, have a transitory mania which exhibits itself in paroxysms of fury as blind and unreasonable as those of a maniac, and which may be occasioned by trivial circumstances. The fact that impulsive responses to emotional excitation have this reflex power is a significant one in the treatment of nervous disease Bucke's description of nervous dyspepsia may find a place here. "All physicians who have been much engaged in general practice have seen cases of dyspepsia in which constant low spirits and occasional attacks of terror rendered the patient's condition pitiable in the extreme. I have observed these cases often, and have watched them closely, and I have never seen greater suffering of any kind than I have witnessed during these attacks. . . . Thus a man is suffering from what we call nervous dyspepsia. Some day, we will suppose in the middle of the afternoon, without any warning or visible cause, one of these attacks of terror comes on. The first thing the man feels is great, but vague, discomfort. Then he notices that his heart is beating much too violently. At the same time shocks or flashes, as of electrical discharges, so violent as to be almost painful, pass one after another through his body and limbs. Then in a few minutes he falls into a condition of the most intense fear. He is not afraid of anything ; he is simply afraid. His mind is perfectly clear. He looks for a cause of his wretched condition, but sees none. Presently his terror is such that he trembles violently and utters low moans, and at this stage there are no tears in his eyes, though his suffering is intense. When the climax of the attack is reached and passed, there is copious flow of tears, or else a mental condition in which the person weeps upon the least provocation. At this stage a large quantity of pale urine is passed. Then the heart's action again becomes normal and the attack passes off." It is not the purpose of this article to suggest remedial or obviating procedure, but it is obvious that the vaso-motor conditions in hypochondria and nervous acme of all kinds acquire new significance in this connection.

Another group of phenomena connected with emotional excitement has recently been adverted to.

In a paper before the International Congress of Experimental Physiology, session of 1892, Professor Hugo Münsterberg details the results of experiments, showing that the emotional states react differently on the extensor and flexor systems of skeletal muscles. After having for some time practised moving an index on a scale ten or twenty centimetres centripetally and centrifugally, until the distance could be quite accurately estimated with closed eyes, he tried the same experiment while experiencing pleasurable and painful emotions. The results are interesting. Purely physical variations, such as would be expected *a priori*, are seen in the under-estimation of the distance in dull or serious moods, and over-estimation when excited or amused. But psychical variations appear when they would hardly have been expected. Thus in unpleasurable emotions the extensor motions are too small, while flexor motions are too large, and during pleasurable emotions the flexor motions are too small and the extensor motions too large. The author does not hesitate to found on this observation the theory, that it is not simply true that painful emotions produce flexor motions and pleasurable emotions extensor motions, but that the psycho-physical effect of the reflexly produced extension and flexion is precisely what we term pleasure or painful emotion. A farther generalization is that extension must always, from the biological stand-point, occur with serviceable, and flexion with harmful, irritations.

Even the infusoria exhibit the same tendency. This lies at one extreme, while at the other the pleasurable emotion of assent is but an associated reproduction of earlier extensor motions, and *vice versâ*. Pain and pleasurable sensations acquire emotional value only through the aid of associated muscle sensations, *i.e.*, such as form the foundation of our empirical ego.

These suggestions are expressed in a somewhat different form in Tuke's well-known text-book. "By acting chiefly on the flexor muscles, fear causes the general bending or curving of the frame; while courage contracts the extensors, and produces expansion and height."

"The opposite muscular states of contraction or tension and relaxation, alike find illustration in the emotion of terror, for with the signs of the former already mentioned, and the stare of the eye, are combined the relaxation of the masseters, the sphincters, and the processes of organic life." "Calmness—a placid condition of the feelings generally—is marked by a gentle contraction of the muscles, indicative of repose, but at the same time of latent power—by the countenance free from furrows, but not relaxed into weakness. Anger or rage contracts the masseters, inflates the nostrils, furrows the forehead, and exposes and rolls the eye-

balls, clenches the fist, and induces a violent action and more or less rigidity of the muscles generally."

"As all movements have for their great end the preservation as well as the enjoyment of the individual, and as contraction and relaxation take place primarily to attain this end, a general expansiveness of expression and gesture is allied with all the emotions which are excited by impressions (or generated by ideas) of a beneficent character; while a general exclusiveness or contraction of features is allied with emotions excited by maleficent expressions; the object of one class of movements being to court and receive, and of the other to avoid and reject." "Pleasurable and painful sensations from without determine, then, the form which the muscles called into action assume; the purpose being to protect the organs. Similar muscular changes arise from the emotions, according as they are pleasurable or painful, in consequence of the harmony between mental and bodily acts."

The existence of impulses of the most recondite and adaptive sorts need not be denied, nor can it be doubted that these reflexly contribute to the emotional element. It must be urged, however, that emotion, strictly speaking, is subjective and must not be identified with its bodily occasions or results. The practical problem is to acquire control over the conditions.

The transition from emotion to sentiment is imperceptible. Joy and sorrow are sentiments growing out of pleasure and displeasure, and these have their counterparts in sense gratification. Conjugal love is the sentiment of which passion is the emotion, for which erotic excitement may afford one sensational basis.

The rhythmical flux of the feelings is explained by physiological oscillations. In the morning, when the current of life is full, emotions are not easily awakened. A morning audience is not a responsive or emotional one. The processes of nutrition exert a powerful effect. Physiological acme, like puberty, and the climacteric, predispose to emotions. The early development of the sensational element of emotion and its preponderance in the lower animals has been thought to imply that feelings are prior to cognitions. A more just analysis recognizes the psychical element of emotion as essentially intellectual, and abandons the attempt to secure a serial relation of the "faculties." An interesting and important field is thus open to the practising physician in the minute study of the pathology and physiology of emotions.

C. L. Herrick.

EPIDEMIOLOGY is the science of epidemics. It is therefore chiefly concerned with the distribution of disease, although it necessarily deals also largely with questions of ætiology (*cf.* Ætiology). The distinctive feature of an epidemic is the sudden and temporary appearance of a disease in a considerable number of persons in a community at the same, or nearly the same, time. The epidemical diseases are naturally, therefore, chiefly, if not wholly, extrinsic or environmental diseases. We cannot well think of intrinsic disease appearing simultaneously in large numbers of people. The explanation of epidemics was formerly simple, although really obscure. The commonest causes assigned were those described as "meteorologic" or "telluric." Exactly what these meant no one knew. "Emanations from the soil," "atmospheric conditions," and the like were the high-sounding paraphrases which have not yet wholly lost their force.

It is only within the last half-century that a more comprehensible set of causes has been introduced, and that the scientific study of the distribution of disease has become a possibility. With the establishment of the doctrine of *contagia viva* the subject of epidemiology became a part of general biology, and the distribution of disease began to be studied as the distribution of plants and animals had long been studied. Contagion and infection became easily interchangeable terms, contagion being only one method of infection.

At the present time we may safely assume the doctrine of a *contagium vivum* at the bottom of most epidemics, although in the last analysis it will be safer to assume the cause as toxic or toxicogenic. A poisoned well might easily produce an epidemic of arsenical poisoning. A car-load of trichinous pigs might as easily produce an epidemic of trichinosis in a community. An infected water-supply or milk-supply may produce an epidemic of typhoid fever. In all of these cases the ultimate assault upon the cells or the protoplasm of the body may be toxic in character, for while the trichinæ are lodged in the muscle, and the bacillus of typhoid fever may multiply in the intestine or in the blood or the tissues, the chief damage is done, in all probability, by substances produced by the invader which are essentially toxic. It is a significant commentary upon the dependence of definition upon knowledge and upon the value of a rational ætiology, that epidemics due to poisoning are seldom so called, being known rather as "cases," while epidemics whose origin is unknown, or not generally understood, are still called "epidemics," and popularly attributed to vague or supernatural causes.

If we allow that what are thus called epidemics are, in reality, due to living organisms such as the spirillum of Asiatic cholera or the bacillus of typhoid fever (and at present the evidence of ætiology certainly lends very strong support to this view), then we have in epidemiology simply to inquire—How may the organisms of infectious or epidemic diseases be so disseminated as to attack simultaneously a number of persons and thus generate an epidemic? Obviously food and drink afford convenient vehicles for the introduction into the alimentary canal of all kinds of particles, not excepting those which may act as the germs of disease. The atmosphere also may contain these minute particles, and, during the act of respiration, deposit them upon the pharyngeal or pulmonary mucous membranes. But even when so introduced into the alimentary or pulmonary passages the germs of disease may conceivably do no damage. They may find their environment unfavorable, or they may be destroyed by the digestive juices, or having penetrated into the body proper they may be captured by phagocytes, or killed by the defensive substances of the tissues. As a matter of fact we find in all epidemics some striking examples of apparent insusceptibility and exemption from attack, as well as cases affected in very different degrees, some lightly some severely.

These facts are usually explained by the doctrine of "predisposition." A in an epidemic suffers severely; B is entirely exempt, and C has only a "mild attack." It is usual to say that A was in a peculiarly "susceptible" condition, while B was not at all "susceptible," and C only slightly so. Theoretically this condition of things might easily have existed and each have received the same quantity of virus. Moreover, clinical experience strongly confirms this view, for in epidemics in general, and in those of typhoid fever in particular, it is the obviously weak or overburdened who most readily succumb to infection. But there is another possibility to be kept in view. The amount of the dose may have something to with the matter, and in this direction we are still very much in the dark.

It is now generally admitted by epidemiologists that there must be an exciting cause acting upon a community before an epidemic can arise. Even Pettenkofer has referred to this cause, in his latest publication upon cholera (see *The Lancet*, 1892), as very likely an organism, but something properly designated as x. The individual condition of susceptibility or immunity he designates as z. Most epidemiologists of to-day regard these two factors as sufficient to determine the question of the disease. But not so Pettenkofer, who adds to these an intermediate requirement, viz., *condition of locality*, which he designates as y. While insisting upon this, Pettenkofer urges that those who omit his y are destitute of epidemiological experience, and by virtue of their inexperience with epidemics easily become mere "contagionists." It is not easy to discover the evidence upon which Pettenkofer bases his claim for the importance of local conditions in the distribution of infectious disease. Those who are familiar with the works of Budd on typhoid fever will not readily accept the views of Pettenkofer,

and the doctrine of parsimony in logic will not allow us at present to require any other factors for disease than the fortuitous concurrence and combination of his *x* and his *z*.

It is uncertain to what extent the air is a carrier of disease, but the tendency of recent inquiries is to diminish rather than increase its importance. It is now generally held, upon the evidence of bacteriology, that the expired air is germ-free, so that this possible avenue, once regarded as important, and popularly still so regarded, is excluded. With pulmonary tuberculosis, diphtheria, and pneumonia, the sputum, when dried and pulverized, may act as the vehicle of disease driven by the air, but it is not yet accurately known to what extent the germs survive, or for how long, under natural conditions. With the exanthemata, particularly small-pox, scarlet fever, measles, and the like, there is every reason to believe that the disease is often disseminated through the air by means of infected epidermal scales driven about. In the diarrhœal diseases, on the other hand, it is apparently the bowel discharges (and only rarely the urine) which contain and convey the infection. Asiatic cholera and typhoid fever are apparently conveyed chiefly, if not exclusively, in this way. To provoke an epidemic of these diseases it is apparently only necessary to contaminate food or drink with (rather fresh) fecal material. Very numerous cases are on record of the dissemination of typhoid fever by infected milk and infected drinking-water, and the same facts are probably true of cholera. Dr. Budd long ago proved that the former disease is common among washerwomen, whose duty it is to wash infected linen soiled with the discharges of typhoid-fever patients, and there is an increasing quantity of evidence that milkmen and others suffering from incipient or walking typhoid may infect the milk which they sell by carelessness in cleaning their hands after defecation. One of the most instructive epidemics ever traced was that at Caterham, England, in February, 1879, where a small quantity of the fecal discharges of one workman, apparently in the incipient stages of typhoid fever, contaminated an otherwise pure water-supply, and led to 352 cases and 21 deaths from this disease. The low fatality may have been due to the enormous dilution of the virus.

If by food we may understand broadly food and drink, then it is probably true that the principal vehicles for distribution of the seeds of disease are *food and fingers*. In the diarrhœal diseases this is certainly true, and it will very likely be found hereafter to be equally true of other infectious diseases, although for diseases of the throat and lungs, such as diphtheria and tuberculosis, kissing may hereafter be found to be the most effective agent of distribution. Of contagion in the popular sense, namely, the "taking" of a disease directly, from mere contact or touching, there is probably no real example, except in kissing or venereal disease; but the hand must certainly be regarded as the ready carrier of the germs of disease to the mouth, so that "contagion" may readily result in infection. It ought to be more widely understood than it is that unclean hands may infect food, and that although contagion in the old sense plays a small part, the co-operation of fingers and food may make a very "short cut" for the distribution of disease. The author has seen epidemics of typhoid fever plainly due to secondary infection of this kind among unclean people, whose families prepare and serve their own food. These cases are more obscure, but not less instructive than those in which a public supply, such as water or milk, shared in common by many, has become infected. It must not be forgotten that if the modern views of the ætiology of contagious disease are correct, there can be no more real mystery in the genesis of epidemics and the distribution of disease than in the genesis of nations or forests and the distribution of plants and animals.

William T. Sedgwick.

EPILEPTICS, THE CARE OF. The care of epileptics really includes their medical treatment as well as all other kinds of help extended to them. But medical care has been given them, such as it is, for some thousands of years, and yet without adding much to the happiness of individuals under treatment, or accumulating much evidence of positive value concerning medication in epilepsy. Our results have been, indeed, almost valueless, for, with all our dosing with bromides, borax, belladonna, and so on through the alphabetical index of the Pharmacopœia, it is extremely doubtful if in ordinary practice one per cent. of the cases of idiopathic epilepsy are cured. Besides the practical incurability and hopelessness of the disease, its victims have suffered untold sorrows in the way of negligence and ill-treatment at the hands of the communities in which they live.

It is a peculiarity of this disease that the seizures may be momentary, or may last for a few minutes only, recurring sometimes frequently, sometimes daily, and sometimes months apart, thus robbing the sufferers of their consciousness and faculties, for brief periods of time at long or short intervals. Between the attacks they may be as rational and as well qualified for all the vocations, duties, and social privileges of life as any other human being.

These facts do not concern only a few members of a community. Epilepsy is a widespread disorder, and it has been calculated that one person in five hundred is thus afflicted. Thus there would be in the neighborhood of one hundred and thirty thousand such unfortunates in the United States alone, and over twelve thousand in the State of New York. Even supposing this percentage to be exaggerated to a very great extent, and that the actual ratio were one to one thousand, the number of epileptics would still be enormous, and would constitute a very large part of our defective classes.

Outside of the efforts, thus far comparatively futile, of physicians to alleviate their purely physical infirmities, and to reduce the number and severity of the attacks, nothing has been done until late years to provide for their mental development and to meet the peculiar conditions of life which they are called upon to endure. Thus no general hospital will receive such cases for treatment, because of the incurable and unpleasant nature of their malady; while much of the time thoroughly capable of acquiring an education, they are debarred for obvious reasons from the schools; the churches are closed to them; very few care to employ epileptics in shops, stores, or offices, or are willing to teach them trades; few epileptics are at liberty to enjoy the companionship of their fellows, who rather are inclined to shun their unfortunate brethren. Thus every avenue for mental or moral development, for occupation, for association with the rest of mankind is closed to them. They are even burdensome to their families. It is little wonder, then, that many of them grow up dull and ignorant, intellectually feeble, normally depraved, irritable in temper, with tendencies to retrogression and degeneration rather than to advance. A few of them become insane and are sent to insane asylums. Others, not insane, but ill adapted for existence under such miserable conditions, drift to the only homes offered them, the almshouses. The almshouse and the asylum are their only refuge when abandoned by their friends. In the State of New York, for instance, where there are twelve thousand epileptics, some four hundred or more are in insane asylums, and some six hundred in the county poorhouses. The rest of these are scattered throughout the State, in their own families, among the rich and the poor, in ratio to population and to the relative proportions of these classes. Many are so slightly affected that they are able in spite of their seizures to pursue some of the ordinary vocations of life. Thus I know personally of a doctor, clergyman, several bookkeepers, a bank president, a stock-broker, several clerks, some dressmakers, shoemakers, masons, and a telegraph operator who are epileptics, and yet able to carry on useful pursuits, albeit under adverse conditions. To all of us are familiar certain well-known historical or literary characters in whom epilepsy failed to restrict the development of their genius, such as Cæsar, Napoleon, Molière, Petrarch, Dostojewsky, and others.

It would seem, therefore, from the above facts that, although there is such a thing as epileptic insanity, the

proportion of insane epileptics to sane epileptics is really very small, much less than ten per cent. taken at the utmost, and that this ratio may be reduced by affording these unfortunates such opportunities for mental and moral development as are enjoyed by other and more happily situated citizens; and not only may the percentage of insanity be reduced, but the comfort and prosperity of all epileptics be increased by proper provision on the part of the State, or through private channels, of institutions of a peculiar character adapted to their peculiar wants. A large public hospital is very far from meeting their requirements, for, as has already been shown, medicinal treatment is uncertain and unpromising. Insane asylums should receive but very few, and almshouses none at all. What is demanded is an institution on the community or village plan, where medical treatment (such as it is) may be given to every member, and where every sort of education, employment, and social privilege commensurate with his needs and conditions may be extended to every beneficiary.

The colony system only can attain this object. A colony for epileptics is not an impracticable scheme proposed by visionaries. It is already an accomplished fact. The Bethel Epileptic Colony, at Bielefeld, in the province of Westphalia, near Hanover, Germany, was founded by Pastor von Bodelschwingh, over twenty-five years ago. He purchased a small farm with one house, and with four epileptics as a beginning, established a charity which for nobility of conception and success in its results has nowhere an equal. It seemed to its beneficent founder feasible to create a refuge where these sufferers might be cured, if curable, might have a home if recovery were impossible, might learn trades, and the great majority become educated, useful, and industrious citizens. From that small beginning there has been a gradual evolution of his idea, until now there are over one thousand epileptics, resident in some sixty or more houses scattered irregularly but picturesquely over a large farm. Everyone who visits this unique colony is deeply impressed with the happiness, contentment, and prosperity everywhere apparent among the inhabitants of this little epileptic world. He sees that it is no longer an experiment, and the previously unanswerable objections to such aggregations are, by its success, answered and silenced. At the time of my visit to Bielefeld, in 1886, there were but eight hundred and twenty-five epileptic patients. The employments were numerous and varied. A school provided instruction for some one hundred and fifty pupils of both sexes. All branches were taught. The dairy and the farm and garden occupied the attention of the greatest number of patients, especially as a large trade in vegetable and flower-seeds was carried on by the colony.

Among the shops for epileptic workmen were those for carpenters, cabinet-makers, painters and varnishers, printers, bookbinders, blacksmiths and foundrymen, tailors, and shoemakers; and among the stores were a grocery, pharmacy, book-store, and a seed-store. The carpenters aided in the building and furnishing of new houses. Plans and drawings for new buildings were made in the architects' room. Epileptics were employed in all the departments of industry relating to building. Books were printed and bound, and sold here, especially popular works for moral and religious instruction. The illumination of mottoes for hospital wards and schoolrooms, and the coloring of picture-cards were features of the work performed; washing, cooking, knitting, sewing, and fancy-work employed many. A bureau had been established for the collection and sale of museum objects, such as antiquities, articles of ethnographic and historic interest, autographs of distinguished people, coins, stamps, bronzes, gems, engravings, etc., and specimens from the animal, vegetable, and mineral kingdoms. For men alone there were over thirty different callings.

The houses presented great diversity of architecture and position. They were well separated, generally inclosed in individual gardens, surrounded by fences or hedges and many trees, and altogether exhibited the home-likeness of a country village, with little or nothing to suggest the restraints and discomforts of large institutions. There was one small cottage set aside for such cases as should become mildly insane, but bad cases of actual insanity were sent to insane asylums. Everything had been thought out carefully for the perfect evolution of this little social world, not only the multiplicity and details of occupations which would give each member of the community his choice of callings, but even the avocations, games, amusements, entertainments that might tend to divert his mind from the contemplation of his misfortunes. And since my visit the colony has continued to expand, to develop new and valuable features, and to confer its blessings upon large numbers of persons afflicted with this disease.

Taking Bielefeld as a model, nine other similar epileptic colonies have been established in Germany, one at Zürich, in Switzerland, and one in Holland. Most of these are not conducted by the state, but are under the jurisdiction of private or church charities. None of them are altogether self-supporting, but some of them approach very near it.

It should be stated that before the founding of the Bethel colony at Bielefeld, a somewhat similar institution, though on a much smaller scale, was begun in France, at a village called La Force, near Lyons. Over forty years ago a noble clergyman named John Bost established this institution, and it is in a flourishing state, doing a vast amount of good and redounding to the credit of his creative genius.

It has been found in all of these colonies that no harm is done by bringing epileptics into contact with each other. They feel on an equality with their fellows in such a place, losing that sense of isolation and singularity which they cannot but observe, in the ordinary world as separating them from the rest of mankind. They enjoy caring for each other and being kind and helpful to their fellow-sufferers. It has been noted, too, that the number of seizures almost always diminishes upon entering upon the new and more hopeful and encouraging life begotten in the busy community.

Within two or three years interest has been awakened in other countries in the matter of provision for epileptics, notably so in America and England, where their peculiarly sad condition had never been noted nor considered. In 1890 Ohio took steps toward the establishment of an institution for epileptics, a commission, consisting of Messrs. J. L. Vance, C. C. Waite, and one other having been appointed by Governor Campbell, pursuant to an act of the Legislature, to select a site and prepare plans for the purpose. Of various sites examined, one at Gallipolis seemed best adapted for the project, and here a tract of one hundred acres was presented to the State by the citizens for the institution. To the writer, who was consulted upon the subject of site and plans, this seemed to be the best location offered, for, although an insufficient space for a large institution, there was plenty of land adjacent which could be subsequently added to the original tract. Contrary to the advice of the writer, the architect felt obliged, probably owing to the demand of the community of Gallipolis for an institution of striking proportions, to group the buildings on a symmetrical plan, such as is frequently carried out in public establishments for the insane. The Ohio epileptic hospital is built on the pavilion or cottage plan, a large number of these being grouped about the centre or administration building. It will therefore not meet in this important particular the requirements of a colony for epileptics, although in respect to provisions for school-buildings, shops, and the like, an effort has been made to fit the institution for the particular kind of care needed by this class. The name of the institution for epileptics in Ohio is also unfortunately chosen, for it is called "The Asylum for Epileptics and Epileptic Insane." The corner-stone was laid with appropriate ceremonies November 12, 1891, an interesting address and historical review being given by General Roeliff Brinkerhoff, President of the Ohio State Board of Charities. Three of the buildings were completed and made ready for occupancy in 1892, and nine additional cottages are

now in course of construction, the last Legislature having made a liberal grant for the purpose.

In California detached buildings are being erected upon the grounds of the California Home for Feebleminded in Sonoma County, with the view of accommodating the epileptics dependent upon the State in pleasant quarters.

Active measures are being carried out also in Massachusetts, Pennsylvania, Wisconsin, and Illinois, for the purpose of procuring State care and separate provision for the same class of unfortunates.

Next to Ohio, the State of New York has manifested the most interest in her epileptic dependents, and in the winter session of 1891–92 a law was passed by the Legislature making the State Board of Charities a Commission to select a site and prepare plans for an institution for epileptics. The law was authoritative in requiring the tract of land secured for the purpose to be four hundred acres or more in extent, and the whole scheme of buildings to be arranged on the colony or village plan. A committee of the State Board of Charities, consisting of Messrs. Oscar Craig, William P. Letchworth, and Peter Walrath, has been busy all of the past summer and autumn (1892) in examining a large number of localities which they were invited to inspect by the officers of various counties. In their report made to the Legislature on Wednesday, January 11, 1893, the State Board of Charities unanimously recommended for the proposed colony a site in Livingston County, consisting of over eighteen hundred acres, the property of the "Shakers," now known as the Sonyea Society of United Christian Believers. The Shakers have dwindled in numbers to such an extent that they decided to give up this colony and rejoin the mother colony near Watervliet, N. Y. The land is beautifully situated in the Genesee Valley, near the town of Mount Morris, and in one of the finest regions of the State. It is exactly fitted to meet the wants of a model colony for epileptics. It is traversed by two streams. One of these, the Cashauqua Creek, flows through the middle of the land in a deep gorge, with a fall of one hundred feet. This gorge and creek are of immense advantage for the complete separation of the sexes in free colony life. The supply of water is abundant, and the conditions for good sewerage perfect and adequate in every respect. The Western New York & Pennsylvania Railroad runs through the land, and two great trunk lines, the Erie Railway and the Delaware & Lackawanna Railroad, are within a mile of the proposed colony. The soil is exceedingly fertile and well adapted for all manner of agriculture, horticulture, the production of berries and fruits for canning industries, and the raising of garden produce and seeds of all kinds. It has some stone and brick-clay, which will prove useful in the development of certain forms of out-of-door employments. It already contains scattered buildings for the accommodation of three hundred patients.

The law which has been introduced into the present session of the New York Legislature embodies provisions for the purchase of this tract of land, and also for the methods of management, government, and admission of patients to the colony. As some of these may be useful to those interested in the establishment of similar institutions, a few of the chief points will be mentioned here and the entire law given below.

The name of the institution is "The Sonyea Colony." Thus any direct reference to its object is avoided in the title. The word "Sonyea" is an old Indian word, meaning sunshine, and is historical in that this point was once the site of an ancient Indian village of the same name. For the present all insane epileptics are to be excluded, but probably ultimately there will be some building for the insane, especially for such as become mentally deranged temporarily while residents of the colony, since their removal from the happy influences of the community system to an asylum for the insane would be very depressing and tend to retard rather than promote their recovery.

There are to be nine managers appointed by the Governor, two of whom are to be women and two to be physicians. They are to represent the eight judicial districts of the State of New York, an additional member to represent the City of New York.

The colony is to have a medical superintendent, steward, matron, and such teachers and other assistants as are necessary.

The main object of the colony is to provide for the indigent epileptics of the State, but private patients will also be admitted to an extent to be determined by the Board of Managers. Epileptics of all ages are to be received and cared for; minors are detained by authority delegated by the parents or guardians; adults are free to go or remain, as they choose, there being no deprivation of liberty of any kind by methods of legal commitment, such as are necessary in asylums for the insane. The charge for maintenance of indigent patients is to be borne by the State, and a limit of $250 per annum per capita is established by the law. But it is expected that the colony will eventually become, to a very great extent, self-supporting.

Patients that become insane are to be sent to asylums in the districts from which they come, in accordance with the lunacy statutes.

A special pathologist to reside in the community and devote his sole attention to the discovery of the causes and cure of epilepsy is one of the features ultimately contemplated in connection with this great institution.

An Act to Establish an Epileptic Colony.—Section 1. Sonyea Colony. There shall be established in Livingston County, in this State, a colony for epileptics, to be known as the Sonyea Colony.

Sec. 2. Objects of such Colony. The objects of such colony shall be to secure the humane, curative, scientific, and economical treatment and care of epileptics, exclusive of insane epileptics; to fulfil which design there shall be provided, among other things, a tract of fertile and productive land, in a healthful situation, with an abundant supply of wholesome water, sufficient means for drainage and disposal of sewage, and sanitary conditions; and there shall be furnished, among other necessary structures, cottages for dormitory and domiciliary uses, buildings for an infirmary, a school-house, and a chapel, workshops for the proper teaching and productive prosecution of trades and industries; all of which structures shall be substantial and attractive, but plain and moderate in cost, and arranged on the colony or village plan.

Sec. 3. Managers of the Colony. There shall be a board of nine managers of the Sonyea Colony, seven of whom shall be men, and two of whom shall be women, appointed by the Governor, by and with the advice and consent of the Senate. Two of said managers shall be well-educated physicians; and all of them shall be citizens of the State, and residents respectively as follows: one in each of the eight judicial districts of the State, with one additional manager for the city and county of New York; but no manager shall reside in the town where said colony is located, or in Livingston County. The full term of office of each appointed manager shall be eight years, after the first appointments; and the term of office of one of such managers shall expire annually. To effect such order of expiration of terms of managers, the first appointments shall be made for the respective terms of eight, seven, six, five, four, three, two, and one years. Appointments of successors, and of persons to fill vacancies occurring by death, resignation, or failure in attendance at meetings shall be made without unnecessary delay. Failure of any manager to attend in each year the whole of two stated meetings of the board, shall cause a vacancy in his office.

The managers shall receive no compensation for their services, but shall be allowed their reasonable travelling and official expenses, when duly verified and approved by an auditing committee of the board, and duly presented to the Treasurer of the colony for payment.

Sec. 4. Land. The Board of Managers, within sixty days from their appointment, shall submit to the Attorney-General the land contract with option in the State, reported to the Legislature by the State Board of Charities at this session, and an official search and abstract of the

title of the tract of land described in said contract, containing eighteen hundred acres, more or less, lately occupied and owned by the United Society of Christian Believers, situated in Livingston County; and if such title be approved by the Attorney-General, and certified by him to be good and free from incumbrance, the Board of Managers shall, within thirty days thereafter, accept a good and sufficient deed of conveyance of said tract of land to the State, to be approved by the Attorney-General; and thereupon the Treasurer of the State, on the warrant of the Comptroller, shall pay therefor, as hereinafter provided, the consideration of $125,000, with proportionate reduction for deficiency, if any, in the quantity of land, which is assumed in said contract to be at least eighteen hundred acres for said purchase price.

Provided, that if such title shall not be approved, or such deed with a good title free from incumbrance cannot be secured, the Board of Managers shall, so soon as practicable, report the facts to the Legislature.

Sec. 5. Buildings and Improvements. Upon securing the conveyance of said tract of land to the State, with the approval of the Attorney-General as aforesaid, the Board of Managers shall immediately put the premises thus conveyed into proper condition for reception of patients; and shall receive them gradually and as rapidly as practicable; and for such uses and purposes shall utilize the present buildings and improvements upon said premises, and adopt a general design including the same, and the recommendations of the State Board of Charities in its said report, and subsequently from the beginning to the end, make all buildings and improvements subserve such design and recommendations and true economy.

Sec. 6. Donations in Trust. The managers may take, and hold in trust for the State, any grant or devise of land, or any gift or bequest of money or other personal property, or any donation, to be applied, principal or income or both, to the maintenance and education of epileptics, and the general uses of the colony.

Sec. 7. State Board of Charities. The Board of Managers of the Sonyea Colony shall annually, on or before the first day of November, for the preceding fiscal year ending September 30th, report to the State Board of Charities the affairs and conditions of the colony, with full and detailed estimates of the next appropriation required for maintenance and ordinary uses and repairs; and of special appropriations, if any, needed for extraordinary repairs, renewals, extensions, improvements, betterments, or other necessary objects; as also for the erection of additional buildings needed by reason of over-crowding, and in order to prevent the same, or to meet the need of sufficient accommodations for patients seeking admission to the colony, and the State Board of Charities shall, in its annual report to the Legislature, certify what appropriations are, in its opinion, necessary or proper.

The said colony shall be subject to the visitation and supervision and to the general powers of the State Board of Charities.

Sec. 8. Powers and Duties of Managers. Five members of the Board of Managers shall constitute a quorum for the transaction of business. The Board shall have the government of the patients, officers, employees, inmates, and inhabitants of the colony, and the general direction and control of all the persons, property, and concerns of the colony, not otherwise provided for by law; including the purchase of supplies and of raw materials for the trades and industries of the colony, and the sale and disposal of the manufactured products and the produce of the land, through its officers or agents, and the supply of necessary assistance to educate and profitably employ the labor of the patients; and shall take charge of the general interests of the colony, and see that its general design is carried into effect, and everything done faithfully and according to the requirements of the Legislature and the by-laws, rules, and regulations of the colony.

The managers shall elect from their number a president and a secretary, and may secure a seal. Documents and papers may be attested by the secretary, with, or without a seal; and when attested under seal shall be received in evidence as if duly acknowledged before an officer authorized to take acknowledgments of deeds.

The managers shall establish such by-laws as they may deem necessary or expedient for regulating the appointments, powers, and duties of officers, teachers, attendants, and assistants, for fixing the conditions of admission, treatment, education, support, and discharge of patients, and for conducting in a proper manner the business of the colony; and they shall ordain and enforce a suitable system of rules and regulations, for the internal government, discipline, and management of the colony.

The managers shall maintain an effective inspection of the affairs and management of the colony, for which purpose they shall meet at the institution at least twice in each year, at such times as the by-laws shall prescribe, provided that their annual meeting shall be held on the fifteenth day of October.

A committee of three managers, to be appointed by the Board at the annual meeting thereof, shall visit the colony once in every month, and perform such other duties and exercise such other powers as shall be prescribed in the by-laws or directed by the Board.

The Board shall keep in a bound book to be provided for the purpose a fair and full record of all its doings, which shall be open at all times to the inspection of its members, the members and officers of the State Board of Charities, and all persons whom the Governor or either house of the Legislature may appoint to examine the same.

Sec. 9. Officers of the Colony. The Board of Managers shall appoint, outside its members, two officers, namely: a superintendent of the colony, who shall be a well-educated physician and a graduate of a legally chartered medical college, with an experience of at least five years in the practice of his profession; and a treasurer, who shall reside in the county of Livingston, and shall give an undertaking to the people of the State, for the faithful performance of his trust, in such penal sum and form and with such sureties as the Comptroller shall approve.

Said officers and each of them may be discharged or suspended at any time by the said Board in its discretion.

The superintendent shall appoint a steward and a matron, who, with the superintendent, shall constantly reside in the colony, and he shall employ an experienced and competent bookkeeper, and such teachers, attendants, and assistants as he may think necessary or proper economically and efficiently to carry into effect the design of the colony; and he shall prescribe their several duties and places and fix their compensation; and he may, at any time in his discretion, suspend or discharge any of them.

The Board shall determine the annual salaries and allowances of the superintendent, steward, and matron, not exceeding, in addition to maintenance supplies, the following sums for salaries: Four thousand dollars to the superintendent; fifteen hundred dollars to the steward; fifteen hundred dollars to the matron, and the Board shall determine the annual salary of the treasurer of the colony, not exceeding two thousand dollars.

Such salaries and allowances shall be paid quarterly on the first days of October, January, April, and July, each year, by the treasurer of the colony, on presentation of the bills therefor, audited, allowed, and certified as prescribed in the by-laws.

Sec. 10. Duties of Superintendent. The superintendent shall be the chief executive officer of the colony, and, subject to the supervision and control of the Board of Managers, he shall discharge the following among other duties:

1. Oversee and secure the individual treatment and personal care of each and every patient of the colony while resident therein, and the proper oversight of all the inhabitants thereof.

2. Have the general superintendence of the buildings, grounds, and farm, with their furniture, fixtures, and

stock, and the direction and control of all persons employed in and about the same.

3. Give, from time to time, such orders and instructions as he may deem best calculated to induce good conduct, fidelity, and economy in any department of labor, or of education or treatment of patients.

4. Maintain salutary discipline among all employees, patients, and inhabitants of the colony, and enforce strict compliance with his instructions and uniform obedience to all the rules and regulations of the colony.

5. Cause full and fair accounts and records of the entire business and operations of the colony, with the condition and prospects of the patients, to be kept regularly, from day to day, in books provided for that purpose.

6. See that such accounts and records shall be fully made up to the first days of April and October in each year, and that the principal facts and results, with his report thereon, be presented to the Board at its semi-annual meetings.

7. Conduct the official correspondence of the colony and keep a record or copy of all letters by himself and by his clerks and agents, and files of all letters received by him or them.

8. Prepare and present to the board at its semi-annual meetings a true and perfect inventory of all the personal property and effects belonging to the colony, and account, when required by the Board, for the careful keeping and economical use of all furniture, stores, and other articles furnished for the colony.

9. Keep a record of all applications for admission of patients, and enter in a book, to be provided and kept for that purpose, at the time of the admission of each patient to the colony, a minute, with the date, name, residence of the patient, and of the persons on whose application he is received, with a copy of the application, statement, certificate, and all other papers received relating to such epileptic patient, the originals of which he shall file and carefully preserve, and certified copies whereof he shall forthwith transmit to the State Board of Charities.

Sec. 11. Duties of Treasurer. The treasurer, among his other duties, shall perform the following:

1. Have the custody of all moneys, notes, mortgages, and other securities and obligations belonging to the colony.

2. Keep a full and accurate account of all receipts and payments in such form as directed in the by-laws, and such other accounts as shall be required of him by the managers.

3. Balance all the accounts on his books on the first day of each October and make a statement thereof, and an abstract of all the receipts and payments of the past year; and, within three days thereafter, deliver the same to the auditing committee of the managers, who shall compare the same with his books and vouchers and verify the same by a further comparison with the books of the superintendent, and certify the correctness thereof to the managers at their annual meeting.

4. Render a quarterly statement of his receipts and payments to such auditing committee, who shall, in like manner as above, compare, verify, report, and certify the result thereof to the managers at their annual meeting, who shall cause the same to be recorded in one of the books of the colony.

5. Render a further account of the state of his books and of the funds and other property in his custody whenever required by the managers.

6. Receive for the use of the colony any and all sums of money which may be due upon any obligations or securities in his hands belonging to the colony, and any and all sums charged and due to the asylum for the support of any patient therein, or for actual disbursements made in his behalf for necessary clothing and travelling expenses, and any and all sums of money due to the colony.

7. Prosecute an action in the name of the people of the State to recover any sum of money that may be due or owing to the colony from all sources, including the bringing of suit for breach of contract between private patients or their guardians and the managers of the colony.

8. Execute a release and satisfaction of a mortgage, judgment, or other lien in favor of the colony when paid, so that the same may be discharged from record.

9. Pay the salaries of the superintendent, treasurer, the matron, and the steward of the colony, and of employees duly appointed as aforesaid, and the disbursements of the officers and members of the board as aforesaid.

The treasurer shall have power to employ counsel, subject to the approval of the Board of Managers.

Sec. 12. Designation and Admission of Patients. There shall be received and gratuitously supported in the colony, epileptics residing in each judicial district, who, if of age, are unable, or, if under age, whose parents or guardians are unable to provide for their support therein, and who shall be designated as State patients. Such additional number of epileptics, whether of age or under age, as can be conveniently accommodated, shall be received into the colony by the managers on such terms as shall be just, and shall be designated as private patients.

Epileptic children shall be received into the colony only upon the written request of the persons desiring to send them, stating the age, place of nativity, if known, Christian and surname, the town, city, or county in which such children respectively reside, and the ability of their respective parents or guardians or others to provide for their support, in whole or in part, and if in part only, stating what part; and stating also the degree of relationship or other circumstances of connection between the patients and the persons requesting their admission, which statements, in all cases of State patients, must be verified by the affidavits of the petitioners and of two disinterested persons, and accompanied by the opinion of a qualified physician, all residents of the same county with the epileptic patient, and acquainted with the facts and circumstances stated, and who must be certified to be credible by the County Judge or Surrogate of the county, and such Judge or Surrogate must also certify, in each case, that such State patient is an eligible and proper candidate for admission to the colony.

State patients, whether of age or under age, may also be received into the colony upon the official application of a County Superintendent of the Poor, or of the Commissioners of Charity or Overseers of the Poor of cities or towns having such officers.

It shall be the duty of the Superintendent of the Poor in every county, and of the Overseer, Commissioner, or Board of Commissioners of every city having supervision of the poor, to furnish annually to the State Board of Charities a list of all epileptics in their respective jurisdictions, so far as the same can be ascertained, with such particulars as to the condition of each epileptic as shall be prescribed by the said State Board.

Whenever an epileptic shall become a charge for his or her maintenance on any of the towns, cities, or counties of this State, it shall be the duty of all Overseers or Charity Commissioners, or other officers of the poor of such city, and of the County Superintendent of the Poor, and of the Supervisors of such county, to place such epileptic in the said colony.

Any parent, guardian, or friend of an epileptic child within this State may make application to the Overseer or Charity Commissioner, or Board of Commissioners or other officers having charge of the poor of any city or town, or the Superintendent of the Poor of any county, or the Board of Supervisors or any Supervisor of such county where such child may be, showing by satisfactory affidavit, or other proof that the health, morals, comfort, or welfare of such child may be endangered or not properly cared for if not placed in such colony; and thereupon it shall be the duty of such Overseer, Charity Commissioner, Poor Officer, Superintendent of the Poor, or Supervisor or Board of Supervisors, to whom such application may be made, to place such child in the said colony, provided that in all cases not properly coming under section thirteen relating to the support of State

patients, the Board of Supervisors shall provide for the support of such cases, and may recover the same from the parents or guardians of such children.

In the admission of patients, preference shall always be given to poor or indigent epileptics or the epileptic children of poor or indigent persons, over all others; and preference shall always be given to such as are able to support themselves only in part, or who have parents able to support them only in part, over those who are able, or who have parents who are able wholly to furnish such support.

Sec. 13. Support of State Patients. Each indigent patient and each patient who is the child of indigent parents received into the colony as aforesaid, shall be provided with proper board, lodging, medical treatment, care, and tuition; and shall be denominated State patient; and the managers of the colony shall receive for each of such patients so provided for, the sum necessary for such provision and purpose, not to exceed the sum of two hundred and fifty dollars per annum, the intent of this act being that the colony shall be self-supporting so far as practicable; which payments, if any, shall be made by the Treasurer of the State, on the warrant of the Comptroller, to the treasurer of the said colony, on his presenting the bill of the actual time and number of patients in the colony, signed and verified by the superintendent and treasurer of the colony, and by the president and secretary of its Board of Managers.

The Supervisors of any county, from which such State patients may have been received into the colony, shall cause to be raised annually, while such patients remain in the institution, the sum of thirty dollars, for the purpose of furnishing suitable clothing for each of such State patients; and the same shall be paid to the treasurer of the colony, on or before the first day of April of each year.

Sec. 14. The Support of Private Patients. The superintendent of the colony may agree with any epileptic who may be of age, or his committee or guardian, or with the parents, guardian, or committee of any epileptic child, or with any person, for the entire or partial support, maintenance, clothing, tuition, training, care, and treatment of such epileptic in the colony, on such terms and conditions as may be prescribed in the By-laws, or approved by the managers. Every parent, guardian, committee, or other person applying for the admission into the colony of an epileptic who is, or whose parents or guardians are, of sufficient ability to provide for his support and maintenance therein, shall, at the time of his admission, deliver to the superintendent an obligation, with one or more sureties, to be approved by the superintendent and treasurer, in such manner and penalty as the managers shall prescribe, to the effect that the obligors will pay to the treasurer of the colony all sums of money at such time or times as shall be so agreed upon, and remove such epileptic from the colony, free of expense to the managers, within twenty days after the service of the notice hereinafter provided for. If such epileptic, his parents or guardian are of sufficient ability to pay only a part of the expenses of supporting and maintaining him at the institution, such undertaking shall be only for such partial support and maintenance and for removal from the institution as above mentioned; and the superintendent may take security by such obligation, or in his discretion by note or other written agreement, with or without sureties as he may deem proper, for such part of such expenses as the epileptic, his parents or guardians are able to pay; but such exercise of discretion shall be subject to the approval of the treasurer and a committee of the managers, in the manner that shall be prescribed in the By-laws. Notice to remove a patient shall be in writing, signed by the superintendent and directed to the epileptic, his parents, guardians, committee or other person upon whose request the patient was received at the colony, at the place of residence mentioned in such request, and deposited in the post-office at Sonyea, or any post-office in Livingston County, with the postage prepaid.

Sec. 15. Discharge of Patients. The superintendent of the colony, with the approval of the managers or of its committee duly empowered, shall have power to discharge patients; provided that no epileptic patient shall be returned to any poorhouse directly through a superintendent of the poor, or otherwise.

In case a patient, not an epileptic, shall be sent to the colony, through mistaken diagnosis of his disease, or other cause, and there received, such patient shall be returned to, and the travelling expenses of such return shall be paid by the person who sent him or her to the colony.

Should an epileptic patient become insane, and be so certified, as prescribed by the statute, such patient, if a State patient, shall be sent to the State Hospital of the district of which he was a resident just prior to his admission to the colony, or, if a resident of New York to the asylum of that county, of if a resident of Kings to the asylum of that county. Said State patient shall be sent to said State Hospital, or County Asylum, in a manner prescribed by the President of the State Commission in Lunacy, at the expense of the State, and any State Hospital or County Asylum to which said patient is to be sent may be required, by and under the regulations made by said President, to send a trained attendant to bring the patient to the hospital or asylum.

In all cases there shall be provided a female attendant for every female patient.

The bills for the reasonable expenses incurred in the transportation of State patients to the State Hospitals, or Asylums of New York and Kings Counties, after they have been approved in writing by the State Commission in Lunacy, shall be paid by the Treasurer of the State on the warrant of the Comptroller from the funds provided for the support of the State Hospitals.

In case any insane person, his relatives, guardians, or friends desire that he may become an inmate of any State Hospital situated beyond the limits of the district of which he was formerly a resident, or outside of New York and Kings, if a resident of either of those counties, and there be sufficient accommodation there to receive him, he shall be received there upon the same grounds and terms, and the same in all respects as are or may be at any time provided by law, respecting transfers of other insane persons.

Private patients, who may become insane, and are so certified, as prescribed by law, shall be committed, subject to the regulations of the State Commission in Lunacy to such institution for the insane as may be designated by such patient, his or her relatives, guardians, or friends, all travelling and other expenses of removal to be paid by them.

After any patient has been delivered to the managers or officers of any of said hospitals or asylums, the care and custody of the managers of the colony over such insane person shall cease; and after any patient shall, as aforesaid, be so certified to be insane as prescribed by law, such patient shall come under the supervision of the State Commission in Lunacy.

Sec. 16. Apportionment of State Patients. Whenever applications are made at one time for admission of more State patients than can be properly accommodated in the colony, the managers shall so apportion the number received that each county may be represented in a ratio of its dependent epileptic population to the dependent epileptic population of the State as shown by statistics furnished by the State Board of Charities.

Sec. 17. Notice of Opening of Colony. So soon as the colony shall be ready for the reception of patients, it shall be the duty of the Board of Managers officially to notify the County Clerks and the Clerks of the Boards of Supervisors of the respective counties of the State, and the Secretary of the State Board of Charities; and to furnish said clerks of the counties and of the Boards of Supervisors with the suitable blanks for admission and entrustments of epileptics to such colony.

Sec. 18. Appropriations. The sum of one hundred and fifty thousand dollars, or so much thereof as may be necessary, is hereby appropriated for the purposes of this act, out of any moneys in the treasury not otherwise appropriated. The Treasurer of the State shall, on the

warrant of the Comptroller, pay to the treasurer of the Board of Managers of said colony, such sums as may from time to time be required for the purchase of land, improvements, and betterments, erection of buildings and furnishing the same, heating, lighting, and ventilating the same, and putting the lands and buildings into proper condition for the reception of patients, not to exceed one hundred and twenty-five thousand dollars for the purchase of the land as hereinbefore provided, and not to exceed twenty-five thousand dollars for such other purposes; provided that such purposes and all requirements upon which such payments shall be made shall be certified to the Comptroller by said Board of Managers, in writing, specifying the items, the purposes for which the said sums are required, and be verified by the affidavit of the superintendent and treasurer of the colony, and of the president and secretary and majority of the said Board of Managers.

Sec. 19. This act shall take effect immediately.

While these measures have been in progress in the United States, a similar movement has been inaugurated in England. The Countess Meath has established at Godalming a small home for epileptics, in which instruction and occupation are among the principal features aimed at. There has been organized in Great Britain also a National Society for the Employment of Epileptics which numbers among its members many medical men of eminence and many citizens of wealth and influence. This society proposes to acquire a tract of land in England for the purpose of colonizing epileptics, according to the system herein advocated.

The care of the epileptic population is then to be summarized as follows:

All are to be treated in accordance with the usual regulations as to diet, hydrotherapy, and medicinal agencies, with the hope that in this way between one and six per cent. of them may be cured, and the disorder in a larger percentage ameliorated.

Out-of-door employment in agriculture and kindred pursuits is to be provided in abundance. All manner of trades and occupations are to be carried on in an epileptic community, organized on the village plan. Facilities for education are to be afforded to almost every extent.

Amusement and entertainment and the enjoyment of social intercourse are to be privileges from which no epileptic will hereafter be debarred.

In this way the happiness of a large number of these miserable creatures will be materially increased, in spite of the distressing disease which they are called upon to suffer, usually for the whole of their lives; and though remedial agents applied to their malady may prove inefficient, their fate can never be as wretched or hopeless as it has been throughout the world heretofore.

Although it is not given to every epileptic to describe his own sufferings as Dostojewsky does in his novel "The Idiot," or to delight the world with music as did the epileptic Handel, or with comedy as did Molière, or with poetry as did Petrarch, or with military exploits as did Cæsar and Napoleon, or with religion as did Mahomet and St. Paul, still it is a consolation to those afflicted with this malady to know that epilepsy and genius may coexist, and that the possession of the disease does not necessarily lead to mental and moral degeneration. The patient may not reach the highest position among mankind, but under the new dispensation he will not be withheld from any attainment in education, nor prevented from exercising all of his capabilities for his own support and for his own welfare and happiness.

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Drs. Henry R. Stedman, W. N. Bullard, and L. W. Baker, in this country, have also contributed to the movement for better care for epileptics, especially in their State of Massachusetts.

Frederick Peterson.

ETHYL CHLORIDE. This has recently been introduced as a local anæsthetic, and promises to prove of decided value. It is obtained by saturating an artificially cooled alcoholic solution of chloride of zinc with hydrochloric acid gas. It is also obtained as a by-product in the manufacture of chloral. Its chemical formula is $C_2H_5Cl_4$. At ordinary temperatures it is a gas, but is easily compressed into a colorless liquid with a pleasant ethereal odor. Below 50° F. it remains a fluid, but at that temperature it is volatilized and becomes a light and very inflammable gas.

Advantage has been taken of its rapid evaporation to utilize the intense cold produced, as a local anæsthetic, in dental and minor surgical practice, and for the relief of the pain of superficial neuralgia. It has been used with satisfaction for the extraction of teeth, opening of abscesses, removing ingrowing toe-nails, and similar painful operations, and has been found to give instantaneous relief in facial neuralgia, intercostal neuralgia, and sciatica.

The method of utilizing this property has been made simple and easy by M. Mounet, of Lyons, who suggested the storing of the compressed fluid in small capsules and tubes, by which means it may be preserved without alteration for a great length of time. When the drug is required for use the point of the capillary tube is broken off, and the opening directed downward on the part to be anæsthetized. The heat of the hand is sufficient to raise the temperature of the fluid above its boiling point, and a stream of the rapidly volatilizing fluid issues as a spray, and may be applied to any part. The stream may be made weaker or arrested by simply closing the opening with the finger, or made stronger by grasping a larger portion of the tube and raising the temperature of its contents. It is considered best to hold the tube from six to ten inches away from the surface, to avoid excessive and useless cold. Each tube contains about two and a half drachms, which is sufficient to annul the sensibility of the skin and the parts immediately beneath, over a surface and to a depth sufficient for small operations. For the removal of teeth the spray is to be directed on the mucous membrane of the gum. The membrane is first dried and then rubbed with glycerine or oil, and the spray applied until the part becomes white. The sound teeth, as well as the mucous membrane of the mouth, must be protected by a napkin, and the patient directed to breathe only through the nostrils. It is said that the teeth may be extracted without pain by directing the spray against the cheek, over the inferior maxillary nerve for the lower jaw, and at the exit of the trigeminal nerve, in front of the ear, for the upper jaw.

It is simple in application and requires no apparatus, which gives it a decided advantage over methyl chloride, CH_3Cl, which has also been used for the same purpose. The low boiling-point of this older anæsthetic (− 1.4° F.)

requires a careful management to control its action and avoid excessive freezing and destruction of tissue. Methyl chloride also at times affects the system, causing more or less disturbance of the brain and mental faculties. Ethyl chloride in no way produces any effect beyond its local action. Its one objectionable feature is its great inflammability, which must be guarded against by performing the operation at a distance from a flame.

Drs. H. C. Wood and Cerna report in the *Therapeutic Gazette*, August, 1892, a series of experiments upon the anæsthetic properties of ethyl chloride when administered by inhalation. Anæsthesia was produced in the animal when the fluid was poured into a closed cone, almost impervious to air, and held closely to the nostrils. The anæsthesia was rapid and of short duration, ten grammes producing insensibility for only two minutes. It also caused the desired effect when injected into the veins, but failed to do so when the vapor was forced into the lungs through a tube inserted into the trachea.

As a result of their experiments they conclude: (1) That the chloride of ethyl is capable of acting as an anæsthetic, but that it is eliminated with extraordinary rapidity, and that its action is extremely fugacious; (2) that the anæsthesia which it produces is always accompanied by a fall of the blood-pressure, which is probably, at least in part, due to a direct depressing effect of the drug upon the heart; (3) that the action of the drug upon the circulation is in no way dependent upon its influence upon the respiration, although it is not certain that the pronounced depression of the blood-pressure is not a factor in influencing respiratory movement; (4) that, at least in the dog, chloride of ethyl produces at first an increase of the respiratory movement, either in rate or amount, or more commonly in each respect, but that finally respiration becomes slow, and at last stops abruptly; (5) that usually, if not always, the cessation of heart-beat and the arrest of respiratory movement occur as nearly simultaneously as may be. They think that the fugacious action and its depressing effects will prevent its becoming used as a safe anæsthetic, but are satisfied that the small amount that may be inhaled during its local use for dental purposes, has practically no effect on the system, as it is very rapidly eliminated.

Beaumont Small.

ETHYLENE BROMIDE. This organic compound has been introduced into therapeutics as a convenient means of supplying bromine in cases where its use is indicated for a prolonged period. The advantage claimed for it is, that it is not combined with potassium, sodium, or any basylous radicle, and its use does not disturb the digestion, the skin, or the mucous membranes, or produce any of the unpleasant effects that the older salts are liable to cause.

It is the di-brom derivative of ethane, in which each bromine atom is attached to a separate carbon atom; its chemical formula is $C_2H_4Br_2$. It is a colorless or faintly brown liquid, containing 90.9 per cent. of bromine. The odor is agreeable and taste sweetish. Its specific gravity is 2.163 at 69.8° F. Below 48° F. it becomes a solid, forming crystals. It is insoluble in water, soluble 1 in 4 of rectified spirit, and miscible in all proportions with absolute alcohol and oils.

The employment of ethylene bromide in epilepsy has been recommended by Dr. J. Donath.[1] He used it in a great number of cases, and reports the details of ten cases in which he was able to watch its effects carefully. As a substitute for the bromides he found it very satisfactory, and the results he considers were much better. The cases were all of long standing and had been subjected to many forms of treatment. Under its use the attacks became milder, shorter, and fewer in number, and in many instances assumed the character of *petit mal*. In three of the cases the convulsions were replaced by simple muscular twitchings without loss of consciousness.

The dose administered was six to twelve drops three times a day. It may be given in capsules with oil or in solution. The following preparations are recommended: (1) Ethylene bromide, 75 grains; oil of almonds, emulsion, 1,500 grains; oil of peppermint, 2 drops; dose, thirty drops three times a day, in a third of a glass of milk. (2) Ethylene bromide, 75 grains; rectified spirits, 75 grains; oil of peppermint, 2 drops; dose, five to ten drops three times a day. In preparing these mixtures the high specific gravity must not be forgotten, it being nearly two and a half times as heavy as water. Before using the drug Donath tested its action on himself, and found that in ordinary doses it did not produce any disturbing effects; but in large doses it was sometimes followed by nausea.

This drug must not be mistaken for ethyl bromide, which it resembles both in name and appearance. A case is reported[2] in which such a mistake was made with fatal consequences. A written order for the anæsthetic, ethyl bromide, was sent to a druggist, who supplied ethylene bromide. Ten drachms were inhaled without producing any insensibility or anæsthesia. The administration was followed by suppression of urine and uncontrollable vomiting, which continued until the patient died, upon the following day. At the post-mortem examination there was found an hyperæmia of the meninges of the brain, also of the lungs, spleen, and kidneys. The liver was much enlarged, of a dirty-yellow color, and the cells were affected by a granular degeneration.

Beaumont Small.

[1] British Medical Journal, July 11, 1891.
[2] The London Lancet, January 10, 1891.

ÉTRETAT. One of the most frequented seaside resorts on the Channel coast. Étretat is in the Department of Seine-Inférieure, France. It is situated between two cliffs, over 250 feet high, and is famous for its picturesque appearance. It was formerly a mere fishing village, but is now very fashionable, so that at the height of the season, in July and August, it is often impossible to secure proper accommodation. Baughan, in the "Northern Watering Places of France," gives the following description of the bathing peculiarities:

The beach of Étretat is lower than the sea at the high tides, from which it is protected by a dyke of bowlders, which, however, is constantly being removed by the waves, which lash the shore with great violence at certain seasons of the year; so much so that it is the custom at Étretat every year at the *fête* of Ascension Day for the priests to go down to the shore to pronounce a benediction on the sea, and to exhort it to respect its limits. Picturesque and charming as Étretat is, the bathing is not so pleasant as in other places along the coast, for apart from the fact that the bowlders are not such a pleasant footing as sand, the bathing is dependent on the state of the tide, and, therefore, hours of meals, occupations, and even the amusements of the place, seem to depend on the tide.

Edmund C. Wendt.

EUGENOL, EUGENIC ACID, is formed from the oil of cloves by oxidation; it may also be obtained from other essential oils, as cinnamon, bay, pimento, sassafras. Its chemical composition is C_6H_3. $C_3H_5(OH)(OCH_3)$. It is an aromatic, oily liquid, colorless, with a strong clove odor. On exposure to the air it turns brown. It is readily soluble in alcohol but only very sparingly so in water. It forms compounds of a definite character with caustic alkalies. It possesses powerful antiseptic properties which are said to be superior to those of phenol. It has also been recommended as a febrifuge, but is inferior to salicylic acid, quinine, antipyrine, etc. Eugenol, which is somewhat analogous to guaiacol, has become of some importance on account of its being suggested for administration in tubercular diseases by Dr. Koch. He recommends its administration during the tuberculine treatment. The dose is forty-five minims during the day, dissolved in spirit and diluted with water. Applied locally, eugenol has a mild local anæsthetic action. It is useful for toothache and for painful affections of the skin; in the latter class of cases it is applied as an ointment with lanoline.

Two derivatives of eugenol—benzoyl-eugenol and cinnamyl-eugenol—have lately been introduced, and are be-

ing used in the treatment of tubercular affections. Their dose and action are as yet uncertain.

Benzoyl-Eugenol, the benzoate of eugenol, occurs in neutral acicular crystals, free from color and odor, but having a faint bitter taste, very slightly soluble in water, but freely in alcohol, chloroform, and ether. With concentrated sulphuric acid it gives a purple-red color, which is characteristic of eugenol; this reaction distinguishes it from benzosol, a compound of benzoyl and guaiacol (the latter gives a pale yellow color). Its melting-point is 158° F.

Cinnamyl-Eugenol also is formed in colorless, neutral crystals, free from odor and taste. Its solubility is the same as the benzoyl salt. With sulphuric acid it gives the same reaction as its fellow salt, but may be distinguished by its melting-point, 194° to 198° F.

Beaumont Small.

EUPHORBIA PILULIFERA. A plant of the order Euphorbiaceæ, which has been recommended as a remedy for spasmodic affections and neuroses of the respiratory tract. It is indigenous to Australia, Brazil, and other southern tropical countries. It derives its specific name from the seeds, which are held in capsules in the axils of the leaf, and when ripe are brown and hard. It is commonly known as the pill-bearing spurge. It is a very common annual herbaceous plant, and has a local reputation as a curative agent in all pulmonary troubles. Dr. Mattheson, of Queensland, was the first to call attention to its value in asthma, paroxysmal dyspnœa, whooping-cough, and other spasmodic affections. Later it was studied by Dr. Marsset, under the direction of Dujardin-Beaumetz, and the result of his researches was published in the *Therapeutic Gazette*, February, 1885. Its action is directed to the respiratory and cardiac centres, and causes a retardation of the respiration and pulse, and when death has been produced it arises from a paralysis of these organs. It does not influence any of the other organs of the body, but when administered it produces an irritant action on the gastric mucous membrane.

Its active principle is an acrid resin, which is soluble in water and dilute alcohol. Experiments on animals show that one part of the resin to one hundred of the animal, by weight, will produce a fatal result.

It has proved of service in all spasmodic affections of the bronchial tubes and lungs, in the dyspnœa of emphysema of the lungs, and in that due to cardiac affections. Dujardin-Beaumetz recommends it to be used in all cases in which iodide of potassium is used to relieve dyspnœa. It has also been used to relieve the spasms and distress of angina pectoris, and in hay asthma and coryza. In the latter diseases it rapidly checked the sneezing and other troublesome symptoms.

The dried plant is used and its virtues are said to be best extracted by water. A decoction may be made by steeping half an ounce of the plant in two quarts of water, the dose to be three or four wineglassfuls during the day. A tincture may be made of one part to five of proof spirit: dose, ten to fifteen minims, three times a day. It is advisable always to begin with small doses and gradually increase the amount, watching its effect, as its action is sometimes violent. The administration cannot be continued for a great length of time owing to its irritant action on the stomach.

Beaumont Small.

EUPHORIN (Phenyl-urethan. Carbonate of ethyl and phenyl). Its formula is $C_6H_5NHCOOC_2H_5$. This is a compound derived from aniline and is somewhat allied to acetanilide. It occurs as a white crystalline powder, with a faint aromatic odor and slight taste, almost insoluble in water, but freely soluble in weak alcohol and wines. It was introduced in 1890 by Dr. Sansoni to replace antipyrine, antifebrine, and other drugs of the same class. It was said to possess all their medicinal properties and to be devoid of their many objectionable effects.

In a large number of cases of fever due to various causes in which it had been used as an antipyretic the temperature fell quickly within one hour. The fall reached its maximum in about three hours, and lasted for five or seven hours. The subsequent rise of temperature was usually rapid. Its action was found to vary in different individuals. It is advised to commence with a dose of three grains, which may be increased until fifteen or thirty grains are given daily. In acute rheumatism fifteen grains daily caused disappearance of the swelling and pain in the joints and lowered the temperature. In chronic cases the results were not so satisfactory. Subsequent observers have also found it of benefit in sciatica, migraine, neuralgia, and in some cases of muscular rheumatism. As an external application its antiseptic properties have been made use of as an application to wounds, ulcers, burns, etc. Dusted on the surface it has acted very beneficially; the parts are rapidly rendered clean and healthy, the secretion is diminished, and cicatrization promoted. It does not cause pain or in any way prove irritating. It may also be used as an ointment. For internal administration it should be given in wafers, or in solution in weak alcohol or with wines. It must never be combined with antipyrine, as chemical decomposition takes place and a fluid results.

Beaumont Small.

EUROPHEN. This is one of the many compounds containing iodine and devoid of any disagreeable odor, that have been introduced as substitutes for iodoform. Chemically it is di-isobutylortho-cresol iodide, its formula being $\left(\begin{matrix}C_4H_9\\CH_3\end{matrix}>C_6H_3O\right)_2HI$. Its relation to cresol and iodine is much the same as that of aristol to thymol and iodine. It is prepared by adding isobutyl alcohol to ortho-cresol with zinc chloride, at a high temperature, which forms isobutyl ortho-cresol. This is dissolved in a dilute alkaline solution and then mixed with a solution of iodine in iodide of potassium, which yields a copious precipitate of the above compound. This is collected, washed, and dried in the dark.

It is an extremely light amorphous yellow powder, with an aromatic odor resembling saffron. It contains 27.6 per cent. of iodine. It is insoluble in water and glycerine, soluble in alcohol up to thirty per cent., and in ether, chloroform, collodion, and fatty oils up to twenty-five per cent. It must be excluded from light and heat, as it is readily decomposed. In contact with water it is slowly decomposed, yielding free iodine. Alcoholic and ethereal solutions also evolve iodine if kept for a long time.

Starch or starchy preparations should never be prescribed with europhen, as the reaction between the two is rapid, particularly when water is added to the mixture, or when the fluid secretions cause the powder to evolve the iodine freely. The metallic salts, especially zinc and mercury, so freely used in dermatology, should never be combined, on account of the well-known incompatibility of these metals. The most durable mixtures are those prepared with oil or lard, vaseline or lanoline. The latter is to be preferred, as it allows of a greater amount of absorption of the fluids, and consequently a more thorough action of the application. Europhen is, however, a dry antiseptic, and is most effective when applied as a powder directly to the part. Its action is due to the continuous liberation of free iodine, which commences as soon as the drug comes in contact with moisture. This gradual escape of iodine, together with the well-known antiseptic properties of the cresol also present, has a very decided effect in checking the growth of bacteria, and also prevents the reducing power of bacteria having an anaërobic growth. It, however, is devoid of bactericidal action, and in no way destroys bacteria or spores. Over iodoform it possesses certain advantages. It is free from the powerful penetrating odor that is so objectionable; its toxic properties are only evident after very large doses, and for internal use it may be administered without fearing any dangerous symptoms. As much as twenty-two grains have been taken daily, for three weeks, without the slightest discomfort. It is extremely light, being about

five times as bulky as iodoform, and readily adheres to the skin or mucous membrane.

The use of europhen is indicated in all cases where iodoform is employed in wounds and ulcers and ulcerated surfaces, and in diseased conditions of the nasal and pharyngeal cavities, of the vagina and uterus, and all mucous surfaces. In various forms of skin disease it has proved beneficial, especially the acute and chronic eczemas. It has also been found useful as an application in erysipelas. An alcoholic or ethereal solution, of the strength of ten per cent. of the powder, has been said to act remarkably well when applied to syphilitic ulcers and to the initial sores. It is also administered internally in all stages of syphilitic disease, but is most recommended as being very active in the third stage, and is thought to replace the iodide of potassium as a specific. The dose to commence with should be one-quarter of a grain, gradually increased to one or two grains. If it is administered too rapidly there is a danger of iodism manifesting itself. The same amount may be used hypodermically, a ten per cent. solution in oil being prepared for this purpose. For external use as an ointment the following has been selected as an excellent combination: Europhen, 3 parts; olive-oil, 7 parts; vaseline, 60 parts; lanoline, 30 parts. *Beaumont Small.*

EVIAN-LES-BAINS. A watering-place and climatic resort on the Lake of Geneva, France.

Location.—Evian is a little town, having a population of 2,600, situated on the southern or Savoy side of the Lake of Geneva. It is built close to the edge of the water, and lies directly opposite the city of Lausanne. It is pleasantly located, with charming views in all directions, and, apart from the popularity of its mineral springs, is known for the genial mildness and equability of its climate.

Access.—By rail or steamer from Geneva, also by rail from Aix-les-Bains.

Analysis.—There are six principal springs, all having about the same composition, and all very faintly mineralized. The temperature of the water is about 54° F. It is colorless, faintly alkaline, and so pure and agreeable to the taste that it is largely used as a mere table-water. The Source Bonnevie, according to an analysis of the *École des Mines*, contains in 1,000 grammes:

	Grammes.
Bicarbonate of lime	0.2210
Bicarbonate of magnesia	0.0150
Bicarbonate of soda	0.0200
Bicarbonate of potash	0.0070
Phosphate of soda	0.0017
Carbonic acid, free	0.0970
	0.3617

Traces of alkaline chlorides.

Indications.—A course of Evian waters is frequently prescribed to supplement the rigorous cure at Aix-les-Bains. According to Dr. Vintras ("Medical Guide to the Mineral Waters of France"), "the Evian waters are drunk, and used for baths and douches. As shown by the analysis, nothing in their chemical composition indicates their well-known therapeutical value. They agree perfectly with the stomach, and act as an excellent diuretic in cases of gravel, enlargements of the prostate, and catarrhal affections of the bladder and kidneys, by the species of irrigation which they produce in the interior of these organs. If there is irritability of the urinary passages, caused by the presence of a calculus, or after lithotritic operations, they are to be preferred to those of Vichy, Vittel, or Contrexéville, which in such cases would be much too exciting.

"Chronic affections of the digestive organs, such as dyspepsia, gastralgia accompanied by acid eructations, pyrosis, chronic irritation of the intestines, chronic diarrhœa, obstinate constipation, hemorrhoids, etc., are all treated with benefit at Evian. Patients suffering from the irritability which accompanies most forms of chronic neuralgia have been relieved from it, after using the waters for some days. It is supposed to have a calmative influence in all kinds of hypersensitive conditions."

The amount of water taken varies from two glasses to twenty-five per day. The baths are soothing and sedative, and patients generally sip several glasses of mineral water while in the tub.

Accommodation.—There are good hotels like the *Grand Hotel des Bains*, a Casino, and two thermal establishments with modern comforts and hydrotherapeutic appliances. Life is gay during the season, there being plenty of amusements. *Edmund C. Wendt.*

EXALGINE. This is the trade name of methylacetanilide. Its chemical formula is $C_6H_5NCH_3C_2H_3O$; it is formed by the addition of the methyl group, CH_3, to acetanilide, $C_6H_5NHC_2H_3O$, replacing one atom of hydrogen. It occurs as beautiful needle-shaped crystals, colorless, with a faintly aromatic odor and slightly pungent taste. It is almost insoluble in cold water, slightly soluble in hot, and very soluble in dilute alcohol. From sixteen to twenty grains may be dissolved in half a drachm of rectified spirit and this solution diluted with two or three ounces of water without producing any precipitation. Its melting-point is 212° F., and it may be heated to its boiling-point, 240° or 250° F., without causing decomposition. By the addition of soda it is decomposed and partially converted into methylaniline. Hydrochloric acid causes the same decomposition. The presence of methylaniline and other compounds of the same base may be detected by the irritating fumes produced when the impure salt is heated with alcoholic solution of potash and chloroform. Its purity may be further tested by dissolving in nitric acid, which forms a colorless solution; when heated this becomes of a bright yellow color, and evolves irritating fumes. Exalgine may be distinguished from acetanilide, phenacetine, and methacetine by treating two grains of the suspected salt with twenty minims of hydrochloric acid. Phenacetine remains undissolved; acetanilide dissolves but separates again in crystals; methacetine also dissolves and gradually colors the solution reddish-brown on the addition of one drop of nitric acid. Another test for the presence of phenacetine or acetanilide is to treat a chloroform solution with ten volumes of petroleum ether; if either of these substances is present a turbid mixture is formed.

Methylacetanilide was discovered in 1874 by A. W. von Hofman. Its therapeutic properties were studied to a certain extent by Kahn and Hepp during their researches upon acetanilide and other antipyretics, but it was not until March, 1889, that Dujardin-Beaumetz and Bardet made known its value as an analgesic, in a communication to the French Academy. A very careful series of experiments, both physiological and clinical, enabled them to indicate its therapeutic qualities with a marked degree of accuracy. With the other members of the aromatic series it was found to possess antiseptic, antipyretic, and analgesic properties, and they also pointed out that its action on the nervous system should make it of value in the treatment of many functional diseases. It was as an analgesic that they particularly advocated its use; the addition of the methyl atom to acetanilide had intensified this action without affecting its antipyretic properties, but it was found that a dose large enough to produce antipyresis, was accompanied by such alarming toxic symptoms that this use could not be considered. They advocated its employment in headache, migraine, neuralgia, neuroses of the viscera, the pains of locomotor ataxia, and in all non-febrile affections accompanied by pain. It was thought to be the most serviceable organic compound yet obtained for this purpose. It proved quite as active and certain as antipyrine, and yet never produced any disturbance of the digestive organs, never gave rise to any rash, nor had they found it accompanied by any distressing symptoms in the cases in which they had used it to relieve pain. It was found to relieve pain by producing insensibility without in any way affecting tactile sensibility or causing any other noticeable change in the condition of the patient. The dose they advised

was from four to six grains (0.25 to 0.40 gramme) in a single dose, or from six to eleven and a half grains (0.40 to 0.75 gramme) in the twenty-four hours.

Following this highly laudatory introduction, the use of the drug became very general, and the reports that followed were chiefly in accord with the statements of Dujardin-Beaumetz and Bardet; but it was also found that toxic symptoms frequently followed its use and that its employment was not without danger.

In Great Britain the notice of the profession was particularly directed to the value of this remedy by Professor Fraser, of Edinburgh,[1] who gave the results of his experience with it in the Royal Infirmary. The remarkable point in Professor Fraser's paper was the smallness of the dose and the success that followed its use in such quantities. The usual dose was half a grain in spirituous solution, repeated three or four times a day, according to the return of the pain. In some cases it was increased to one and two grains, and in a few instances four grains were given; the largest quantity given was fourteen grains during the twenty-four hours. In the cases of neuralgia and angina half-grain doses would relieve the pain in ten or fifteen minutes, and in one hour there would be perfect ease, which lasted from three to nine or ten hours, and in many instances a complete cure was obtained. In sciatica and locomotor ataxia one and two grains secured the same freedom from suffering. In cancerous disease and in the pain accompanying an aneurism the success was less marked, and it was in these cases that the larger doses were given. Dr. Fraser considers that the smaller dose is the proper method of administering the drug, and that all its virtues may be as readily secured as with the larger doses. When given in this way, there is not the slightest danger of any unfavorable symptoms, as in none of his cases did any such occur. He considers methylacetanilide to be an analgesic of much value, not so powerful as opium, but devoid of any of the latter's disturbing influence on the system and free from any danger. The following table, arranged by Dr. Fraser, shows at a glance the diseases in which he used this remedy and the successes and failures in each class of cases:

Disease.	Number of observations.	Successful.	Unsuccessful or doubtful.
Facial neuralgia	8	8	..
Sciatica	10	9	1
Herpetic neuralgia	10	9	1
Neuralgia of arm, in hemiplegia	11	11	..
Locomotor ataxia, first case	2	2	..
Locomotor ataxia, second case	1	1	..
Toothache, first case	2	2	..
Toothache, second case	2	2	..
Toothache, third case	2	2	..
Toothache, fourth case	2	.	2
Cardiac angina	2	2	..
Pleuritic pain, first case	1	.	1
Pleuritic pain, second case	4	4	..
Rheumatic synovitis	4	4	..
Blennorrhagic rheumatism	2	1	1
Gastric pain, cancer	2	2	.
Gastric pain, catarrh and cicatrized ulcer	4	2	2
Cancer in abdomen	10	6	4
Carcinoma of liver	2		2
Aneurism of aorta	4		4
Lumbar abscess	3		3

Following Dr. Fraser's paper came a number of reports of successful results with half- and one-grain doses, by Drs. Herschell,[2] Farrar,[2] Holden,[3] Maloney,[4] and many others. In these cases there was the usual success in pains of a purely neurotic character, and less favorable effects where it was due to organic disease or mechanical causes. It was found to be of greatest service in spare persons of a nervous temperament, and those subject to neurotic derangements. Contrary to the views of Dujardin-Beaumetz, it proved to be of much service in certain febrile troubles, particularly the headache and neuralgia of the epidemic of influenza, but in such cases it was inferior to the other new antipyretics, antipyrine and acetanilide.

The small doses recommended by Dr. Fraser, however, were not accepted generally. On the continent the doses of four to six grains were more frequently given; in England it was often found necessary to increase the dose to this amount, and many from its first use had adopted the larger doses of Dujardin-Beaumetz. Many reports of its complete failure were also made, but it has been very generally accepted as having useful analgesic properties, and promises to remain as a permanent addition to our armamentarium.

Exalgine has been used with equally favorable results in infantile troubles. Dr. Moncorvo [5] publishes his experience of its use in twenty-one cases of children ranging from one to twelve years of age, in which it was given for the relief of pain. He considers it a very useful agent. It was well borne in every case, no unfavorable symptoms being ever noticed. The dose commenced with was three-fourths of a grain, increased in some cases to five grains. In one case choreic symptoms were present and were improved.

Its use in chorea has been reported upon by Dr. Hugo Lowenthal.[6] Thirty-five cases were treated with doses of three grains, usually three times a day, never exceeding fifteen grains in the twenty-four hours. The effects were very satisfactory. The mild cases were cured quickly, but the more severe ones were less influenced and required more time. The beneficial effects of the treatment were most marked in the cases in which it was given early in the course of the disease, in two cases a cure being effected in eight days. A favorable influence over the mental state was also noticed; the fear and nervousness were lessened and the intelligence brightened. In some of the cases in which it was administered for a prolonged period, nausea, vertigo, headache, and other distressing symptoms were noticed.

Unfortunately the occurrence of toxic symptoms are not infrequent. No fatal termination has yet been reported, but the condition of the patient becomes very alarming both to the friends and to the physician. The toxic disturbances, however, are far in advance of its fatal dose. Experiments on animals have shown that the lethal quantity is seven and a half grains for each two pounds of the weight of the animal, and three grains, it has been found, will give rise to severe symptoms. The poisoning arises from the action of the drug on the nervous centres as well as from the alteration that occurs in the condition of the blood. The changes in the blood are the same as are produced by all aniline compounds, by which the hæmoglobin is altered into methæmoglobin and the function of oxidation interfered with. The approach of the toxic action is noticed by a sense of fulness in the head, a constriction and oppression of the chest, dyspnœa, vertigo, dizziness, numbness, disturbances of vision. This is followed by a rapid pulse, shallow respiration, and all the sensations of death with symptoms of asphyxia and collapse. Unconsciousness is common in the severe cases of poisoning; convulsions do not so frequently occur. Generally, very large quantities are given before any ill effects are noticed. In one instance [7] the drug was continued for seventeen days, in gradually increasing doses, and during the last seven days eighteen grains were administered daily. In another case [8] thirty-six grains were given within nine hours, and in another,[9] twenty-four grains within two hours. The ill effects of the drug generally follow the prolonged use of the drug, or the administration of large doses, but in some instances very small doses have produced very alarming effects. An instance [10] is reported in which two doses of three grains caused all the serious symptoms of poisoning, and another instance in which two doses of five grains were given with the same effect. A remarkable [11] case is reported in which, in an adult, two doses of one and two grains, respectively, produced most profound prostration. The symptoms came on about an hour after the last dose, while the patient was sitting at a table engaged in a game of cards. He first complained

of a fulness in the head and suddenly fell prostrate, unable to speak or move, and gasping for breath. A second attack took place in about an hour, and the oppression and dyspnœa continued for several hours. Very different to these cases are those in which very large quantities have been given without evil consequences. Dr. Churton[12] reports two such cases. In the refilling of a bottle of medicine a mistake was made by which a solution was prepared of one grain to a drachm, instead of one grain to the ounce. The medicine was given as usual, four grains instead of half a grain being contained in each dose. This was continued for several days, and during the last twenty-four hours before the mistake was detected the patient was given forty grains. The pulse and respiration were rapid, and the patient complained of a burning sensation in the stomach, but no other effects were noticed. The second patient was given twenty-four grains from the same preparation without producing any other effect than slight vertigo and a sense of being "dazed," which caused her to walk unsteadily. The quality of the drug is vouched for, as it was given to a number of patients with satisfactory results, and small doses were again given to the first patient, and its analgesic action secured.

The quality of the drug undoubtedly affects its action, and in many instances explains the varying results that follow its use, but certain conditions of the system must exercise a decided influence, probably by promoting the decomposition of the drug and the formation of more toxic compounds. Mr. Bokenham[7] dwells upon this point in his remarks upon two cases of poisoning and suggests that some condition of the blood preceding menstruation may assist this reaction. The activity of the action is also influenced by the time of its ingestion. Professor Fraser and others, who find benefit in the small doses, always recommend that it should be given on an empty stomach, while those who use the larger doses advise it to be given after meals, and others still have remarked that the toxic symptoms arise when it has been given before meals. In the majority of cases the toxic symptoms pass away without requiring any assistance, but when the depression and dyspnœa are severe, stimulating remedies must be used. Alcohol has been resorted to in most of the cases of poisoning with apparent benefit, and hypodermic injections of ether have also been employed. In the cases reported by Dr. Jones[7] marked relief was secured by the use of strychnine in addition to the stimulants. Two minims of the liquor strychniæ were given hypodermically and ten minims of tincture of digitalis by the mouth. In these cases the inhalation of nitrite of amyl and $\frac{1}{100}$-grain doses of nitro-glycerine increased the cyanosis, showing that the arterial as well as the venous blood was altered.

The following conclusions have been arrived at by Marandon de Montyel[13] from clinical observations on patients in whom its use had been pushed to its physiological limits:—It has no influence on digestion. If the stomach is empty it causes an increased flow of saliva, a bitter taste, and a sense of tightness about the epigastrium. The pulse, respiration, and temperature are lessened in patients without convulsive tendencies. Vertigo, flashes of light and ringing in the ears are frequent. A local or general cyanotic surface, sensations of cold, numbness, and formication, are prominent symptoms. Its action is prompt and recovered from promptly, the brain being the first organ affected and the first to recover. When administered after meals its physiological action is less marked. *Beaumont Small.*

[1] British Medical Journal, February 17, 1890.
[2] Ibid., July 19, 1890.
[3] Ibid., September 27, 1890.
[4] Ibid., October 18, 1890.
[5] Bull. Gén. de Thérap., May 30, 1891.
[6] Berlin klin. Wochen., March, 1892.
[7] British Medical Journal, February 8, 1892.
[8] Medical Press and Circular, March 16, 1892.
[9] The Therapeutic Gazette, February, 1892.
[10] British Medical Journal, July 12, 1890.
[11] Ibid., May 3, 1890.
[12] The London Lancet, May 28, 1892.
[13] La Tribune Médicale, June, 1892.

EXAMINER, MEDICAL. The medical examiner system of Massachusetts, enacted in place of the coroner's inquest system which was abolished in 1877, has now (1893) been in successful operation for nearly sixteen years, and it is safe to say that no return to the coroner system will ever be made in Massachusetts. The law is quoted in full, and its advantages are fully stated in the second volume of this work.

The following statistics relative to the operation of this law are quoted from the registration reports of Massachusetts, for the years 1885 to 1891 inclusive:

TOTAL DEATHS, AND DEATHS BY SEXES, INVESTIGATED UNDER THE MEDICAL EXAMINER LAWS IN MASSACHUSETTS, 1885–1891.

YEARS.	SEX.						TOTALS.*
	Males.	Per cent.	Females.	Per cent.	Unspecified.	Per cent.	
1885.....	973	76.1	286	22.4	19	1.5	1,278
1886.....	1,027	74.5	319	23.2	32	2.3	1,378
1887.....	1,191	76.5	350	22.5	15	1.0	1,556
1888.....	1,261	76.4	373	22.6	17	1.0	1,651
1889.....	1,253	75.8	388	23.4	13	0.8	1,654
1890.....	1,303	73.5	449	25.3	21	1.2	1,773
1891.....	1,362	74.0	457	24.8	21	1.2	1,840
Totals.....	8,370	75 2	2,622	23.6	138	1.2	11,130

In the following table the same deaths are classified by the modes of death:

RECAPITULATION.

YEARS.	HOMICIDE.		SUICIDE.		ACCIDENT OR NEGLIGENCE.		NATURAL AND UNKNOWN CAUSES, INCLUDING ALCOHOLISM.		TOTALS.
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	
1885..	45	3.52	181	14.17	567	44.37	485	37.94	1,278
1886..	47	3.41	157	11.38	678	49.17	496	36.00	1,378
1887..	52	3.34	173	11.12	748	48.07	583	37.47	1,556
1888..	52	3.15	190	11.51	785	47.55	624	37.79	1,651
1889..	51	3.08	199	12.03	792	47.89	612	37.00	1,654
1890..	35	1.97	196	11.05	862	48.62	680	38.36	1,773
1891..	60	3.26	187	10.16	866	47.07	727	39.51	1,840
Totals	342	3.07	1,283	11.53	5,298	47.60	4,207	37.80	11,130

In the following table are presented the number of autopsies, the total expenses incurred in each year, and the average cost of investigation of each case, so far as the medical examinations were concerned. The expenses of 1891 had not been made up at the time of writ-

Year.	Total number of cases examined.	Autopsies.	Total expenses.	Average expense of each case.
1885.....	1,278	165	$16,322.54	$12.77
1886.....	1,378	202	18,024.22	13.08
1887.....	1,556	188	18,626.26	11.97
1888.....	1,651	219	19,611.53	11.88
1889.....	1,654	216	19,489.69	11.78
1890.....	1,773	206	20,710.63	11.68

ing, but it is safe to say that the average expense of each case was still further reduced as compared with that of previous years.

After the system was inaugurated, and had been in successful operation for three years, a careful inquiry of

the expenses under the old coroner laws, and also under the present system showed a decided lessening in the expenses, the two chief causes of the reduction being the abolition of the useless coroner's jury, and the diminution in the number of inquests.

It is a sufficient comment upon this law that more than eighteen thousand cases of sudden, suspicious, and violent deaths have been investigated under its authority, and in a far more satisfactory, intelligent, and economical manner than could have been possible under the old *régime*. *Samuel W. Abbott.*

EXMOUTH. A popular sea-bathing resort in Devonshire, England. Exmouth is ten miles from Exeter and occupies a fine situation on the Devon coast. The beach is remarkably good. The climate is moderately warm and equable, although the place is not so well sheltered from winds as Budleigh Salton, some five miles distant. There are fine coast and inland views, and the usual facilities for seaside enjoyments. Season, June to September. The place, though foggy, is healthy.
Edmund C. Wendt.

EXPECTORANTS. The well-known action of oil of turpentine upon the bronchial mucous membrane seems to be possessed by its derivatives, terpin hydrate, terebene, and terpinol. Terpin hydrate was recommended in 1885 as a very efficient agent in chronic bronchial catarrh, and preferable to oil of turpentine on account of the absence of unpleasant physical properties. Since then it has been employed by a large number of clinicians, and has been found to be a reliable remedy in bronchitis and whooping-cough.

Terpin Hydrate, $C_{10}H_{16}3H_2O$, is a hydrate of oil of turpentine that often forms when the oil is in contact with a small quantity of water for some time. On a large scale it is obtained by mixing oil of turpentine with alcohol and nitric acid. It is in the form of large colorless crystals, having no odor and only a very slight aromatic taste. It dissolves in 250 parts of water at 15° C., in 32 parts of boiling water, and in 10 parts of alcohol.

Terpin hydrate was introduced by R. Lepine, of Lyon, as an effective remedy for chronic bronchitis. He had used it in several hundred cases, and had observed that doses of 0.2 to 0.6 (three to nine grains) daily rendered the sputa less tenacious and more copious, and facilitated expectoration. In cases of bronchorrhœa larger doses, 1.5 daily (twenty-two grains), lessened the quantity of sputum. Such doses also increased the action of the kidneys, but, when these organs were normal, never caused albuminuria or hæmaturia.

The observations of Lepine have been corroborated by a number of clinicians in large hospitals. Thus Germain Sée found terpin hydrate very effective in catarrhal affections of the respiratory mucous membrane, the morbid secretion gradually diminishing under its prolonged use. In catarrhal forms of phthisis, he observed that the mucopurulent secretion lessened and often entirely ceased. He employed it also to arrest the hæmoptysis of the early stage of phthisis, and held it to act more rapidly than ergotin.

Dr. Lazarus, of Berlin, employed terpin hydrate in a large number of cases of bronchitis with good results. Marked effects, however, occurred only when he used large doses, from twenty to thirty grains daily. To avoid unpleasant effects on the digestive organs, the medicine was given in pills and taken during meals. He regards as the special indication for terpin hydrate great irritability of the bronchial mucous membrane with very scanty or very tenacious secretion. The effect observed was an increase of the sputum, which became more fluid and was easily expectorated. Usually the catarrhal symptoms vanished in from eight to fourteen days.

Dr. Manasse, of Berlin, used terpin hydrate for several years in a large number of cases of bronchitis. When small doses were given no very striking effects resulted; but large doses, from thirty to forty-five grains daily, proved decidedly efficient in chronic bronchial catarrh. In no case, although hundreds were treated, did any unpleasant incidental effects occur. He found terpin hydrate very useful also in whooping-cough, of which he treated forty-one cases, varying in age from nine months to twelve years. Every case was carefully observed, the frequency and severity of the paroxysms being noted daily. To children under one year of age he sometimes gave as much as 1.5 (twenty-two grains) daily, and never observed any injurious action on the digestive or urinary apparatus. And in no case, when 2.5 to 3.0 daily were given to older children, did the urine become albuminous or bloody. As a rule, in four or five days the paroxysms were less numerous and always less severe. The bronchial catarrh, which was present in most cases, diminished more rapidly than usual, and finally disappeared entirely. All the cases treated with terpin hydrate recovered. The medicine was given in the form of powder:

℞. Terpini hydrati..... 5.0–10.0
Div. in part. æqual. No. x. S.: One powder three times daily.

The following formulæ have been recommended:

℞. Terpini hydrat 3.0
Saech. alb.,
Mucil. acaciæ .....āā q. s.
M. ft. pil. No. 30. S.: One to four pills three times daily.

℞. Terpin hydrat 2.0
Spiritus,
Aq. dest.,
Syr. menthæ pip.....āā 50.0
M. S.: One tablespoonful from three to six times daily.

Codeine.—Codeine has recently come into use as a means of allaying cough. According to numerous reports, it is generally as effectual as morphine or the preparations of opium. Often it has been observed that the cough of mild forms of bronchitis ceased in a few days. But its principal advantage is that it does not depress the functions of the alimentary canal. The use of morphine is usually followed by a diminution of appetite, and often by constipation. Codeine, while it allays the cough, does not interfere with the appetite, or with the normal action of the bowels. This has been especially observed in phthisis, in which codeine was found to mitigate the cough without lessening the desire for food. When, to test the difference in action, Dover's powder was given to patients that had been taking codeine, the appetite, which had improved under the use of codeine, diminished again, showing the decided superiority of codeine. It has been found to be very useful in the bronchitis of children, and, in appropriate doses, has been given to infants, without any unpleasant effects.

Codeine should, therefore, be preferred to morphine in all cases of severe cough in which it is necessary to maintain a good appetite, as in bronchial catarrhs complicating chronic wasting diseases, in children, and in persons subject to constipation. Especially, should codeine be preferred to morphine to relieve the cough of phthisis; for if the means used to mitigate this tormenting symptom interfere with digestion and nutrition, little hope of saving life can be entertained.

The salts of codeine commonly used are the sulphate, phosphate, and hydrochloride. They all readily dissolve in water, and are usually prescribed in aqueous solution with a small quantity of syrup, or together with sugar, in the form of powder. The dose for adults is one-fourth to three fourths of a grain; for infants, one-sixtieth of a grain; and for children three or four years of age, one-fifteenth to one-tenth of a grain, from three to five times daily. *Samuel Nickles.*

EYE DISEASES, NOMENCLATURE AND STATISTICS OF. No successful effort has been recently made to decide upon a complete and scientific nomenclature of eye diseases, and in the present state of ophthalmology it would be difficult, if not impossible, to do so. When

such action is taken, it must be by some representative scientific body, as the American Ophthalmological Society, not by an individual. The nomenclature presented below is, strictly speaking, neither complete nor scientific, but practical; for it covers and enables us to study the statistics—to us the most important side of the question—of upward of three hundred thousand eye patients, as reported in the leading eye hospitals in this country. It was prepared from the lists of diseases as they appeared in the twenty-four annual reports of the ten different eye hospitals enumerated at the close of this article. Each disease was recorded, and when the list was complete, it was placed under its proper heading for final use.

The statistical portion is based upon a study of the 301,744 cases of eye disease embodied in the reports above referred to.

The tables explain themselves. Each disease is credited in the first column with the number of cases of such affection found in the grand total of 301,744 recorded cases, while the second column shows the relative frequency of each such affection, this frequency being expressed in numbers which indicate how often the disease is encountered in 1,000 of the cases which form the basis of this inquiry. When the proportion is materially less than one in a thousand, no entry whatever is made in the second column; and, furthermore, these entries are made only in round numbers.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
I. Affections of the Lids:		
Abscess	1,180	4
Anchyloblepharon	42	
Blepharitis	11,899	40
Blepharo-conjunctivitis	1,747	6
Blepharo-phimosis	14	
Blepharospasm	390	1
Burn	306	1
Canities	2	
Cellulitis	22	
Coloboma	10	
Cretaceous deposits	10	
Distichiasis	89	
Ecchymosis	348	1
Ectropion	573	2
Eczema	1,289	4
Elephantiasis	3	
Emphysema	37	
Entropion	545	2
Epicanthus	70	
Erysipelas	32	
Erythema	24	
Favus	15	
Foreign body	164	
Herpes	67	
" zoster ophthalmicus	47	
Lagophthalmos	84	
Madarosis	6	
Malignant disease	45	
Nictitation	114	
Œdema	698	2
Phtheiriasis	109	
Poison	23	
Ptosis	391	1
Trichiasis	1,091	4
Tumors	378	1
Angioma	112	
Chalazion / Cystoma	4,183	14
Dermatoma	50	
Carried forward	26,209	—

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Brought forward	26,209	—
I. Affections of the Lids (*Continued*):—		
Tumors (*Continued*):—		
Enchondroma	1	
Epithelioma	236	1
Fibroma	152	
Hordeolum	1,999	7
Horny growth	23	
Lipoma	13	
Lupus	5	
Millium	22	
Molluscum contagiosum	100	
Papilloma	19	
Syphiloma	11	
Verruca	238	1
Ulcer	79	
" syphilitic	7	
Wound	590	2
Xanthelasma	78	
Total	29,782	Equal to nearly 10 per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
II. Affections of the Conjunctiva:		
Abscess	25	
Argyria	20	
Atrophy	16	
Burn	1,084	4
Caruncle, abscess of	4	
" inflammation of	13	
" hypertrophy of	9	
" tumor of	5	
Chancre	1	
Chemosis	81	
Conjunctivitis	324	1
" blennorrhœal	274	1
" catarrhal	44,705	149
" chronic	8,091	27
" croupous	194	1
" diphtheritic	79	
" follicular	91	
" gonorrhœal	196	1
" granular	7,685	26
" hæmorrhagic	9	
" lachrymal	810	3
" neonatorum	1,223	4
" phlyctenular	9,632	32
" purulent	1,416	5
" rheumatic	20	
" scrofulous	47	
" traumatic	1,682	6
" vernal	52	
Ecchymosis	688	2
" subconjunctival	1,064	4
Foreign body	1,679	6
Hyperæmia	774	3
Hypertrophy	71	
Carried forward	82,064	—

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Brought forward.	82,064	——
II. Affections of the Conjunctiva (*Continued*) :—		
Irritation	13	
Lithiasis	2	
Lymphangiectasis	8	
Œdema	99	
Pemphigus	3	
Pterygium	1,689	6
Symblepharon	293	1
Tumor	66	
Angioma	3	
Carcinoma	24	
Cystoma	80	
Dermatoma	17	
Fibro-lipoma	3	
Granuloma	8	
Gumma	2	
Melano-sarcoma	2	
Pinguecula	268	1
Polypus	136	
Ulcer	112	
Wound	540	2
Xerosis	24	
Total	85,456	Equal to about 28 per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
III. Affections of the Cornea :		
Abscess	297	1
Anæsthesia	1	
Burn	465	2
Calcareous deposits	9	
Fistula	3	
Foreign body	20,251	67
" " in cornea and anterior chamber	12	
Herpes	32	
Keratitis	6,560	22
" bullosa (pemphigus)	9	
" dendritic	1	
" diffuse	38	
" fascicular	277	1
" hypopyon	181	
" interstitial	965	3
" malarial	35	
" marginal	103	
" neuro-paralytic	6	
" phlyctenular	8,403	28
" punctate (descemitis, see serous iritis)		
" pustular	62	
" serpens	4	
Carried forward	37,714	——

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Brought forward	37,714	——
III. Affections of the Cornea (*Continued*) :—		
Keratitis, traumatic	1,274	4
" ulcerative	1,523	5
" vascular	116	
Kerato-conjunctivitis	489	2
" conus	115	
" cyclitis	10	
" iritis	1,272	4
Kerato-irido-cyclitis	6	
" scleritis	7	
Leucoma	1,553	5
" adherent	584	2
" total	49	
Metallic incrustation	20	
Necrosis	73	
Opacity	5,540	18
Pannus	935	3
Staphyloma	610	2
Tumor	4	
Cyst	2	
Dermoid	3	
Epithelioma	12	
Ulcer	8,518	28
" perforating	224	1
" rodent	3	
" serpiginous	104	
" syphilitic	1	
" traumatic	239	1
" with prolapse of iris	290	1
Wound	1,976	7
" abrasion	411	1
" penetrating	92	
" rupture	133	
" with prolapse of iris	34	
Total	63,936	Equal to about 21 per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
IV. Affections of Sclera.		
Burn	4	
Episcleritis	596	2
Foreign body	46	
Gumma	8	
Scleritis	259	1
Sclero-choroiditis, anterior	13	
Sclero-keratitis	49	
Staphyloma	99	
Tumor	1	
Wound	154	
" contusion	1	
" of sclera and cornea	31	
Total	1,261	Equal to not quite one per cent. of all eye cases.

Eye Diseases.

V. Affections of Iris and Ciliary Body.	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Aniridia	10	
Atrophy of iris	2	
Coloboma of iris	99	
" of iris and ciliary body	3	
" of iris and ciliary body and choroid	19	
Cyclitis	81	
Displacement of iris, traumatic	7	
" of pupil	7	
Exclusion of pupil	2	
Foreign body in iris	22	
Hetero-chromia iridis	3	
Hyperæmia of iris	30	
Irido-choroiditis	565	2
" cyclitis	237	1
" cyclo-choroiditis	7	
" dialysis	108	
" donesis	119	
Iritis	3,501	12
" exudative	2	
" hemorrhagic	2	
" plastic	664	2
" purulent	9	
" recurrent	43	
" rheumatic	118	
" serous (uveitis serosa, descemetitis, etc.)	196	1
" spongy	7	
" syphilitic	895	3
" traumatic	478	2
Mydriasis	482	2
medicinal	227	1
paralytic	19	
traumatic	18	
Myosis	31	
Occlusion of pupil	404	1
Persisteut pupillary membrane	7	
Synechiæ, anterior	597	2
" posterior	1,167	4
Tumor of iris	10	
cyst	5	
granuloma	1	
gumma	41	
melano-sarcoma	1	
in ciliary region	8	
Wound of iris	166	
" with prolapse of iris	80	
" with rupture of iris	30	
Total	10,530	Equal to about three and one-half per cent. of all eye cases.

VI. Affections of the Lens.	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Aphakia	190	
Capsulitis	2	
Cataract	74	
" calcific	44	
" capsular	556	2
" congenital	366	1
" cortical	44	
Carried forward	1,276	——

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Brought forward	1,276	——
VI. Affections of the Lens (*Continued*) :—		
Cataract diabetic	3	
" hard	7,401	24
" incipient	2,188	7
" inflammatory	116	
" lamellar	112	
" morgagnian	15	
" nuclear	28	
" polar	27	
" " anterior	130	
" " posterior	79	
" secondary	232	1
" soft	449	1
" traumatic	1,289	4
Dislocation of lens	473	1
" " congenital	4	
" " traumatic	16	
Foreign body in lens	14	
Sclerosis of lens	5	
Total	13,857	Equal to a little over four and one-half per cent. of all eye cases.

VII. Affections of the Choroid and the Vitreous.	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Albinism	52	
Atrophy of choroid	888	3
Cholesterin crystals in vitreous	11	
Choroiditis	918	3
" atrophic	6	
" circumscripta	1	
" disseminata	193	
" exudative	114	
" metastatic	5	
" plastic	66	
" sclero-posterior	450	1
" serous	5	
" suppurative	2	
Choroido-retinitis	352	1
" " central	43	
" -scleritis	14	
Coloboma of choroid	21	
Colloid excrescences in choroid	1	
Cysticercus in vitreous	1	
Detachment of vitreous	2	
Foreign body in vitreous	79	
Growths and opacities in vitreous	510	2
Hemorrhage into vitreous	202	1
" in choroid	25	
Hernia of choroid	5	
Hyalitis	82	
" diffuse	5	
Hyperæmia of choroid	4	
Persistent hyaloid artery	11	
Rupture of choroid	65	
Synchesis scintillans	10	
Tubercles in choroid	1	
Tumor of choroid	28	
Total	4,172	Equal to a little over one per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
VIII. Affections of the Retina:		
Atrophy	21	
Cysticercus	2	
Detachment	800	2
Embolism of central artery	54	
Epilepsy	3	
Glioma	79	
Hemorrhage	167	
" at macula lutea	15	
Hyperæmia	108	
Hyperæsthesia	43	
Œdema	8	
Opaque nerve-fibres	45	
Perivasculitis	1	
Retinitis	289	1
" alba	2	
" albuminuric	177	
" diabetic	7	
" exudative	19	
" hemorrhagic	192	
" leucocythæmic	5	
" macular	13	
" pigmentosa	213	1
" proliferous	5	
" serous	24	
" syphilitic	14	
" traumatic	4	
Retino-choroiditis	50	
Rupture	2	
Thrombus of retinal vein	2	
Tumor	1	
Total	2,365	Equal to about three-quarters of one per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
IX. Affections of Optic Nerve:		
Atrophy	2,352	8
" congenital	10	
" incipient	55	
Concussion	1	
Hemorrhage on disk	2	
Hyperæmia of disk	12	
Neuritis	564	2
Papillitis	35	
Retro-ocular neuritis	18	
Neuro-retinitis	679	2
Œdema of disk	2	
Persistent nerve-sheath	3	
Total	3,733	Equal to a little over one per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
X. Amblyopia and Amaurosis:		
Amaurosis	7	
" cerebral	2	
" congenital	5	
" fugax	2	
Amblyopia	608	2
" cerebral	7	
" congenital	50	
" hysterical	21	
" from insolation	1	
" toxic:	366	1
alcohol	5	
alcohol and tobacco	30	
quinine	1	
tobacco	188	
uræmia	2	
Chromatopsia	7	
Hemeralopia	96	
Hemianopsia	29	
Nyctalopia	3	
Scotoma	36	
" scintillans	1	
Total	1,497	Equal to nearly one-half of one per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
XI. Glaucoma:		
Glaucoma	317	1
" absolute	83	
" acute	126	
" chronic	474	1
" hemorrhagic	13	
" secondary	64	
" simple	57	
" subacute	13	
Glaucomatous degeneration	90	
Total	1,237	Equal to nearly one-half of one per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
XII. Errors of Accommodation and Refraction:		
Anisometropia	279	1
Asthenopia	715	2
" accommodative	779	2
" muscular	116	
Astigmatism	5,139	17
" compound	154	
" " hyperopic	4,228	14
Carried forward	11,410	—

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Brought forward.....	11,410	——
XII. Errors of Accommodation and Refraction (*Continued*):—		
Astigmatism compound myopic..	760	2
" irregular..... ..	41	
" hypermetropic.....	3,477	11
" mixed.....	642	2
" myopic	1,538	5
Hypermetropia.....	23,467	78
Myopia	8,334	27
Paralysis of accommodation....	189	
" " " traumatic.....	3	
Paralysis of accommodation, post diphtheritic.....	4	
Presbyopia.....	9,638	32
Spasm of accommodation.....	153	
Total.....	59,656	Equal to nearly 20 per cent. of all eye cases.

XIII. Affections of the Nerves and Muscles of the Globe:	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Diplopia	189	
Esophoria.....	88	
Exophoria.....	476	1
Hyperphoria	34	
Hyperesophoria.....	3	
Hyperexophoria	4	
Nystagmus...	475	1
" horizontal.....	15	
" monocular	1	
" rotatory.....	12	
" vertical.	1	
Ophthalmoplegia externa.....	10	
Paralysis of external rectus.....	393	1
" of inferior rectus.....	19	
" of inferior oblique	5	
" of internal rectus	65	
" of superior oblique....	52	
" of superior rectus.....	30	
" of 3d nerve.....	354	1
" of 3d nerve, partial....	67	
" of 2d, 3d, 4th, 5th, and 6th nerves.....	1	
Paralysis of 2d, 3d, 4th, and 6th nerves	1	
Paralysis of 3d, 4th, 6th, and 7th nerves	3	
Paralysis of 3d and 4th nerves...	4	
" of 3d, 4th, and 6th nerves	7	
" of 4th, 5th, 6th, and 7th nerves	43	
Rupture of external rectus (traumatic).....	1	
Rupture of inferior rectus (traumatic)	2	
Rupture of internal rectus (traumatic).....	1	
Strabismus :		
" alternating	26	
Carried forward	2,382	——

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Brought forward	2,382	——
XIII. Affections of the Nerves and Muscles of the Globe (*Continued*) :—		
Strabismus: convergent.....	7,384	24
" deorsum vergens.....	5	
" divergent	1,098	3
" periodic.....	64	
" sursum vergens.....	15	
Totals.....	10,948	Equal to a little over one-third of one per cent. of all eye cases.

XIV. Affections of the Globe:	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Anophthalmos.....	97	
Burn	22	
Malformation (congenital).....	16	
Dislocation	2	
Exophthalmic goitre.....	30	
Exophthalmos.....	163	
Foreign body in anterior chamber.....	15	
Foreign body in globe	84	
Hyphæmia.....	317	1
Hypopyon	319	1
Intra-ocular hemorrhage.....	61	
" tumor	23	
Megalophthalmos	31	
Microphthalmos	40	
Neuroma optic nerve.....	1	
Panophthalmitis	182	
Phthisis.....	2,217	7
Sympathetic irritation	36	
" inflammation.....	116	
Wound:	376	1
Contused.....	376	1
In ciliary region.....	109	
Cornco-scleral	32	
Gunpowder explosion	19	
Gun-shot.....	41	
Perforating.....	67	
Rupture.	201	
Total.....	4,993	Equal to about one and one-half per cent. of all eye cases.

XV. Affections of the Lachrymal Apparatus:	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Abscess of caruncle.....	1	
" of lachrymal gland	1	
" of " sac	875	2
Carried forward	877	——

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
Brought forward.....	877	——
XV. Affections of the Lachrymal Apparatus (*Continued*):—		
Cancer lachrymal gland.....	2	
" " sac.....	19	
Closure of puncta.....	4	
Cyst over lachrymal sac.....	33	
Dacryoadenitis.....	12	
Dacryocystitis.....	1,879	6
" acute.....	89	
" blennorrhœal.....	182	
" catarrhal.....	1,004	3
" chronic.....	99	
" phlegmonous.....	55	
Dacryolith.....	2	
Epiphora.....	1,790	6
Fistula, lachrymal.....	154	
Foreign body in canaliculus.....	2	
Hypertrophy of lachrymal gland.	15	
Malposition of puncta.....	51	
Obstruction of canaliculi.....	54	
" of lachrymal duct (stricture).....	1,522	5
Stillicidium.....	15	
Supernumerary lachrymal gland.	1	
Tumor over lachrymal sac.....	11	
Wound over lachrymal sac.....	9	
Total.....	7,881	Equal to about one-quarter of one per cent. of all eye cases.

	Total number of cases.	Number of cases of such disease in 1,000 cases of eye disease in general.
XVI. Affections of the Orbit:		
Abscess.....	39	
Caries.....	19	
Cellulitis.....	98	
Contusion.....	5	
Emphysema.....	1	
Foreign body.....	3	
Fracture.....	9	
Necrosis.....	56	
" from phosphorus.....	1	
Periostitis.....	51	
Tumor.....	97	
Aneurism.....	1	
Carcinoma.....	8	
Cyst.....	38	
Exostosis.....	20	
Hæmatoma.....	4	
Osteoma.....	1	
Sarcoma.....	11	
Wound.....	87	
Total.....	549	Equal to about one-sixth of one per cent. of all eye cases.

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EYE SYMPTOMS, DIAGNOSTIC SIGNIFICANCE OF; AND ETIOLOGY OF EYE DISEASES. The study of the causes of eye affections is not only important with reference to the treatment of these diseases, but often proves of service in the practice of clinical medicine in general. The eyes are so often involved in consequence of derangements of other organs that ocular symptoms are not rarely the earliest signs of internal diseases. Thus, kidney disease and diabetes are sometimes recognized by the oculist before the necessity for the family physician has been felt. Syphilis, acquired or congenital, may reveal itself for a time in the eye only, and various diseases of the central nervous system are first seen in their incipiency by the ophthalmic specialist or require his methods for their correct localization. In order, therefore, that this article shall be of full value to the general reader, it must involve the diagnostic significance of mere symptoms as well as the etiology of ocular lesions.

Affections of the eyes, like diseases in general, may be classified etiologically as either *primary diseases*, in which the derangement is directly due to some cause from the outer world, or *secondary affections*, which result from a pre-existing anomaly in some other part of the system. While this distinction must be kept in view for the purpose of research, our knowledge is not yet sufficiently complete in every instance to maintain it in practice. In the case of the eye, perhaps more than in the case of any other organ, there occur, moreover, affections which may be termed intermediate between primary and secondary diseases. For there are many eye troubles which are primary in the sense that they are caused by infection, an occurrence originating in the outer world, but secondary inasmuch as such infection will take place only if the germs have previously gained a foothold in some other part of the economy.

The frequent occurrence of eye symptoms and lesions in consequence of other diseases depends on the exceptionally intimate connection between the visual organ and other parts of the economy, as well as on the complicated and hence delicate histological structure of the eye. Through the general circulation germs and poisons can reach the eye, while the nutrition of the ocular tissues reacts readily to changes in the blood or the walls of the vessels. Infections gain access through the extensive lymphatic connections, through fissures in the walls of the orbit, or along the channel of the tear-duct. The nutritive integrity of the optic nerve is influenced by morbid processes in many parts of the brain or even spinal cord, and derangements in the co-ordination of the extrinsic and intrinsic muscles of the eye indicate in the most sensitive manner any disease in the large central area from which their nerves originate.

The etiological dependence of any eye affection on a given anomaly in some other part of the body may be proven in various ways. It is suggested by the coincidence or sequence of the two disturbances, and the probability of a relationship increases with the frequency of the observations. As some forms of eye trouble may have different modes of origin in different cases, the occasional occurrence of an eye disease in the course of other disturbances, but which may also be seen at times without the coexistence of the latter, does not exclude a relationship. But if a characteristic ocular lesion is seen only in connection with certain internal diseases, as the "albuminuric" form of retinitis in kidney diseases, the relationship is clearly established.

The etiological proof is also furnished whenever a morbid process can be watched clinically or traced pathologically in its encroachment from some adjacent struct-

ure into the orbit. In other instances the dependence of ocular disturbances upon pre-existing other anomalies may be shown by the influence exerted upon them by the treatment of the suspected condition. Unless such influence, however, is very striking, and the prognosis of the eye-trouble is fully known, this mode of reasoning is liable to errors. The most satisfactory proof of the relation of any morbid occurrence to any eye anomaly is only furnished by the experimental production of the latter. But this method has been as yet but little pursued.

For reasons of convenience the plan of this article will be to detail the etiological significance of the various eye affections from the standpoint of the oculist, while a survey of the eye symptoms and lesions to which any specified internal disease may give rise can be obtained from the classified index.*

I. Lachrymal Apparatus.

1. The lachrymal gland—very rarely the seat of disease—may undergo chronic inflammatory enlargement in acquired *syphilis*. A few observations are on record of swelling of the gland during an attack of *mumps*, and a similar subacute inflammation has also been interpreted as a vicarious form of mumps, the diagnosis being based on the existence of mumps in others in the same dwelling. In *leucocythæmia* the tumefaction characteristic of that disease may also, though rarely, occur in the lachrymal gland.

2. Lachrymation, or the overflow of tears, indicates over-activity of the gland, but not necessarily impaired drainage of tears, as is shown by ordinary crying. It occurs during the course of all irritating forms of disease of the anterior parts of the eye. It may also result, though less frequently, from eye-strain. In some instances it depends on *irritability* of the *mucous lining of the nose*, due to sharp crests on the nasal septum or to enlarged turbinated bodies.

Obstruction of the tear-passages is not necessarily accompanied by steady lachrymation, but if in this condition a flow of tears is started by eye-strain or irritation by wind and dust, the tears can only escape by running over the lower lid. In about one-half the cases of lachrymal stricture the disease of the tear-passage seems to be by itself the cause of continuous overaction of the tear-gland.

3. Obstruction of the lachrymal canaliculi may result from extension of conjunctival inflammations. Strictures just above or in the lachrymal sac and suppurative inflammation of the sac, dacryocystitis, are usually, if not always, of *nasal origin*. The suppuration of the sac in the latter form is, of course, the direct result of the action of pus microbes. It is not merely the more serious forms of nasal disease; like syphilitic ulceration, lupus, and polypi which lead to disease of the lachrymal duct, but more frequently even transient acute catarrh, especially in connection with stenosis of one or both sides of the nose. Quite often a one-sided lachrymal disease corresponds to the narrower side of the nose. In a large proportion of cases of lachrymal obstruction permanent anomalies can be found in the nose, such as enlargement of the inferior turbinated body and malformation of or crests on the septum. The extension of infection from the sac to the skin covering it (phlegmonous dacryocystitis) and the subsequent formation of a lachrymal fistula can sometimes be traced to the influence of an acute nasal catarrh.

Dacryocystitis is an occasional occurrence during small-pox.

II. Lids.

1. The various forms of diseases of the skin of the lids, eczema, lichen, acne rosacea, and favus, are, as a rule but an extension of the same affection on adjacent parts of the facial skin, and their causes, so far as they are known, are also the same. Herpes, more common in the vicinity than on the lid itself, may, however, also involve the lids, or even be limited to them (herpes zoster ophthalmicus). The accompanying neuralgia and local anæsthesia show that it is due to *disease of the fifth nerve*.

Globules attached to the cilia like beads on a string are the eggs of lice. Direct infection leads occasionally to a *vaccinia* pustule on the lid. *Chancre* of the lid has also been observed. Of secondary *syphilitic* eruptions condylomata are more common than ulcerating papules. Ulceration may be due to *lupus vulgaris, lupus erythematosus, epithelioma*, or *rodent ulcer*.

Multiple tumors of the lids have been seen in *leucocythæmia*.

Ecchymoses, most commonly of traumatic origin, occur without trauma in *scurvy* and in *purpura hæmorrhagica*.

2. Œdema of the lids, if bilateral, is an early sign of *renal disease* and of *arsenical* poisoning. Mere puffiness, not pitting on pressure, has not this significance. It is not uncommon in irritative *nasal disease*, especially *hay fever*, and it may also occur with some slight forms of conjunctivitis, or as the result of any inflammatory action in cornea, sclera, or iris. *Irritation* of a *hypersensitive nasal membrane* causes at times a sudden transient, one-sided, or bilateral œdema of the skin of the lids, sometimes resembling urticaria, sometimes more like erysipelas. Frequent repetition of such attacks leaves the lids either dusky or permanently puffy. Genuine erysipelas, *i.e.*, the infection by the streptococcus, differs from these pseudo-erysipelatous attacks by its accompanying fever and its progressive tendency. A condition which a hasty observer can mistake for erysipelas is the inflammatory œdema of the lower lid induced by the extension of phlegmonous infection from the lachrymal sac to the surrounding skin.

3. The only disease of the tarsus known etiologically is the chronic inflammatory hypertrophy of (late) *syphilis*. In some instances of a similar disease, however, syphilis is not present.

4. Chalazion, the inflammatory enlargement of a Meibomian gland, is perhaps in some, probably rare, instances of *tubercular* origin, as Tangl [1] has found the bacillus tuberculosis, and Kœnigshoefer and Maschke [2] have observed the tuberculin reaction, in such cases. In the majority of cases this harmless tumor is not tubercular, according to clinical experiences as well as bacteriological tests by Weiss,[3] and Deutschmann.[4]

5. Blepharitis, inflammation of the edge of the lid, appears in the squamous, interstitial, and ulcerative forms. In the latter the ulceration is due to pus microbes, but whether the other forms depend on parasites is unknown. There are, however, four conditions, one or more of which often maintain the blepharitis, or cause it to relapse after the cessation of local treatment. These are, (*a*) eye-strain (hypermetropia or astigmatism); (*b*) insufficient length of the skin of the upper lid [5] causing gaping of the lids during sleep; (*c*) obstruction of the tear-passages, and (*d*) nasal disease, sometimes in the form of stenosis, sometimes in that of atrophic rhinitis. Some of the alleged factors stated in the books as causes of blepharitis, viz., scrofula and unhealthy surroundings, are not confirmed by experience in actual practice.

Blepharitis is a very common sequence of *measles*.

6. Of the distortion of the lids, ectropion is mostly due to cicatricial shrinkage of the skin after burns or lupus, sometimes also to hypertrophic swelling of the conjunctiva from long-standing irritation by the tears in consequence of lachrymal obstruction, especially in elderly people. A characteristic form of ectropion is that due to cicatricial adhesion of the skin to the margin of the orbit from caries of the orbital rim in scrofulous children. Entropion is most commonly the result of conjunctival shrinkage after trachoma. Inversion of the cilia —trichiasis—is generally due to the same cause; sometimes to long-continued interstitial blepharitis. Partial turning in of the lashes—distichiasis—may occur congen-

* The writer has not aimed at absolute completeness in the present place, and will therefore not include the etiological bearing of rare eye diseases based on very exceptional occurrences or on deductions supported by insufficient evidence. On the other hand, it would be superfluous to merely tabulate those eye-affections the etiology of which is not known. As there is a reference at the end of the article to the general literature of the subject, the quotations in the text are limited to the more important or recent researches, or such as are not included in the references appended.

itally. In old people with relaxed skin the puffiness engendered by tears under an eye-bandage (after operations), or accompanying irritative diseases of the eye, may cause transient spasmodic entropion.

7. Anomalies of the muscles of the eyelids are always of nervous not of muscular origin. Spasm of the orbicularis muscle is either tonic or clonic. The former accompanies to a variable degree all irritative diseases of the anterior part of the eyeball which cause photophobia; it may be due also to foreign bodies in the conjunctival sac. The most distressing form of tonic blepharospasm is the spasm sometimes persisting in neurotic patients after the original ocular disease itself has disappeared. In some instances its continuance depends on the existence of tender spots (neuritis ?) in the distribution of sensory nerves of the face around the orbit. This is at any rate the interpretation of the curative results obtained by Von Graefe and others by neurotomy of the supra-orbital and other nerves.

Clonic blepharospasm appears in various forms. Mere fibrillary twitching of a transient character occurs from eye strain and a variety of influences, like overwork, insufficient sleep, etc. Fibrillary twitching of the orbicularis, as well as the adjoining facial muscles, generally one-sided, the tic convulsif of neurologists, is a serious and often incurable disease of the facial nerve. Its pathology is generally not known; in certain not common instances it is a reflex which may start from *eye strain*[6] or *conjunctival irritation* (personal observation), from *nasal anomalies*,[7] or from *defective teeth*.

Spasmodic winking of the lids is but a localized form of *chorea* and quite often the movements, at first limited to the lids, extend later on to other facial muscles. The subjects usually have a neurotic disposition, revealed by the family history or their own neurotic antecedents or subsequent history.

Often a reflex origin can be detected, either eye strain (H. or As.) or follicular hypertrophy of the conjunctiva or nasal anomalies, and the correction of these defects may prove the reflex character. It must not be overlooked that the disposition to such exaggerated reflexes is augmented by all influences which lower the resisting power of the organism, as close confinement, overwork, disturbances of digestion, anæmia, etc.

Lagophthalmus, the inability to close the eyelids, is the result of *paralysis* of the *facial nerve* and may depend on a peripheral facial neuritis (sometimes from disease of the ear or the temporal bone) or on an affection of the central nucleus of the facial nerve.

Ptosis, the (partial or complete) inability to open the lids, is either due to excessive thickness of the lids (after trachoma or from subcutaneous tumor) or to lesion of the third nerve. A slight form is not rarely congenital, probably from ante-natal nuclear disease (often involving the recti muscles as well). The significance of recent paralysis of the motor oculi can be treated to better advantage in connection with paralysis of the ocular muscles.

The lid aperture is of more than average width (but without muscular weakness) in high *myopia* and in exophthalmus, especially in *exophthalmic goître*. Characteristic of the latter trouble is Von Graefe's sign. On looking downward the upper lid normally follows the movement of the eyeball, while in *exophthalmic goître* the upper lid lags behind, and with extreme downward version of the eye more than the usual amount of the ocular surface is exposed.

III. Conjunctiva.

1. Conjunctival hemorrhages occur in purpura, but also from violent cough, especially whooping-cough, and other violent exertion, as in epileptic attacks or from slight trauma. They have been considered diagnostic of death from asphyxia. If they occur without sufficient provocation in elderly people they indicate vascular disease and danger of apoplexy. The conjunctiva of the eyeball presents the best conditions for the observation of *jaundice*.

Sudden chemosis of the conjunctiva indicates in some instances that a *purulent inflammation* of the *cerebral meninges* is encroaching upon the orbital contents.

2. Chronic conjunctival hyperæmia (often associated with blepharitis) is indicative of *eye-strain*, *lachrymal obstruction*, or *nasal stenosis*. Chronic catarrh is often a secondary infection of a conjunctiva habitually congested. It may depend in other cases on *skin diseases*, as eczema of the lid, or of parts adjoining it, or it may be the remnant of a former acute conjunctivitis. Acute follicular conjunctivitis leaves in some persons a permanent enlargement of the adenoid tissue which at times becomes complicated with catarrhal inflammation, but without it, too, may constitute an easily overlooked source of irritation. It is also stated (Foerster) that a chronic catarrhal conjunctivitis of very tedious course may be kept up by masturbation.

3. Acute conjunctivitis is probably always an infection, excepting the form due to the influence of the ultra-violet rays of the electric arc light.[8] The severe but transient form, which when epidemic is popularly known as "pink-eye," has been traced by Weeks[9] to the invasion by a characteristic small bacillus. There are probably various micro-organisms capable of causing contagious conjunctivitis. Other forms are apparently due to common saprophytic bacteria, which are frequently found in the conjunctiva and always on the skin. Whenever the conjunctiva is wounded or chemically irritated, catarrhal infection commonly follows. Contagious, and hence clearly of parasitic origin, is the form of acute conjunctivitis which in many of the persons affected causes follicular enlargement and may even resemble trachoma (although different in its course).

A rather rebellious form of conjunctivitis, usually not severe, but sometimes leading to considerable hypertrophy, is at times observed in connection with *purulent rhinitis*. Transient conjunctivitis is also a regular symptom of *measles* during the initial period. Conjunctivitis with hemorrhages has been observed in attacks of *influenza*.

The most violent conjunctivitis is that caused by the *gonorrhœal* virus, usually transferred by towels, hands, etc. The *gonococcus* is likewise the cause of all cases of characteristic conjunctivitis neonatorum. The infection occurs in the vagina and leads to visible inflammation on the third day after birth. If the conjunctivitis appears before this date the case was one of protracted birth with early rupture of the membranes. The proof of the origin of this scourge of infants is furnished both by the regular presence of the gonococcus in the secretion as well as by its absolute prevention by means of nitrate of silver (two per cent.) dropped into the conjunctival sac at birth (Credé's method). The insignificant conjunctivitis of babies, of irregular occurrence and of a duration of but a few days, is usually not caused by the gonococcus. Whether this parasite ever occurs in a form of diminished virulence after long existence in the maternal passages is not unlikely on the strength of clinical evidence, but not yet proven. An entirely different, mild, not dangerous, but persistent form of conjunctivitis, not due to the local action of the gonorrhœal virus, but occurring during the course of gonorrhœa, has been described by Haltenhoff. Diphtheritic conjunctivitis is caused by the bacillus characteristic of *diphtheria*, but the conditions necessary for its invasion usually escape analysis, as the patients are generally free from diphtheria in other parts of the system. It has been, however, produced by the coughing of diphtheritic patients hurling the virus into the eye of the attendant. Whether croupous conjunctivitis is due to the same parasite is not yet known.

Trachoma or granular conjunctivitis is a disease so unmistakably contagious that there can be no doubt as to its parasitic origin. Yet none of the attempts made by Sattler, Michel, and various others to identify the virus (as a micrococcus) have led to satisfactory or convincing results. The disease has often occurred in an epidemic form in former times in armies, schools, and other institutions. Cleanliness and isolation have within recent years diminished the frequency of such epidemics.

In its non-epidemic form the disease is not apt to spread to others as long as care is taken in the use of towels, handkerchiefs, etc. Hence it is evident that unsanitary surroundings and poverty favor its spreading. A factor, which the writer believes has not received due attention, seems to account for the variable contagiousness. Observation shows that the disease is, or at least can be, transferred by means of the conjunctival secretion. Sporadic cases, however, of pure trachoma are often not accompanied by any secretion whatsoever, or show pus only during periods of aggravation. Epidemic trachoma, on the other hand, furnishes copious conjunctival pus. It seems, therefore, not unlikely that the more virulent and contagious forms of granular lids represent a mixed infection by the trachoma virus, associated with some microbe causing catarrhal inflammation.

Burnett has pointed out that the negro has nearly absolute immunity against trachoma. Chibret has likewise credited the Celtic races of Europe with being less prone to take the disease,[10] a statement which is not confirmed by the distribution of the disease in this country. Chibret has also called attention to the comparative immunity of localities of an altitude over two hundred metres, from which rule numerous exceptions, however, have been pointed out by others. Occasionally trachoma is limited to one eye. Whether the disease in these instances is etiologically different from ordinary bilateral trachoma is not known. The writer has observed the frequent coincidence of one-sided trachoma with one-sided nasal obstructive lesions.

Goldzieher [11] has described a disease resembling trachoma, but due to syphilis and curable by antisyphilitic treatment.

4. Xerosis, an inflammation with the occurrence of characteristic white, fatty-appearing spots on the conjunctiva, and often leading to corneal ulceration, or even necrosis, is a disease indicative of grave danger to life, and is observed mainly in ill-nourished infants. The disease is often accompanied by hemeralopia. Von Graefe originally described it as coincident with encephalitis, but Jastrowitz [12] has since shown that the lesions found in the brain, viz., fat-granules in the neuroglia cells, do not signify inflammatory, but simply degenerative change. Indeed, xerosis has been seen in the course of various exhausting diseases—typhus, small-pox, etc.

Jewezki [13] has seen the disease remarkably often among workmen in a glass furnace. In the xerotic patches Kuschbert and Neisser have found a pure culture of a characteristic bacillus. But while the existence of this bacillus has been confirmed, it has been shown by Fick, Weeks, and others, that it is but a common parasite of the normal conjunctival surface, and not peculiar to or causative of xerosis.

5. Tuberculosis of the conjunctiva may either result from extension of the same disease in the nasal cavity or from metastasis of tuberculosis of internal organs.

6. Pemphigus of the conjunctiva has been seen in connection with *pemphigus* of the skin. It may lead to partial or complete obliteration of the conjunctival sac by adhesion of the lids to the eyeball.

IV. Sclera.

Episcleritis occurs in some instances in persons of rheumatic or of gouty history and is often influenced by corresponding remedies (salicylates and antipyrin) in such a decisive manner that a rheumatic or—as the case may be—gouty origin is strongly suggested. In other instances, however, no such relationship can be demonstrated.

V. Cornea.

1. The superficial opacity of the cornea with new formation of vessels known as pannus is the result either of irritation by inverted eyelashes or of trachomatous disease of the lids. A circumscribed surface opacity with vascular connection is sometimes caused by a relatively bland foreign body (especially grain-husks) embedded in the cornea. Another form of superficial vascular keratitis beginning with circumscribed corneal exudations near the limbus, and of very persistent course, the writer has found associated with *hypertrophic rhinitis*.

2. Herpes vesicles limited to the cornea have been described by Horner as a not infrequent occurrence (together with herpes labialis) during the course of or after *inflammatory disease of the respiratory passages*.

3. Phlyctenular keratitis, usually considered indicative of infantile *scrofula*, is so often associated with, or preceded by, subacute *suppurative rhinitis* that a causative relation of the latter is strongly suggested. This form of rhinitis and consecutively corneal phlyctenulæ frequently follow *measles*. Attention has also been called to the frequent coincidence of head-lice and phlyctenulæ (rare in this country). On the other hand, both clinical sequence as well as therapeutic results show that *eczema* of or around the lids and ulcerative blepharitis may induce phlyctenular disease as well as even deeper corneal infiltration. The attempts to identify the alleged microorganism of phlyctenular keratitis (Burchardt) cannot be called satisfactory.

4. A superficial form of linear corneal infiltration (with loss of epithelium) assuming an arborescent shape has been referred by Kipp [14] to *malarial influence*, on account of the patient's history and the influence of quinine on this disease. But a similar form has been met with by Emmert in non-malarial cases, and termed by him keratitis dendritica. It has been seen more often following influenza during the recent epidemics. Another form of corneal disease, characterized by its name keratitis punctata superficialis, has also been described but very recently, and has been known to follow in the wake of influenza. Superficial corneal infiltrations, often leading to ulceration, depend often upon disease of the conjunctiva, especially trachoma, but also, though less frequently, on chronic catarrhal conjunctivitis with hypertrophy of the fold of the fornix. Another source of similar corneal disease is ulcerative blepharitis.

5. Inflammation of the substance proper of the cornea often occurs without assignable cause. A variety has been ascribed by Arlt to *rheumatic influence*, and is said to be characterized by the ground-glass appearance of the cornea, by epithelial abrasions, which sometimes lead to shallow ulceration, and by the indolent course. Recent observations (Berger) confirm the view as to the rheumatic origin of this form by the marked influence upon it of antipyrin and salicylates. A similar form of keratitis the writer has seen following herpes frontalis. The existence of a gouty keratitis in the form of small circumscribed interstitial opacities has been confirmed by Chevallereau by the chemical detection of uric acid in the opaque spot.

The most characteristic form of deep keratitis of extremely indolent course, usually affecting one eye ahead of the other and followed regularly by the formation of a very delicate but persistent net-work of vessels in, and not merely on the surface of, the cornea,[15] occurs in children or young persons with *hereditary syphilis*. Most observers agree that this disease is by itself diagnostic of inherited syphilis.

It has also been asserted that some forms of interstitial keratitis depend on carious teeth and yield only to the extraction of the latter (Galezowski).

A central interstitial keratitis, often with iritis, has been found by Chibret associated with neuralgia of the fifth nerve and apparently secondary to the latter trouble.

6. What is commonly called keratitis punctata, or keratitis postica, is not a disease of the cornea itself, but a deposit of clusters of cells on the posterior surface of Descemet's membrane in connection with the serous (or, much more rarely, the plastic) form of iritis, and also in certain acute attacks of circumscribed chorio-retinitis.[16]

7. Corneal ulceration is the result of local infection, and in those instances of spreading ulcer (ulcus serpens) which have been examined bacteriologically the pus-forming staphylococci and streptococci were found. As these micro-organisms are widely disseminated, they can easily gain access to any wound, or even scratch, by foreign bodies. The most virulent infection results from the presence of the pus of *dacryocystitis*. Where such

virulent pus is not present, it evidently requires special conditions, but imperfectly understood, for the occurrence of progressive infection. Some of these conditions are pre-existing disease of the conjunctiva, especially trachoma, lacerated wounds of the cornea, for instance, by sawdust blown into the eye, and an enfeebled state of the system, as on recovery from typhoid fever and other exhaustive diseases. *Variola* may cause corneal ulcers either by the extension of pustules localized on the cornea or by infiltration occurring at a later stage, which subsequently breaks down. Ulcers also occur, though not commonly, in *diabetic* patients. In *scrofulous* children some ulcers, of a very persistent character, give the characteristic reaction to tuberculin injections and heal under its use so promptly as to raise a suspicion as to their *tubercular* origin. But the presence of the tuberele bacillus has not yet been demonstrated.

8. Necrosis of the cornea—complete or partial—has been observed in consequence of invasion by mould fungus (aspergillus glaucus, Leber). The cornea turns yellow and the disease is accompanied by pus in the anterior chamber. Necrosis of the cornea is also a rare complication of *facial erysipelas*. After experimental division or *destructive disease* of the *fifth nerve*, corneal necrosis is common, unless the lids are kept closed. It is not yet definitely known whether this accident results only from trauma and desiccation of the exposed and anæsthetic cornea, or whether the trigeminus exerts an influence on its nutrition.

9. A neurosis of the cornea, characterized by intense pain and photophobia, but with scarcely any injection of the pericorneal vessels, is sometimes seen weeks or months after minute injuries to the cornea. Careful inspection shows that it is due to an inflammatory condition of the minute cicatrix left by the injury.

VI. Iris.

1. Unequal intensity of color of the iris of the two eyes has been found by Féré[17] sixty-two times in the examination of seventy-six cases of *hysteria*, and is considered by him as a characteristic hysterical stigma. Discoloration of an iris (especially a blue iris) may, however, remain as well after iritis. The existence of a past iritis is revealed by deposits on the anterior capsule of the lens, which are rarely absent when the dilated pupil is examined (unless the iritis was treated early and thoroughly by atropia).

2. Plastic iritis may depend on various well-known causes. A localized inflammation of the iris results from the pressure of a swelling lens undergoing cataractous change, even where no infection exists. Severe contusion of the eyeball is often followed by iritis, probably due to secondary infection. Ulcers of the cornea frequently lead to the same result, and iritic complication is not rare in parenchymatous keratitis, whatever be its cause. The most frequent cause of non-traumatic iritis is *syphilis*. Syphilitic iritis is an early manifestation, and usually bilateral. In the later stages of syphilis a (one-sided) iritis is sometimes seen with *gummatous* tumors in the iris. It must not be overlooked that in a person who has once acquired syphilis, iritis may also occur from other causes, in which case anti-syphilitic treatment has no influence upon it. Another known cause of iritis is *rheumatism*. While the origin is often suggested by the patient's previous or present rheumatic history, it can be but rarely proven by any specific influence of recognized anti-rheumatic remedies. Very often the name "rheumatic" iritis hides our ignorance of its causation. Iritis may also accompany *gonorrhœal rheumatism*, and is indeed sometimes observed as the only manifestation of this disease. Whether *gout* can provoke iritis is still a matter of doubt. Similar doubts exist as to the origin of iritis from *kidney disease*. *Diabetes* leads occasionally to a rebellious iritis, which improves when the systemic condition is controlled. *Influenza* has been followed rather frequently by iritis during the recent epidemics. In *leucocythæmia* characteristic infiltration with diffuse inflammation has been observed in the iris. Tumors in the iris, with subsequent diffuse iritis, can be referred etiologically either to this disease, viz., *leucocythæmia* (rare), to *tuberculosis*, or most commonly to *syphilis* (gummata).

A cause of iritis which has as yet received but insufficient attention is *nasal suppuration*. Ziem has pointed out the possible connection between rebellious iritis and *suppuration* of the *accessory sinuses* (especially the maxillary antrum). The writer's experience has also included cases of recurrent iritis which were regularly preceded by acute coryza.

Iritis is usually one of the manifestations of sympathetic ophthalmia, the inflammation of an eye due to chronic inflammation of the ciliary region of the other eye, generally dependent on the presence of a foreign body. Such iritis is, however, associated with inflammation of the ciliary body, and often also of the deeper parts of the eye.

Unlike the plastic form of inflammation, serous iritis is a local disease of which we know no etiological connection with other disturbances.

VII. Pupil.

1. The pupil is smaller during the first few weeks of life, and also during the senile period, than during youth and middle age. It is also narrower in hypermetropia than in the short-sighted eye under the same illumination. The absolute width varies inversely with the intensity of the light.

2. The pupil is contracted in iritis as well as in severe inflammation of the cornea or conjunctiva, or even in intense irritation by the presence of foreign bodies. It is characteristically wide and immobile in glaucoma, even if attended by inflammatory symptoms. It enlarges in all diseases of the eye or optic nerve in which the sensibility to light (not merely the distinctness to sight) is reduced, and attains a medium width in one-sided absolute blindness. If the pupil is normal in size and reaction in an eye said to be blind, the condition is either hysteria or simulation. The pupil is still wider in bilateral blindness, as the perception of light by one eye influences the pupil of the other. The pupil of a blind eye, therefore, still responds to the illumination of the other (sensitive) eye. If in double-sided blindness the pupils react to light, the lesion must be situated in the brain above the pupillary centre in the corpora quadrigemina, *i.e.*, in the cortex or white substance of the occipital lobes. Such instances have been observed after cerebro-spinal meningitis.

3. A wide and absolutely immobile (*i.e.*, not sensitive to illumination) pupil indicates paralysis of the motor oculi nerve, be it by the effect of drugs on its termination, by disease of the trunk, or of the central origin of the nerve. The pupil, if wide from inactivity of the third nerve, is enlarged still further by the local effect of atropin.

Dilatation of the pupil is also caused by activity of the cervical sympathetic nerve, either experimentally or as the result of irritating lesions in acute disease of its origin in the cervical spinal cord. Under these circumstances the reaction to light is not impaired. The influence of the sympathetic upon the pupil is also manifested in a reflex manner whenever painful impressions are made upon the skin. This dilatation, very slight ordinarily, is more easily observed in so-called "nervous" subjects, but particularly during incomplete ether or chloroform narcosis. Indeed, during surgical anæsthesia the pupil is an index of the sensibility.

Contraction of the pupil indicates activity of the third nerve or paralysis of the sympathetic. In paralysis of the cervical sympathetic in man, from disease or injuries, the resulting contraction is only moderate and not always permanent.

4. The pupil is contracted during natural sleep and during narcosis, but dilates whenever pain is felt and whenever asphyxia occurs. The narrowness of the pupil during *opium stupor* serves to distinguish this condition from *coma*, in which the pupil is wide.

5. Pupillary disturbances are very common in diseases of the nervous system, but they are generally not charac-

teristic symptoms. In *meningitis* narrowness is usually seen, while dilatation in this disease indicates brain pressure from effusion or hemorrhage. All localized destructive lesions in the brain dilate the pupil when they involve the nucleus or the trunk of the third nerve—for instance, *syphilitic meningitis, apoplexy,* and *embolic* infarctions. In *general paresis* pupillary symptoms have been found in one-third to two-thirds of all cases. They consist rather in equality of the two pupils than in marked dilatation or contraction in either eye. In fact, inequality of the two pupils, if not explicable by an intra-ocular or peripheral nerve lesion, may be considered a grave symptom, even during apparent health, indicative of cerebral changes. It is a very common precursor of various forms of insanity.

6. Pupillary inequality occurs in at least one-third of *tabetic* patients, usually early. Less common in this disease is the "Argyll-Robertson pupil"—a marked contraction without reaction to light, but with slight increase in the contraction during efforts at accommodation (usually bilateral). The same form of pupil occurs also in other forms of disease of the cervical spinal cord. In Pott's disease of the cervical region the pupil is occasionally disturbed, sometimes dilated, more often contracted. *Epileptics* often show a permanently wide pupil. The same may result (by reflex stimulation of the sympathetic ?) from pelvic or intestinal irritation (worms). Various transient pupillary changes are not uncommon in *hysteria.*

Enlarged glands, tumors, and aneurisms pressing upon the *cervical sympathetic* nerve cause pupillary contraction.

7. Pupillary dilatation and immobility, with paralysis of the accommodation, is a characteristic symptom of *ptomaïne poisoning* from tainted meats, sausages, or fish. The same paralysis of the third nerve occurs in *belladonna* poisoning. Whenever this condition comes on suddenly, either in one eye or in both, without other nervous symptoms, the first suspicion should be that of local *atropin* or *belladonna* action.

VIII. Accommodation.

1. Enfeeblement of the accommodation reveals itself by inability to read or to see distinctly at a proximity at which the patient could formerly see distinctly. As the accommodative power diminishes normally from youth until about the fifty-fifth to sixtieth year, when it is practically lost, the age of the patient must be taken into account in all consideration of the faculty of adjustment. Likewise the refraction of the eye must be known before the accommodation can be measured. Of intra-ocular conditions the prodromal stage of glaucoma manifests itself by rapid diminution of accommodation.

2. The accommodative power is further reduced in many conditions which derange nutrition or lower the general vigor, as neurasthenia, kidney disease, diabetes, derangements of the liver, after hemorrhages, and during recovery from exhausting fevers. More characteristic is the influence of carious teeth, in consequence of which Schmidt[18] saw the accommodation enfeebled 73 times in 92 instances, and sometimes only on the side of the defective teeth. This observation does not seem to have been confirmed by others.

3. Absolute paralysis of the accommodation without pupillary change follows diphtheria very frequently in the course of two to four weeks. It is indeed characteristic of the after-effect of the diphtheritic poison. Whether the same paralysis can follow scarlatina and mumps, or whether an error had not been committed in the diagnosis of these affections in the instances observed is an open question, with greater probability of the latter view. An incomplete paralysis of the accommodation, with either normal or contracted pupils, may be a hysterical symptom, but occurs also in ataxia.

4. When accommodation and sphincter of the iris are paralyzed together, the cause may be local or general belladonna influence, ptomaïne poisoning, or lesions of the third nerve, particularly cerebral syphilis, less commonly ataxia.

5. Spasm of the accommodation is a term often misapplied in ophthalmic literature. The correction of farsightedness by involuntary contraction of the ciliary muscle is not a spasm properly speaking, as it serves a useful purpose and is not maintained when the eyes are not used in the dark. It is distinguishable from true spasm by relaxing under ophthalmoscopic examination. True spasm simulating myopia is not common. It occurs perhaps more often in low degrees of astigmatism than in any other condition, and is brought on by overuse of the eyes and a neurotic disposition. The writer has once seen it accompany hemiplegia from brain lesion.

IX. Asthenopia.

1. The inability to use the eyes persistently, on account of indistinctness of sight or discomfort and pain, headache, and other nervous symptoms induced by steady application, is so common a complaint, and due to so many different influences, that it deserves special mention in an article of the present scope. While the most important cause of asthenopia are optic defects, viz., hypermetropia, astigmatism, or insufficiency of the accommodative power, we cannot ignore accessory influences due to conditions of the general system even in connection with ametropia. Besides asthenopia may occur in optically perfect eyes. According to the writer's experience in private practice about twenty-five per cent. of the patients with asthenopic complaints do not belong to the class which can be relieved by glasses.

2. The cardinal symptoms which indicate anomalies of refraction (H. or As.) or insufficient accommodation (presbyopia) are either blur on persistent eye-use or discomfort, described as fatigue and ache (much less commonly as a burning or shooting pain) or both. But in patients with any neurotic disposition—and this comprises a large class of civilized communities — these annoyances are apt to be complicated by headaches, feeling of pressure in the head, and, more rarely, vertigo, or even nausea. While such accessory neuroses can be checked just as promptly as the asthenopic symptoms proper by means of suitable glasses, and their dependence on eye strain be thus proven, a critical experience shows that they occur only in individuals whose antecedents or family history indicate a neurotic disposition, or who have been subjected to damaging influences, as continued overwork with confinement, anæmia, or diseases deranging nutrition, like intestinal disturbances, or who are the victims of neurasthenia. Indeed, by removing such injurious factors, if possible, the neuroses can sometimes be relieved without attention to the eyes, although the eye strain persists. It can be further observed that the degree of ametropia which can exist in different persons without asthenopic complaints varies with the health and muscular vigor. While delicate individuals may at times be sensitive to half a dioptry of astigmatism, or three-fourths dioptry of hypermetropia, persons in perfect health do not necessarily suffer from two dioptries of ametropia until age reduces their accommodation, or weakening influences of any kind enfeeble their power of endurance.

3. Other ocular conditions which may cause asthenopia are blepharitis and chronic conjunctivitis (especially when due to lachrymal obstruction), the intra-ocular irritation due to myopia (not the mere optic condition of M.), and slight choroiditis, perhaps not yet sufficient to damage sight. These causes are more apt to produce burning and smarting eyes, sometimes with blur, on using the eyes, as contrasted with the predominance of aching from accommodative or refractive anomalies.

To what extent anomalous tension of the external muscles of the eyes is responsible for asthenopic symptoms is at present a subject of much discussion. That a certain class of authors have enormously exaggerated the importance of so-called "heterophoria," or want of balance of the recti muscles, cannot but be patent to any unbiased observer in practice. On the other hand, cases do certainly occur, even if they are not common, in which asthenopia and discomfort are associated with tendency to

strabismic deviation of the eyes whenever binocular vision is obviated. But whether these two conditions bear a causal relation to each other, or whether both are indicative of neurasthenia, requires further study.

4. Of extra-ocular causes of asthenopia nasal anomalies—stenosis or suppurative processes—are the most important. Nasal influence manifests itself, however, more frequently in the form of itching and burning of the lids (especially in the morning), and irregular, dull, or shooting pains than in the form of typical asthenopic symptoms, although the latter, too, are sometimes referable to a nasal origin. A variety of influences—anæmia, recovery from exhausting diseases, stomach troubles, defective teeth—may cause asthenopia indirectly by enfeebling the accommodation, but such cases may be termed of accommodative origin, and can be benefited by glasses. In other instances, however, neurasthenia proper, or the nervous breakdown from disturbed digestion, leads to inability to maintain the use of the eyes without increasing discomfort, which no glasses can benefit. Foerster[19] has described, under the name kopiopia hysterica, a variety of incurable asthenopia, dependent on chronic sclerosing parametritis. No confirmation of his observations have as yet been recorded by others.

X. Lens.

1. Opacity of the lens, cataract, occurs whenever any extensive rent is made in the lenticular capsule by any traumatism. It may result also from severe concussion of the eyeball, without perforating wound, following the injury in such cases in the course of weeks or months. Of intra-ocular conditions which may lead to cataract may be mentioned recurrent attacks of iritis, chronic cyclitis, chronic or absolute glaucoma, chronic choroiditis, and retinal detachment, as well as high degrees of progressive myopia. Senile cataract is very common in advanced age, even in perfect health and with ideal eyes, especially if we examine the extreme periphery of the lens. Fortunately not every instance of peripheral senile cataract proceeds to opacity of the pupillary area.

2. The most common condition leading to premature senile cataract is *diabetes mellitus*. Whether *kidney disease* has the same influence, as Deutschman has asserted, is not yet definitely decided. Hogg[20] has called attention to the frequent association of *prostatic enlargement* and *stricture of the urethra* with senile cataract.

3. Zonular, or lamellar cataract, commonly congenital and not rarely a family anomaly, has been referred by Horner and his disciples to the influence of *rickets* (sometimes ante-natal). While the coincidence of the two affections has been shown to exist in about forty per cent. of the cases, no such relationship can be proven in other instances.

4. Cataract has been known to come on rapidly in persons struck by *lightning*.

Diffuse cataract can be produced in animals by *naphthalin poisoning*.

XI. Choroid and Vitreous Body.

1. Choroidal changes occur frequently in high degrees of myopia. The least dangerous lesion is pigmentary absorption, permitting a view of the choroidal vessels. More serious is hypertrophy of the pigment in the form of irregular masses. The gravest form is constituted by central white plaques (of inflammatory or atrophic origin ?) which damage central vision. Hemorrhages into the retina and vitreous body, evidently from choroidal vessels, are another familiar accident in strongly myopic eyes.

2. In the more common forms of choroiditis, characterized by yellowish plaques of infiltration, generally with pigmented border and later on by white atrophic spots with diffuse pigment proliferation, and not due to myopia, no cause can, as a rule, be ascertained, except it be *syphilis*. But the statements as to the frequency of syphilitic choroiditis vary very much. Extreme opinions are, perhaps, represented by Hutchinson[21] and by Alexander.[22] While the former maintains that syphilis should be suspected in every case and its existence tested by mercury, although he admits that it is not the only cause of choroiditis, Alexander—from an exceptionally large experience—believes that syphilis is not responsible for areolar or disseminate choroiditis, except when associated with opacities of the vitreous body. The same observer, in harmony with general experience, describes as syphilitic the following forms, viz.: *a*, irido-choroiditis with vitreous opacities; *b*, vitreous opacities without visible choroidal change, except, perhaps, atrophic patches in the most anterior region; *c*, gummata in the choroid; *d*, diffuse chorio-retinitis, especially in the peripheral parts of the ocular tunics, simulating retinitis pigmentosa (the same form may occur in hereditary syphilis); and *e*, many of the cases of the ordinary areolar or disseminate choroiditis, if attended with vitreous opacities, and especially so, if they become complicated with a central exudative chorio-retinitis, characterized by the sudden appearance of a white plaque near the macula with opacity of the vitreous and deposits on the posterious surface of the cornea, as described by Bergmeister. Yet the present writer has seen three cases which correspond exactly to Bergmeister's description, except that they were not preceded by previous choroiditis and pursued a less malignant course, but which occurred in patients *free* from syphilis.

3. In the course of *cerebro-spinal meningitis* a purulent choroiditis (sometimes irido-choroiditis), and always (?) binocular, characterized by a yellow reflex on illuminating the pupil, is not uncommon. It necessarily leads to atrophy of the eyeball. Browne[23] has described another variety of choroiditis, in the form of a few central whitish foci, either reabsorbed later on or leading to circumscribed atrophy, as characteristic of a transient *meningitis* in children. A suppurative choroiditis due to septic embolism and leading rapidly to suppurative ophthalmitis, generally one-sided, but sometimes even affecting both eyes, is an occasional accident in *pyæmia*, particularly, but not exclusively, of *puerperal* origin. *Relapsing fever* is often followed by various forms of choroiditis, particularly a serous irido-choroiditis, with opacities in the vitreous body (Logetschnikow). *Malarial* poisoning also may affect the uveal tract, manifesting itself in some instances by vitreous opacities even with hemorrhages, in others by a diffuse chorio-retinitis.

4. Opacities in the vitreous body occur in many of the more acute forms of choroiditis. They may be formed, however, without ophthalmoscopically visible (or easily overlooked) changes in the choroidea, from traumatism by perforating or blunt force, in myopic eyes or in the course of syphilis and malaria. In many instances no local or constitutional cause can be detected.

5. Hemorrhages occur in the vitreous body from trauma, violent exertions (probably only in the case of sclerotic or other vascular disease), in progressive myopia, in malaria, purpura, and in high degrees of anæmia, and in hypertrophy of the left ventricle of the heart.

6. The vitreous may be the seat of a free cysticereus vesicle, the embryo of which has entered the eye through the blood-vessels in consequence of eating measly pork (more rarely from auto-infection from an intestinal tænia).

7. In extensive miliary tuberculosis—and less frequently in tubercular meningitis—tubercles may be seen in the choroid by means of the ophthalmoscope, in the form of multiple yellowish raised exudations in the choroidal tissue underneath the normal retina, of a size less than that of the optic disk. Single larger tubercular tumors in the choroid are less common. Of course, tuberculosis leads soon to further inflammatory charges and opacity of the media.

XII. Retina.

1. Of all intra-ocular lesions, the affections of the retina and of the optic nerve are of the greatest interest to the general practitioner on account of their frequent dependence on nervous or constitutional lesions which are not rarely revealed by this localization earlier than by any other symptoms.

In the normal eye ophthalmoscopic examination does not show any pulsation of the retinal arteries, but very often a slight pulsating movement is seen in the larger portions of the retinal veins as they are traced in their course across the bright optic disk. The systolic dilatation of the arteries is evidently too slight to be seen ordinarily in vessels of such small calibre. But the increased intra-ocular tension caused by the systolic influx of blood suffices to compress visibly the more yielding veins. Where the intra-ocular tension is low, or where the sclera is freely distensible the venous pulsation is not visible. On compressing the eyeball with the finger, the pulsation of the veins becomes more distinct, and with increasing pressure the arteries also begin to pulsate visibly. When the intra-ocular tension is increased by glaucoma the arterial pulsation is likewise manifest.

2. Pulsation of the retinal arteries without increased tension of the eyeball or other ocular symptoms is often found in *insufficiency* of *the aortic valves*, much less frequently in other *cardiac* or *valvular* anomalies. It has also been seen in rare instances of extreme *anæmia* (and sometimes in acute fever, pneumonia, and phthisis). Very feeble arterial pulsation has been observed in one eye in aneurism of the arch of the aorta, or of the large arteries of the neck on the corresponding side of the body.

Dilatation of the retinal arteries up to the normal calibre of the veins was observed by Becker in *exophthalmic goitre* (four times in six cases). Of extreme dilatation of all retinal vessels, Knapp records a case in connection with general dilatation of the vascular system. Venous congestion due to compression of the jugular veins, by goitre and other tumors, or to pressure of any kind upon the venæ cavæ, may reveal itself, too, in the veins of the retina. In a case of venous congestion due to cardiac malformation, Liebreich found the retinal veins distended and of a cyanotic appearance.

3. Miliary aneurism of the retinal arteries coexistent with miliary aneurism of cerebral arteries (the most frequent cause of apoplexy) have been found at autopsies, but have but rarely been seen ophthalmoscopically.

4. Sclerosis of the walls of the arterial system extends into the retinal vessels in about one-half of all cases (Raehlman [24]). It reveals itself by tortuosity of the vessels, and thickening and opacity of their walls, so that the (normally invisible) walls are indicated by a marked double contour. There are irregular contractions in the calibre of the vessels, so that the column of blood may appear spindle-shaped in some of the branches. As long as hemorrhages have not occurred vision is not disturbed.

Changes similar to those produced by arterio-sclerosis have been observed in the retinal arteries in advanced syphilis. Indeed, in this disease the thickening of the wall may proceed to obliteration of the calibre of an arterial branch. Fuerstner and Haab have shown that this obliterating syphilitic endarteritis co-exists in the retinal and cerebral arteries, and that the ophthalmoscope may hence facilitate the diagnosis of cerebral syphilis. Frequently the changes in the syphilitic retinal vessels, however, are accompanied by syphilitic retinitis.

5. Very characteristic changes are found ophthalmoscopically in embolism of the central artery. With immediate blindness the retinal arteries are found nearly empty (at least at first), the veins distended, and turbidity around the edges of the disk, with a cherry-red spot in the centre of the macula. The embolus is derived from some lesion in the heart or arterial system, but in some instances no source can be found. Kern [25] has recently shown that the diagnosis of embolism in the alleged cases is often wrong, and that the lesion may be a thrombus in an atheromatous artery. Sometimes only a single retinal branch is obliterated. A few times the permanent blindness was preceded by short transient spells of blindness, perhaps due to temporary occlusion by an embolus too small to arrest the circulation completely, but increasing in size by gradual coagulation in the vessel.

Remarkable narrowness of the arteries has been observed in a few instances of sudden blindness in persons with enfeebled circulation, but in whom no embolus existed in the vessels (Alf. Graefe and Knapp). While the pathology of this "ischæmia retinæ," as it was termed, is not clear, the influence of the retinal anæmia upon the sight was proven by the relief on lowering the intra-ocular tension (by paracentesis or iridectomy).

6. Retinal hemorrhage may occur in the course of most forms of retinitis or severe inflammation of the optic nerve. They are very profuse and multiple in thrombosis of the central vein of the retina, a condition manifesting itself by intense congestion and tortuosity of all the veins, with hemorrhages along the vessels and inflammatory cloudiness of the papilla.* Thrombosis of the vena centralis is sometimes referable to general ill-nutrition (marasmus), sometimes to pulmonary *emphysema*—oftener to disease of *the heart* or *arteries*. It has also been observed after extensive burns of the skin, and after facial erysipelas. Emphysema of the lungs, if complicated with hypertrophy of the left ventricle, is also apt to cause retinal hemorrhages without thrombosis. Hemorrhages into the retina are observed as well in *pernicious anæmia*, and even in ordinary severe *anæmia* from loss of blood in *kidney disease*, in *diabetes*, in *gout* (?), in disease of the liver with jaundice, after trauma of the eye, after violent exertions or coughing-spells, and after death by asphyxia. If produced in apparent health, without trauma to account for them, they indicate vascular disease, *arterio-sclerosis, fatty degeneration*, or *syphilitic endarteritis*, and serve as a warning of threatening cerebral apoplexy. There has been observed, however, a rare form of extensive hemorrhage in young people (of fifteen to twenty-five years) in apparently perfect health, in whom it has no such grave general significance.

The disturbance of sight produced by hemorrhages depends on their size, extent, and location.

7. Inflammations of the retina present so many different characteristics that the ophthalmoscopic observer can recognize their cause in the more typical forms with certainty and even in the less pronounced instances with some probability. The most common form, viz., the retinitis albuminurica complicating *kidney disease*—always bilateral—consists in its simplest form in turbidity of the edges of the disk, fatty-looking white patches, often with brownish border, in the retina, at first near the papilla and later on all over the fundus, dilatation of the veins, and hemorrhages partly along the vessels, partly in the form of small spots around the centre of the retina. Later on, a characteristic star-figure, made up of small white dots around the macula, is common. The walls of the vessels often appear as visible white contours. But deviations from this type also occur. The disease is sometimes limited to a narrow zone around the papilla, and still more rarely consists only in inflammation of the optic disk with hemorrhages.

Albuminuric retinitis, especially in the last-mentioned forms, may be simulated (rarely) by optic neuritis of cerebral origin. In its less pronounced type it resembles the retinitis caused by diabetes. In most instances, however, the ophthalmoscopic examination can recognize kidney disease when manifested by retinal lesions.

Retinitis occurs in at least seven per cent. of all cases of renal affection. It is most common in interstitial nephritis, less so in parenchymatous kidney disease, and rare in amyloid kidney. In nephritis following scarlet fever and the kidney trouble of pregnancy the retinal lesions are not considered of prognostic significance and may disappear without injury to sight as the causative affection heals. But in Bright's disease, not coming under this etiological category, it is a sign of great importance. Miley [26] examined 164 cases of Bright's disease with regard to the significance of the albuminuric retinitis. Of 51 patients who had retinitis, 27 died inside of two years; while of 105 whose eyes were normal only 28 succumbed within the same time (8 patients

* It is not yet certain whether these appearances are necessarily due to thrombosis or whether there exists a hemorrhagic or apoplectic retinitis without thrombosis.

had other ocular lesions independent of their disease). According to microscopic researches by the Duke Charles Theodore (of Bavaria) the retinal lesions are the result of hyaline degeneration and obliterating endarteritis of the retinal vessels.

8. *Diabetic* retinitis in its most typical form consists of small white spots irregularly scattered throughout the centre of the retina, not arranged in star-figure, without colored border, and without involvement of the optic disk. The disease is bilateral, but often more advanced in one eye. If the ophthalmoscope shows in diabetes retinal lesions like those of Bright's disease, albumin will also be found in the urine. In other cases of diabetes mellitus there occurs no typical retinitis, but simply hemorrhages followed by irregular patches of white retinal degeneration. Many such eyes become affected with glaucoma.

9. Diffuse, but more or less striated retinal opacity with copious hemorrhages along the dilated vessels, especially near the retinal centre, is seen occasionally in *leucocythæmia*, while a similar form of retinitis, but, it is said, with more diffuse multiple but small hemorrhagic spots, is more characteristic of *pernicious anæmia*.

10. *Syphilis* may affect the retina in various ways. The typical simple retinitis of syphilitic origin described by Jacobson appears as slight cloudiness of the papilla and retina with venous dilatation and, usually, fine vitreous opacities, but without plaques or hemorrhages, and generally with but moderate interference of sight. It is an early form, usually occurring inside of two years after infection, and being protracted only if not treated. In other instances more marked opaque striæ accompany the vessels as they emerge from the papilla. Ole Bull considers a very faint peripapillary opacity and vitreous turbidity as quite common in the first period after infection, and claims that it is characterized by an irregularly ring-shaped relative scotoma, which surrounds the point of fixation but includes the blind-spot (optic disk), but he states that the scotoma can only be detected with gray, not with white objects.

Hirschberg,[27] on the other hand, states that there occurs, commonly within the first two years of syphilitic infection, a form of retinitis, or perhaps syphilitic panophthalmitis, which is not rarely overlooked, as it need not reduce sight much, but may annoy the patient by flickering. It is accompanied often by fine deposits on the posterior surface of the cornea, and usually by fine vitreous dust, while in the retina there can be seen, on close examination, faint pinkish-yellow, later on, whitish spots, adjoining some of the smaller vessels in a manner comparable to berries on a stem. The form of retinitis characterized by Von Graefe as a late manifestation of syphilis and termed by him central relapsing retinitis, as it appears in the form of a central grayish retinal cloudiness which relapses even under specific treatment, does not seem to have been often observed. Late syphilis also manifests itself by obliterating endarteritis in the retina, sometimes with hemorrhages. The retina is likewise involved, as seen by its turbidity and the invasion of its anterior layers by pigment in the diffuse chorio-retinitis observed both in tertiary and in hereditary syphilis (the disease beginning peripherally in the latter case and resembling retinitis pigmentosa).

11. In *gout* Hirschberg[28] has described a retinitis characterized by white dots in the deeper layers and arranged in lines partly radiating from the macula and partly crossing these so as to form a network, together with small hemorrhages. Hutchinson considers a diffuse retinitis with hemorrhages suggestive of gout. Retinal hemorrhages with sclerosis in the form of opaque striæ have been observed a few times in connection with marked oxaluria.

12. A *septic* retinitis, in the form of white plaques, which speedily develops into panophthalmitis, is a dangerous accident due to embolism from some pyæmic source in *puerperal fever*, extensive *phlegmons*, malignant *endocarditis*, or surgical pyæmia.

Retinitis of traumatic origin, macular injury by intense solar illumination and by lightning, extension of inflammation of the optic nerve into the retina, and participation of the retina in choroiditis, complete the list of retinal inflammations the etiology of which is more or less understood. There remain comparatively rare instances of inflammatory retinal affections—diffuse retinitis with turbidity of the entire membrane, central transient retinitis causing a circumscribed scotoma, retinitis punctata albescens, retinitis proliferans with connective (?) tissue striæ—the origin of which are not known.

An inexperienced observer may mistake patches of opaque (myelated) nerve-fibres which sometimes radiate from the papilla in normal eyes, for retinitis or neuroretinitis, but the normal vessels and the absence of all diffuse turbidity, as well as the location of the opaque spots, should guard against this error.

13. The only etiological data we possess regarding the origin of pigmentary retinal degeneration (retinitis pigmentosa) refer to consanguinity on the part of the parents of the victims in one-fourth to one-third of the cases, the occasional occurrence of the disease in several members of a family, as well as the comparative frequency of other degenerative conditions, like deaf-mutism, in such families.

XIII. Optic Nerve.

1. The vascularity of the optic nerve varies within such wide physiological limits that the diagnosis of either papillary congestion or, on the other hand, of anæmia, must be received with caution. An intensely congested optic disk means really neuritis, while pathological pallor has only been observed in the last stages of cholera, in grave anæmia, and in quinine amaurosis.

2. It is best to describe the inflammation of the intra-ocular end of the optic nerve as papillitis, since inflammation of the trunk of the nerve back of the eyeball (retro-bulbar neuritis) is not necessarily visible ophthalmoscopically. Whenever the ophthalmoscope shows swelling and turbidity of the optic disk, indistinctness of its edges by reason of cloudiness, and dilatation of the veins (often with hemorrhages), we speak of papillitis, and if the cloudiness extends into the retina, of papillo-retinitis, while optic neuritis refers to inflammation of the nerve, no matter whether it extends down to the visible end of the nerve or not.

Papillitis of intra-ocular origin accompanies retinitis, especially the albuminuric form; the more violent forms of early syphilitic retinitis, also—sometimes—exudative choroiditis and acute forms of chorio-retinitis. Sympathetic ophthalmitis may also begin in the form of neuritis.

3. Of extra-ocular causes facial erysipelas may lead to optic neuritis. One-sided papillitis—which is otherwise much less frequent than the bilateral affection—may be due to orbital disease, phlegmon of the orbit, inflammation of the sheath of Tenon, caries (tubercular or syphilitic) of the orbital walls or—least of all, numerically—orbital tumors. Suppuration of the antrum of Highmore or of the frontal sinus has also been found as a rare cause of optic neuritis.

4. Papillitis of one or both eyes is sometimes, but not often, due to (late) *syphilis* of the optic nerve. More frequently, if syphilis is the cause, the neuritis is secondary to its cerebral localization. Neuritis, usually bilateral and of grave danger to vision, although the visible papillary inflammation is generally very slight, has been observed after severe *hemorrhages*—especially hemorrhages from the *stomach*,—after *measles*, *typhus* and *typhoid* fever, *mumps*, and particularly often after *influenza*. In other instances rheumatism, suppression of menstruation and of bleeding from hemorrhoids, "taking cold," have been accused as causes of optic neuritis, but without definite proof.

5. Papillitis may also result from poisoning by bisulphide of carbon, or more frequently from lead-poisoning. In most instances, however, poisons affecting the optic nerve cause retrobulbar neuritis, which can but exceptionally be recognized ophthalmoscopically and which will hence be referred to under the head amaurosis (XIV., 6).

6. Of chief interest to the clinicist is the relation of optic neuritis to diseases of the brain. Von Graefe made a distinction originally between ordinary optic neuritis of cerebral origin, which he called the descending neuritis, and the condition termed by him choked disk (Stauungspapille). While in the former case the autopsy shows a uniform inflammation of the nerves from the chiasm to the eye, choked disk may exist with but little evidence (to the naked eye) of neuritis of the nerve-trunk, but with intense swelling and venous stasis of the intra-ocular end. Accordingly von Graefe assumed a creeping down of the inflammation along the nerve in the former case, while he attributed the choked disk to interference with the return of venous blood by increased intracranial pressure. He based this explanation on the fact that choked disk commonly accompanies conditions which raise the intracranial pressure like tumors. But it was soon shown that this mechanical view was untenable on account of the free anastomoses of the veins of the orbit with the facial vein. Subsequently Schmidt, and, later on, Manz, tried to prove that the venous interference was an indirect one, due to dropsical exudation between the sheaths of the optic nerve, which transmitted the intracranial pressure to the central vein after it enters the optic nerve. That this intervaginal dilatation does exist in such cases has been shown by autopsies. But its significance has been overthrown by Deutschman.[29] His experiments showed that any degree of compression of the nerve by intravaginal fluid comparable to what exists in pathological cases, is insufficient to produce optic neuritis. Its real pathogenesis he seeks in the influence of germs or toxines carried down the intravaginal space from the brain by the current of fluid, and he therefore considers the papillitis as a transmitted infection. While the distinction between ordinary optic neuritis and choked disk can be maintained ophthalmoscopically in extreme cases of either type, average experience shows that the two conditions really merge into each other.

The cerebral disease which most commonly leads to papillitis is *tumor* of the brain. The association of the two conditions is so frequent that in doubtful cases the diagnosis of cerebral tumor is materially confirmed by the presence of optic neuritis. According to Reich[30] neuritis (or the atrophy resulting from it later on) was found in 95.4 per cent. of eighty-eight cases of tumors examined during life and after death. In the analysis of ninety-six reported cases, Edmonds and Lawford[31] found neuritis in eighty-six per cent. of all tumors of the cerebellum, the cerebral ganglia, or the base of the brain, but only in forty-six per cent. of the tumors seated in the cerebral cortex. Hughlings Jackson, on the basis of a large personal experience, thinks that optic neuritis would ultimately set in in every case of tumor were it not for the premature death of some patients. For sometimes the neuritis is a late accident. Occasionally it disappears without leaving any lesion, sometimes to relapse again. Oftener it changes into atrophy of the nerve. In spite of the intense swelling of the papilla vision is but little reduced in some patients. The affection is almost invariably binocular.

Inflammation of the optic nerve, but often with less intense papillary venous congestion than in the choked disk of brain tumors, occurs also in other cerebral affections, but is not nearly so common as in tumors. It has been observed in instances of *pachymeningitis*, of *meningitis*, tubercular, syphilitic, and otherwise, but only very rarely in the *cerebro-spinal* form. It is not uncommon in *abscess* of the brain, especially abscesses of the temporal lobes from ear disease, and in such cases it is unilateral on the side of the abscess. It has also been seen in *hydrocephalus internus* and in thrombosis of the cavernous sinus. In cerebral *embolism* and softening and in *apoplexy* it is very uncommon, except when the effused blood gets in between the membranes at the base. In *diffuse sclerosis*, the *non-inflammatory* forms of *insanity*, and *degenerations* in the brain, optic neuritis is a very exceptional occurrence. A few times optic neuritis has been seen in connection with acute myelitis of the spinal cord. The disease has also been known to follow sunstroke.

7. Atrophy of the optic nerve shows itself by white discoloration of the papilla, often with a greenish-blue or grayish tint, and by failure of sight. If of intra-ocular origin or secondary to optic neuritis the vessels of the atrophied optic nerve are generally contracted. But if the atrophy is due to other causes the vessels may retain their normal calibre.

Atrophy may follow any papillitis which does not speedily cease. It may also result from intra-ocular disease in which the optic disk was not primarily inflamed, such as embolism of the central artery, persistent forms of retinitis (retinal pigmentary degeneration), choroiditis, and chorio-retinitis, and especially glaucoma. It may be the consequence of previous optic neuritis, due to any of the causes mentioned in the former paragraph, as facial erysipelas, lead-poisoning, orbital disease, syphilis, and the various brain troubles engendering inflammation of the optic nerves. With but little intra-ocular manifestation an optic neuritis, involving principally the trunk behind the eye, may follow *loss of blood*, especially from the *stomach*, measles, *typhus* or typhoid fever, mumps and influenza and lead to atrophy. Retrobulbar neuritis due to *tobacco* and *alcohol* poisoning rarely leads to extensive atrophy, but the inflammation of the nerve caused by diabetes may terminate in complete degeneration.

8. Atrophy may occur without previous neuritis by compression of the nerve from traumatic hemorrhages into the orbit or fracture of the walls of the optic canal, from exudation into the orbit or tumors of its walls, from irregular growth of the sphenoid bone (as in acromegaly) or exostoses on its upper surface, from suppurative inflammation of the sphenoid sinus, from anomalously situated or arterio-sclerotic vessels of the circle of Willis, constricting the nerve, or from aneurisms or tumors of any kind pressing upon it. If the compression occurs between the chiasm and the eye the atrophy becomes visible ophthalmoscopically in the course of weeks, while if the function of the optic tracts posterior to the chiasm be destroyed it will require many months or years before the atrophy descends to the intra-ocular end of the nerve. If the cause of the paralysis of the nerve is situated between the basal ganglia and the cortex of the occipital lobes, the atrophic changes may not reach the eye at all in adult life, although during infancy the degeneration pursues a more rapid course. The cerebral affections which may cause atrophy by compression of the region of the chiasm, are distention of the third ventricle by *internal hydrocephalus* and *basilar meningitis* (besides tumors of the bones of the base of the skull). Foci of softening and apoplectic effusion lead but rarely to atrophy by compression. Whenever the inducing cause is at the periphery of the brain, away from the chiasm, the affection is unilateral, but bilateral if the lesion is situated at or near the chiasm.

9. Atrophy not traceable to compression of the nerve is frequent in *multiple sclerosis* of the brain and in *general paresis;* somewhat less common in other forms of mental disease dependent upon degenerative changes. In these instances it is always bilateral, but often unequally advanced in the two eyes, and does not necessarily proceed to complete optic paralysis. Blindness from atrophy is an occasional incident in the course of polio-encephalitis inferior—or in the progressive sclerosis of the nuclei of the upper cranial nerves.

10. Atrophy of the optic nerve is often of spinal origin. In *locomotor ataxia* optic atrophy has been counted in from twelve to twenty-six per cent. of all cases by different observers. It may be one of the earliest symptoms. Its prognosis, if of spinal origin, is always bad, although a temporary standstill for some years is occasionally observed. It may complicate also—though less frequently—other spinal affections, such as myelitis of the lateral columns and injuries of the cervical cord. In Friedreich's hereditary ataxia and similar forms of family afflictions (Sanger Brown) it has been noted as a frequent incident. Atrophy of spinal origin is always bilateral.

In a moderate proportion of cases of progressive optic atrophy no cerebral or spinal cause can be established, although many of the patients present distinct neuropathic tendency, revealed either by their own antecedents or by the family history.

The disturbance of sight in optic atrophy may consist mainly in failure of central vision or in narrowing of the visual field, or it may depend on both factors. It is not possible to determine the cerebral, spinal, or idiopathic origin of optic atrophy by visual tests alone, except in cases secondary to retrobulbar axial neuritis (see XIV., 6) or in affections of the chiasm (see XIV., 5).

XIV. Amaurosis; Amblyopia; Hemianopsia.

The present paragraph is to include all those instances of blindness and of impaired sight which are not due to intra-ocular disease, or to lesions visible ophthalmoscopically, at least at the start. The causes are either affections of the optic nerves, diseases of the nervous system, or systemic morbid conditions. Amaurosis of cerebral origin may, in certain instances, be associated with optic neuritis, but this condition is but a complication in such cases, and does not by itself account for the blindness. In default of objective signs, the location of the trouble must be determined by testing the vision in the centre and in the periphery of the retina, by measuring the visual field for white and colors, and by taking into consideration the pupillary symptoms and the condition of the ocular muscles, of course, with due reference to any nervous or systemic phenomena.

1. Congenital poor vision, but with perfect visual field and normal color-sense, is quite common in an eye more hypermetropic or more astigmatic than its fellow. Occasionally patients discover this stationary defect only late in life. To what an extent such an eye loses still further in sight by non-use, in case of strabismus, is an open question.

2. Sudden loss of sight in one eye may occur from compression of the optic nerve, by traumatic fracture of the orbital walls, by orbital hemorrhages and phlegmons. Gradual blindness can be due to slow compression by tumors and hypertrophic growth in the orbit, or of the sphenoid bone. In these cases the ophthalmoscope shows optic atrophy after the lapse of weeks.

3. One-sided transient blindness has been attributed in some instances to reflexes from carious teeth of the same side. The cases are, however, few in number and mostly not of convincing character. Other instances of so-called reflex amaurosis attributed to neuralgic affections of the fifth nerve or sensitive cicatrices on the face, are perhaps better substantiated, but are also rare. Ziem, Berger (and a few others) have reported unilateral amblyopia with restricted field of vision in suppuration of the maxillary or of the frontal sinus.

4. Unilateral so-called *crossed* amaurosis of cerebral origin has been described by Charcot, in cases of apoplexy or embolism in the posterior part of the internal capsule of the other side of the brain, together with anæsthesia of half of the body (on the side opposite the lesion). But in these cases there was also concentric limitation of the visual field, and impaired color perception on the part of the other eye (on the side of the lesion). In other cases the blindness was not complete, but the impairment of sight was simply more intense in the opposite eye, but of the same character as in the less involved eye. No anatomical explanation can at present be given of these seemingly paradox observations.

Very similar to these visual troubles due to organic cerebral lesions are the eye symptoms in hysteria. The most characteristic form is unilateral amaurosis (generally with normal pupillary reaction), or amblyopia with concentrically constricted visual field and color-blindness, or restricted color-fields. The area sensitive to blue is often smaller than the field for red (contrary to the normal state). The affected eye corresponds to the side of the hemianæsthesia, if present, or to the side of the ovarian tenderness. Often the other eye, too, has a constricted field with diminished color-sense, but good central vision.

In the so-called traumatic neuroses, the hysterical or neurasthenic conditions following sudden injuries, subjective failure of sight is but rarely noticed, but very frequently the visual field of both eyes for white and colors is found concentrically narrowed on testing. It has been noticed in such instances that the retinal periphery is quickly fatigued, so that in successive perimetric tests the visual field contracts during the examination.

5. Bilateral amblyopia is necessarily produced by all the causes mentioned in " XIII., arts. 7 and 8, which lead to atrophy of the optic nerves, while at the very start it is sometimes impossible to recognize the atrophy ophthalmoscopically, at least with certainty. If in these cases the patient complains of one eye only, careful tests will still reveal a slight impairment of the sight, color-sense, or visual field of the other eye.

In cases in which both optic tracts back of the chiasm, or the posterior region of the chiasm itself, are injured by pressure of tumors or apoplectic effusions, or by hydrocephalic bulging of the floor of the third ventricle, the atrophy may not reach the intra-ocular end of the nerve until after the lapse of months. Yet there may be bilateral blindness or amblyopia. The seat of the cause is suggested in these instances by either symmetrical or homonymous sector-shaped restriction of the visual fields of both eyes (see explanation under the head of Hemianopsia).

6. Bilateral impairment of central vision with normal or very slightly constricted visual field may be due to retrobulbar neuritis. The diagnosis is based on the detection of a small oval central scotoma for colors, at first only relative for red and green, later on absolute for these colors and sometimes even for blue, with, however, almost normal color-sense in the periphery of the field. The lesion consists of neuritis limited to that bundle of fibres of the optic nerve which supplies the macular region, and it extends throughout both nerves from the eyes to the chiasm (axial neuritis). If not checked this inflammation leads ultimately to barely visible atrophy of the temporal half of the optic disk. Sometimes, but rarely, there is a slight diffuse cloudiness and congestion of the papilla from the start; occasionally there are small retinal hemorrhages.

The most common causes of retrobulbar neuritis are chronic alcoholism, tobacco-poisoning, or the joint influence of both agents, or diabetes mellitus. Almost the same form of optic neuritis may occur also in the course of multiple sclerosis of the brain, sometimes, however, with more diffuse involvement of the optic nerve. Lead-poisoning, too, may lead to the same form of retrobulbar neuritis, although more commonly the lead neuritis involves the entire area of the optic nerve. There is, besides, a so-called idiopathic retrobulbar neuritis, the cause of which cannot always be detected by clinical analysis, though menstrual suppression and exposure to cold are sometimes accused in a vague manner.

7. Sudden blindness, complete or nearly so, of both eyes is (rarely) produced by a diffuse meningitis of the cortex, by cortical œdema, or increased intracranial pressure from tumors. Cortical lesions are the most probable cause in transient blindness after cerebro-spinal meningitis with retained pupillary reaction. Similar observations have been made after scarlet fever, variola, measles, and other infective fevers, sometimes with recovery, sometimes ending in permanent blindness. The nature of the lesion is not known.

A cortical origin, too, we must assume in the transient blindness of both eyes during uræmia, sometimes without loss of pupillary reaction. The cause of the uræmia is kidney disease, generally that which occurs in pregnancy, but also other varieties, as, *e.g.*, that following scarlatina. Transient blindness in periodic spells has been observed as a malarial manifestation. Lead-poisoning has also been known to cause a temporary blindness comparable to uræmic amaurosis. A similar blindness lasting several days has a few times been observed dur-

ing gastric disturbances, disappearing within some hours after the action of an emetic.

There are on record a small number of cases of absolute blindness without intra-ocular cause, observed upon the cessation of a persistent blepharospasm, but followed by spontaneous recovery in every instance.

8. Complete, though transient blindness, or, in less severe instances, marked reduction of vision, has been observed after large doses of quinine. There was marked pallor of the optic disk and narrowness of the retinal vessels. When sufficient sight had returned to measure the visual field, it was found enormously restricted, and in some of the instances it did not regain its full extent. A similar affection has been known to follow an overdose of salicylate of sodium.

9. A few instances have been reported of sudden interference with sight, not due to any actual diminution of visual acuity, but to inability to interpret the visual perceptions, although the mind was otherwise not disturbed (Wilbrand[32]). The condition has been termed psychic blindness and referred to lesions of the occipital cortex. The same condition has been noticed rather often in general paresis of the insane, but on account of the mental failure of these patients it is more easily overlooked.

10. Hemianopsia, or loss of one-half of the visual field of both eyes can only be produced by a lesion of the optic paths situated somewhere between the chiasm and the occipital cortex. It is either homonymous, involving the internal half of the field of one eye and the external half of the other, or it consists in loss of either the temporal halves or the nasal halves of the field of both eyes.

Homonymous hemianopsia is often described wrongly by the patient as failure of the eye on the side of the blind half of the field, and in such instances the nature of the disturbance is only recognized on perimetric measurement. The central vision is generally perfect. The onset is nearly always sudden. Since either optic tract supplies fibres to the external half of the retina of the same side, and to the nasal half of the retina of the opposite eye, the loss of one-half of the field of vision can only be due to a lesion of the optic fibres back of the chiasm and on the *opposite* side of the brain (see article "Visual Centres," by the writer, in Vol. VII. of this work). If the nerve-path involved be the optic tract in its continuity or at its central termination in the external geniculate body, the pulvinar of the thalamus opticus, or the anterior corpus quadrigeminum, the vertical line separating the blind half from the intact part of the visual field runs exactly through the point of fixation (fovea centralis). Wernike has pointed out that in these cases the pupils will respond only if light is thrown into either eye from the perceiving side, while they remain immobile when the light is situated on the blind side (Wernike's hemiopic pupillary reaction). The lesion producing this hemianopsia may be a hemorrhage or hemorrhagic cyst, a focus of softening or a tumor, on the opposite side of the brain, in any locality where it can involve or compress the optic tract or its central termination.

If the lesion is situated in the occipital lobe, involving either the cortex or the white fibres which connect the cortex with the termination of the optic tract, the hemianopsia does not always extend quite up to the point of fixation, but may leave an area of a few degrees in width intact on the blind side of the fovea centralis. This was illustrated in a unique case reported by Foerster,[33] in which left hemianopsia of cortical origin supervened in a man who had previously a right hemianopsia, likewise due to cortical lesion, and who still retained a central area of about three degrees with good sight.

Hemianopsia of cortical (or subcortical) origin is further distinguished by the pupillary reaction when the light is on the blind side, as well as on the intact side of the field, since the lesion does not involve the reflex circuit of the pupillary fibres. The lesions found in the occipital cortex in a number of reported autopsies of cases of hemianopsia were generally foci of softening, less often effusions of blood or circumscribed tumors, involving the *cuneus* or its immediate neighborhood. As the cortical area representing the visual centre is an extensive one, it may be only partially destroyed by disease, and hence the hemianopsia is not always complete, viz., it does not always mean loss of the total half of each visual field, but may be limited sometimes to corresponding sections of each half of the two fields. Cases have also been reported—presumably of cortical origin—in which there was only color-blindness, but not impaired sight for white in the defective part of the field.

11. Hemianopsia involving only the nasal or the temporal halves of both retinæ can be caused exclusively by lesions injuring the fibres in the chiasm itself—tumors of the pineal gland or the sella turcica, localized periostitis, and circumscribed tubercular or syphilitic meningitis.

12. A transient form of homonymous hemianopsia has been termed amaurosis fugax, scotoma scintillans, or ophthalmic migraine. It is popularly known as blind headache. In the most typical cases a peripheral flickering, setting in suddenly, is followed by more or less complete blindness of one-half the visual field, lasting from some minutes up to (exceptionally) over an hour, while the attack is terminated by severe headache. In other instances there may be general amblyopia instead of hemianopsia, or the visual disturbance may be so slight that the patient lays the most stress on the headache. While such spells have been observed in some patients with cerebral tumors, and often, too, in *general paresis* of the insane, they are, on the other hand, a very common complaint, and generally of no grave significance. They are but a form of migraine, and like the latter may be of reflex origin, sometimes from *nasal* anomalies (Hack, and personal observations). In the writer's experience these attacks of fugitive scotoma have also been averted by removing the eye strain of astigmatism, and by relieving *chronic intestinal catarrh*. Whether ophthalmic migraine is occasionally the equivalent of epileptic attacks is an undecided question.

XV. Diplopia.

1. Double sight occurs whenever the two eyes are not directed toward one and the same point—on account of paralysis of an ocular muscle or mechanical interference with the movements of the eyeball. In ordinary concomitant strabismus diplopia is absent, by reason of the mental suppression of the images in the deviating eye, but the double sight can be made manifest by holding a colored glass in front of one of the eyes, or by shifting the retinal images from their usual position by means of prisms.

2. In rare instances two or even more images of the same object are seen by one eye on closure of its fellow (monocular diplopia or polyopia). This may be due to an optic defect—facets of the cornea or lenticular irregularity from incipient cataract—whereby two separate retinal images are formed. Such diplopia is stopped by looking through a pinhole in a screen. But monocular diplopia—not of optic origin—has also been observed in pure *hysteria*, and in the hysteria complicating organic brain disease.

XVI. External Muscles of the Eye (and Levator Muscle of the Lid).

Strabismus, or the deviation of an eye from the position necessary for single binocular vision, is either concomitant or paralytic. The significance of these two forms is entirely different. The former is due to abnormal tension of one of the recti muscles, while the latter is caused by paralysis of one or more ocular muscles.

1. In concomitant strabismus the deviation of the eye is practically the same toward whichever direction the patient looks, and the deviation remains the same whichever eye the patient uses for fixation (with rare exceptions). The patient may either depend on one eye exclusively (usually the better one) for vision, or he may use alternately either eye. The strabismus is more commonly

constant; sometimes, however, it is periodic. The causes of concomitant strabismus are usually intra-ocular. As a rule (but not without exceptions) convergent strabismus is associated with hypermetropia and divergent squint with myopia. Frequently, but not necessarily, the deviating eye is the weaker one. An eye whose vision is enfeebled by corneal opacity, or intra-ocular disease, is apt to turn outward. Convergent strabismus of hypermetropic eyes sometimes comes on suddenly during childhood, especially after febrile diseases. In such cases the patients complain for a time of double sight without paralysis of any ocular muscle. As a rule, diplopia is not observed in concomitant strabismus.

2. Paralytic strabismus always causes an annoying diplopia. The paralytic deviation of the eye and the resulting double sight increase quantitatively when the eyes are turned in the direction of the weakened muscle, and diminish or disappear when the eyes are turned in the opposite direction. In paralytic strabismus the unaffected eye is used for fixation naturally,* and if it be covered and the affected eye be directed toward a given point, the so-called secondary deviation of the normal eye is greater than that of the affected eye. The trouble may vary from slight paresis to absolute paralysis of one or more muscles.

3. Paralytic squint may be simulated by mechanical hinderances to the movements of the eyes, such as tumors in the orbit. The elongation of the eyeball in high myopia and its protrusion in exophthalmic goître may interfere with the converging power mechanically, but this condition is not due to a paralysis. The only (and rare) cause known to damage the eye muscles directly is *trichinosis*.

4. The lesions causing paralysis of the ocular muscles may involve the motor nerves in their course through the orbit, in their intra-cranial portion, at their nuclei in the basal gray substance from the third to the fourth ventricle, or possibly in the paths connecting the nuclei with the cerebral cortex. The seat of the lesion can be diagnosticated only by the careful consideration of all the symptoms presented by the case, and not always with certainty. It must be remembered that while the fourth and the sixth cranial nerves supply only one muscle each (viz., the superior oblique and the external rectus), the motor oculi innervates the superior, inferior, and internal recti and the inferior oblique muscle as well as the levator of the lid and the sphincter of the iris, and that all these fibres of the third nerve are united in the trunk but separated at the central termination as well as at the peripheral distribution. Both anatomical reasoning and clinical observations show that isolated paralysis of either the pupil, the lid, or the three recti together (viz., superior, inferior, and internal) can only be of central origin, but that a simultaneous involvement of all the muscles controlled by the motor oculi is more likely to be due to a lesion of the trunk of the nerve. It has, however, been learned that isolated paralysis of the internal rectus may be of peripheral origin.

5. Many of the cases of paralysis of the internus or externus muscles cannot be referred to any constitutional cause, and are usually described as rheumatic, but without any proof of their rheumatic origin. The writer[34] has ascertained that many such paralyses are preceded by severe acute coryza, and are evidently due to extension of infection from the *nose*. Orbital causes of paralysis are represented by traumatism, fracture of the walls of the orbit or of the rim of the sphenoid fissure, phlegmon, and tumors.

6. The intra-cranial part of the motor nerves may be compressed by *hemorrhages, meningeal exudations, tumors* of the brain or skull, or *thrombosis* of the cavernous sinus, and in rare instances by aneurismal basilar arteries. Quite common are paralyses, usually multiple, from localized *syphilitic basilar meningitis*. The nerves are also implicated often in fractures at the base of the skull.

7. The nuclei of the motor nerves of the eye may be injured to a greater or less extent by hemorrhages, softening, or tumors, especially syphilitic or tubercular, involving the region between the basal ganglia and the medulla oblongata. There occurs, besides, a progressive ophthalmoplegia externa, due to disease limited to the nuclear gray substance, sometimes of syphilitic origin, in other cases due to a non-syphilitic polio-encephalitis inferior. Disease of the nuclei may also occur before birth, as isolated or multiple paralyses of the lid elevator and the recti muscles are not rarely congenital.

Clinical evidence and scant autopsies have shown a nuclear origin as well in the isolated and often transitory paralyses which are often observed in *syphilis*, in *tabes* (where they may be one of the earlier symptoms), in *multiple sclerosis*, in *diabetes*, in *purpura hæmorrhagica*, in *poisoning by lead, tobacco, carbonic oxide*, and *ptomaïnes* of spoiled meat. The same may be said of the relatively infrequent paralyses following diphtheria (while paralysis of the fibres of the third nerve supplying the ciliary muscle is so common from this cause). Transitory or even permanent palsies of ocular muscles have been known to follow the acute exanthemata, various infectious fevers, and especially *influenza*. Within some years comparatively many cases have been reported of *periodic paralysis* of the *motor oculi* nerve, sometimes complete, sometimes only limited to some of its branches. The spells are preceded by headache, last some days or weeks, and then cease entirely, but return after irregular intervals. The cause is probably central.

8. Of lesions above the nuclei of the motor nerves but little is known in relation to ocular paralysis. Isolated ptosis—paralysis of the levator muscle of the lid—has been observed in disease of the posterior region of the parietal cortex of the opposite side. It is probable that the transitory and often variable pareses observed occasionally in hysteria are due to cortical influences. A few instances of paralysis of associated movements of both eyes (upward, downward, or lateral), but without paralytic strabismus, have been observed (O. Bull),[35] which on clinical evidence can only be referred to disease of the hemispheres of the brain.

9. A not uncommon symptom of localized cerebral disease, especially apoplexy or softening, is conjugate deviation of both eyes to one side, attributable to spasm rather than to paralysis of the internal rectus of one eye and the external rectus of the other. It may be due to either irritative or destructive lesions of the hemispheres or of the basal region, especially the pons. Landouzy states that turning of the eyes toward the paralyzed side indicates a destructive lesion in the neighborhood of the pons, while hemispherical injury causes the eyes to turn away from the palsied side, but that in case of contractures the deviation toward the convulsed limbs means hemispherical, and away from the side of the spasm, pontine irritation.

10. Nystagmus—rhythmic oscillation of the eyes—is generally congenital, or acquired during early childhood in connection with any intra-ocular disease or defect causing imperfect sight. But if it originates after early infancy its significance is entirely different. The acquired nystagmus is a comparatively frequent affection in coal-miners, brought on by the constrained position and the inevitable fatiguing turning of the eyes to one side, perhaps also by the insufficient illumination. If acquired without this provocation it is symptomatic of either malformation of the skull and brain or of *multiple sclerosis*, of hemorrhagic or embolic *foci* in the *thalamus opticus*, the *fourth ventricle*, the *restiform body*, or the *cerebellum*, of *infantile encephalitis*, or of *Friedreich's* hereditary form of *ataxia*.

XVII. Orbit.

1. Hemorrhage into the orbital cavity is quite rare from any but traumatic causes. In the latter case, if the force has not been directed against the orbit itself, the hemorrhage denotes *fracture* of the base of the skull. Severe coughing fits, *scurvy*, and *vascular degeneration* have caused effusion of blood in rare instances. Gaseous infiltration of the orbit—emphysema—can only hap-

* Except when its sight is much less than that of the other eye.

pen from violent expiratory efforts after a fracture of the wall has established communication between the orbital and nasal cavities.

2. Orbital affections may be simulated by empyema of the frontal or of the ethmoid sinus. But these suppurations can also extend into the orbital cavity, causing phlegmon or abscess. Other causes of orbital phlegmon may be *facial erysipelas* or *furuncles*, orbital traumatism and infection, *thrombosis* of the *cavernous sinus* or extension of a *suppurative meningitis*. Phlegmons of *pyæmic* origin have been observed, in surgical pyæmia and in severe infectious fevers. Inflammation of the sheath of Tenon occurs sometimes after severe coryza, and has been seen often secondary to *influenza*. Caries of the orbital wall may be due to *syphilis*, *tuberculosis*, or infection by pus microbes.

3. Exophthalmus, or protrusion of the eyeball, is caused by any tumor or tumefaction in the orbital cavity and is somewhat simulated by the prominence of highly myopic eyes. Exophthalmus forms a prominent symptom of Graves' (or Basedow's) disease—*exophthalmic goître*. There are, however, rare cases of this disease without exophthalmus.

Enophthalmus—the receding of the eyeball into the orbit—is a common appearance in all wasting diseases.

BIBLIOGRAPHY.—The numerous observations upon which this review is based are scattered throughout ophthalmological and neurological literature, and are summed more or less completely in the larger text-books on the eye and on the nervous system. Many details will be found in the different ophthalmic contributions to this REFERENCE HANDBOOK, especially the article by Dr. Moore on "Medical Ophthalmoscopy," in Vol. V. Very complete accounts of the connection of the nervous system, with optic nerve and retina can, be found in Leber's classical treatise in vol. v. of Graefe and Saemisch's *Handbuch der ges. Augenheilkunde*, 1877, and in the articles on the retina (1887) and optic nerve (1888) by De Wecker, and on amblyopia by Nuel (1887) in De Wecker and Landolt's "Traité complète d'Ophthalmologie." Very full also is the part on muscular anomalies by Landolt and Eperon in the same work. Reference should also be made to the "Medical Ophthalmoscopy" by Gowers, 1879 (and second edition in 1881). Good *résumés* of the same subjects are given by Mauthner, "Gehirn und Auge," 1881, and "Die Nuclearlaehmungen der Augenmuskeln," 1885. The relations between the uterus and the eyes are summed up by Cohn in "Uterus und Auge," 1890. On the connection between the nose and the visual organ full references can be found in Berger, "Rapports entre les Maladies des Yeux et celles du Nez et des Cavités voisines," 1892, and in H. Gradle, "The Etiological Relations of Nasal Diseases to Affections of the Eyes," in "Transactions of the Ophth. Section of the Am. Med. Assn., 1892," (and *Journal of the Am. Med. Assn.*, September 10, 1892). The importance of syphilis is well portrayed in Alexander's "Syphilis und Auge," 1889.

A complete *résumé* of eye symptoms in general pathology was first brought out by Foerster, in Graefe and Saemisch's *Handbuch der ges. Augenheilkunde*, vol. vii., 1877. In 1885 Jacobson wrote his short but thorough monograph, "Beziehungen der Veränderungen und Krankheiten des Sehorgans zu Allgemeinleiden und Organerkrankungen," in which—as in the present article—the relations are classified from the ophthalmic standpoint, while tabulation from the medical point of view is again the plan in Berger's large compilatory work, "Les Maladies des Yeux dans leur Rapports avec la Pathologie générale," 1892. The latest review of the subject is the volume by Knies, "Die Beziehungen des Sehorgans und seiner Erkrankungen zu den übrigen Krankheiten des Körpers," 1892. *H. Gradle.*

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[13] Centralblatt f. prakt. Augenheilkunde, 1890, p. 489.
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[33] Archiv f. Ophthalmologie, Bd. 36. i., p. 94. (Another case by Schweigger, Archives of Ophth., 1891, vol. xx., p. 83.)
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FALMOUTH. A popular sea-side resort in Cornwall, England. Falmouth, although nine hours by rail from London, is a fashionable sea-side resort, which has lately become quite prominent. The harbor is one of the finest in England, and the sandy beach is very attractive. The climate, though humid, is mild and agreeable. Bathing is the chief attraction. Invalids of various kinds live there in winter and spring, owing to the climatic and sanitary advantages of the place. *Edmund C. Wendt.*

FEL BOVIS. The action of ox-gall in assisting the absorption of fats and oils, and its aid in maintaining intestinal antisepsis, has suggested its use as a proper means of treating typhoid fever. Dr. Adolph Zea reports the result of ten cases in his own wards, and forty-eight cases treated by medical friends, as very gratifying. His method of conducting the case is as follows: If seen early, a dose of calomel is given to relieve the digestive tract of its contents; alcohol in the form of whiskey is given at first as a stimulant, and, if additional stimulation is required, strychnine, caffeine, ammonia, camphor, or small doses of quinine; dilute muriatic acid in large quantities of water as a beverage, and fel bovis purificatum siccum, in doses of two to four grains, three to six times a day in pill form or capsule. The diet consists of fluids—milk, gruel, beef-tea—in small quantities frequently given. The milk should always be boiled, but may be given hot or cold according to the wish of the patient. Preparations of beef extracts and juices may also be given.

The benefit of this treatment is shown in a reduction of the temperature after the drug has been given for a few days, and a freedom from all distressing abdominal symptoms and complications. Convalescence is also thought to be more rapid than under any other line of treatment.

It is urged that if bile is essential in health, it is still more so in such a condition as enteric fever, when the functions of all the organs are in abeyance and the normal secretion of bile, so much required, is lacking. It is uncertain how it acts, whether by passing direct from the stomach into the intestines, or whether it is first absorbed and then secreted as human bile. If the article is pure and not altered by age it is perfectly unirritating and may be given without the fear of its causing any unfavorable results. Whenever pain, vomiting, or any symptoms of gastric irritation arise, it is due to the presence of proteid matter and other impurities in the drug, which have imparted the poisonous properties.

W. H. Porter contributes, in Merck's *Bulletin*, July,

1890, an article on the properties of ox-gall. He has used it in great quantities for over ten years, giving as much as twenty-five or thirty pounds during a year. He insists upon the necessity of procuring good preparations, both free from impurities and not spoiled by exposure to the atmosphere. He recommends that only the purified inspissated bile should be used.

The physiological action of ox-bile is summed up by him as follows: 1. It acts on the fats and promotes their absorption by the lacteals. In all forms of milk diet he thinks that two grains of the purified gall in capsules should be given before the diet is commenced in the morning, and repeated during the day according to the quantity of milk ingested. 2. It contains a diastatic ferment and has an important action in the conversion of starch into glucose. 3. It promotes a normal peristalsis of the intestine which favors absorption and prevents constipation. 4. The bile-acids stimulate the minute muscles of the villi, the contractions of which force the contents of the lymph-sacs onward and favor absorption. 5. The presence of the bile stimulates the activity of the epithelium and promotes a secretion of fluid from the follicles. 6. It prevents putrefactive changes and may be looked upon as nature's chief internal antiseptic. 7. It aids the final solution of albuminoids and their conversion into the diffusible peptones. *Beaumont Small.*

FELIXSTOW. A rising spa on the Suffolk coast, England.

Location.—Felixstow Spa is about twelve miles from Ipswich, and two and a half hours from London. Having a southerly aspect, comparatively dry air, a bracing climate, a fine beach, and a chalybeate spring, it is growing in popular and professional favor. In *The Lancet* of November 12, 1892, Dr. Macnaughton Jones gives the following particulars of the place:

"Facing the German Ocean, between Harwich on the south and Bawdsey at the mouth of the Deben River on the north, Felixstow beach occupies an amphitheatre which has at one point of the crescent Landguard Fort, commanding the entrance to Harwich, and at the other a picturesque villa perched just above the cliffs of red crag and London clay that bound this part of the coast and over which there is a delightful walk to Felixstow ferry. The famous golf grounds and the well-known golfing club—the links of which are splendidly placed on the side of the Deben river, close to the sea, about two miles from the eastern side of the town—attract many visitors. The capital bathing beach and the safe sands render Felixstow a typical place for children, and each year it is growing more in popular favor as a children's holiday resort. Dr. Taylor, having tested personally and with others the medicinal properties of the spa, was induced to try its aëration by artificial means, hoping thus to get rid of the smell and unpleasant taste due to the decomposition of the pyrites which is found in the London clay of the soil. In this he has been most successful. The taste reminds one of the Weinbrunnen spring at Schwalbach—sparkling and mildly chalybeate."

Analysis.—According to Dr. Frankland, one hundred thousand parts of the water yield the following ingredients:

	Parts.
Total solid residue dried at 130° C.	85.30
Lime as carbonate	11.76
Magnesia as carbonate	2.16
Total magnesia as carbonate	5.78
Soda	22.25
Potash	1.21
Chlorine	30 44
Sulphuric anhydride	3.40
Silica	1.51
Alumina and peroxide of iron	0.11
Organic carbon	0.063
Organic nitrogen	0.019
Ammonia	0.070
Nitrogen as nitrates	0.0
Phosphoric acid	0.0

These constituents are probably combined in the water in the following manner:

	Parts.
Carbonate of lime	21.00
Carbonate of magnesia	4.54
Sulphate of lime	4.01
Sulphate of magnesia	1.52
Chloride of magnesium	7.36
Chloride of sodium	39.60
Chloride of potassium	1.92
Silicate of sodium	3.07
Alumina and peroxide of iron	0.11

Indications.—According to Dr. Jones, the constitution of such a water would justify the belief that it must prove of use in cases of atonic dyspepsia, and as a mild purgative, from the sulphate and chloride of magnesia which it contains; both used internally and as a bath such a spa should prove of efficacy in gouty rheumatism and muscular neuralgias. A spring which can yield an unlimited supply within a few yards of the beach of one of the most salubrious of English sea-coast resorts, in a neighborhood with a singularly dry climate and a soil that quickly absorbs moisture, free from moist exhalations, and that by its situation is protected from the severity of the east winds, is well worth developing. The drinking-water of Felixstow is singularly pure, being drawn from an artesian well which is sunk in the chalk.

Accommodation.—There are plenty of good apartments, charmingly situated villas, and an excellent hotel, which is beautifully situated and within a few hundred yards of the spa. There are many pleasant drives in the vicinity (Jones). There is a "Spa House," resembling somewhat a German *Kursaal*. There is also a large "Convalescent Home." *Edmund C. Wendt.*

FEVER. Recent investigations have somewhat modified our views of fever, particularly as regards its dangers. They have taught us, among other things, not to base the prognosis of a disease upon the height of the fever that is present, to the neglect or exclusion of other symptoms. The term fever is here limited in its signification to elevation of temperature, although it is still frequently employed to designate a group of symptoms of which elevated temperature is one of the most prominent and one of the most important.

Elevation of temperature and increased heat-production are not synonymous terms, neither is the one a measure of the other. The temperature curve, as described by the record of thermometric readings, serves but to denote the balance between opposing tendencies, of which heat-production and heat-dissipation are the most important, but possibly not the only factors. Macalister has aptly said, "The constancy of the temperature of the body in health, under widely varying internal and external conditions, is a fact so familiar that we have ceased to wonder at it; yet it rests upon a perpetual balance of opposing tendencies which is as mysterious and as beautiful as anything in our frames." And the same may be said of the temperature in fever, except that the conditions are abnormal. No one, perhaps, has given us a more lucid explanation of the nature of fever than the author referred to in his Gulstonian Lectures of 1887, which have done much to mould the thought of succeeding years.

Macalister[1] considers the fever mechanism under three heads, namely, first, a thermogenic, or heat-producing mechanism; second, a thermolytic, or heat-dissipating mechanism; and third, a thermotaxic mechanism, whose office is to exert a controlling or equalizing influence upon the mechanisms for the production and dissipation of heat. Our definite knowledge of these three mechanisms is by no means equal, but like that of most physiological phenomena, grows less as we ascend farther from the lower animal kingdom. Our knowledge therefore of thermolysis is comparatively full, for this mechanism is found even in the cold-blooded animals. We know less of thermogenesis, and have only recently learned anything of its connection with the nervous system; while we have little more than inferential knowledge of thermotaxis, which is believed to reach full development only in the mature human being.

Thermolysis.—Thermolysis, or the mechanism of heat-dissipation, is too well understood to justify extend-

ed description in this place. It acts chiefly through the blood-vessels and sweat-glands of the skin. It is under the supervision of the vaso-motor centres of the medulla and spinal cord. These centres are perhaps of two kinds, vaso-constrictor and vaso-dilator in character. A certain part of heat-dissipation, amounting, perhaps, to twenty per cent. of the total heat-loss, is accomplished through the respiratory organs, and these are also under the control of a centre in the medulla oblongata, with, it is believed, a motor and inhibitory action. It has further been determined that these centres governing thermolysis are susceptible to elevation of temperature in such a manner that the result is an increase of the discharge of heat from the body. This mechanism is believed to be a common property of the animal kingdom, being found well developed in the cold-blooded animals as well as in the warm.

THERMOGENESIS.—The muscles are the seat of heat-production, the "thermogenic tissue par excellence." They produce four-fifths of the body-heat in health, and perhaps a larger ratio of it in pyrexia. The remaining fraction is supplied by the secreting glands and the alimentary canal during digestion. As secretion and digestion are at a low ebb during fever, this fraction becomes less, and the muscles remain almost the sole producers of heat.

Modern investigations have but confirmed the old doctrine that the formation of heat is materially increased in fever, that the process of heat-formation in the muscles is chemical in nature, and for the most part a process of oxidation (combustion). Oxygen is absorbed and carbonic acid is discharged. The absorption of oxygen and the discharge of carbonic acid do not always, however, bear a constant relation to each other. A measure of the one cannot be used for the estimation of the other in a given case. The more recent investigations of Finkler and others have yielded results differing but little from those obtained in 1877 by Colasanti. The latter observer found the average increase in the amount of oxygen absorbed in fever to be 18 per cent., and the increase in the excretion of carbonic acid 24 per cent. Finkler found, under circumstances fairly similar to those of Colasanti, that the increase of oxygen absorption was 13.8 per cent., and of carbonic acid discharge 15.3 per cent. He found, further, that the increased absorption of oxygen kept pace with the stage of the fever; that it increased as the fever rose, remained stationary in the fastigium, and declined with defervescence. The highest percentage he found was 36.6 per cent. of oxygen increase, and 37.6 of carbonic acid lost. It is admitted by all investigators, however, that we have no means of determining with absolute precision the amount of oxygen which is absorbed in fever. This fact is largely accounted for by the uncertainty which must exist as to the respiratory quotient, or the ratio of oxygen that is used in the production of carbonic acid in respiration. It is probable, too, that, just as in health, a certain part of the oxygen that is absorbed in fever is used in the production of other combinations than carbonic acid, particularly in the production of water. But the respiratory quotient is admitted to be lower in fever than in health, since in fever only fats and proteids are oxidized. Colasanti [2] and Lilienfeld,[3] while admitting this fact, assert that the respiratory quotient in fever does not materially differ from that of the same animal in health, under the conditions of nutrition which are present in fever. Finkler [4] thinks the reduction of the respiratory quotient more rapid than occurs in hunger, owing to the greater rapidity of oxidation that takes place. All agree, however, that the oxidation-products in fever are the same as those of health, and that additional products, if formed, are produced in very small amounts. According to Regnault and Reiset,[5] a fourth to a third of the absorbed oxygen, in hunger, is available for combination with hydrogen to form water. If, as is claimed by Colasanti and Lilienfeld, the same ratio exists in fever, heat-production ought to be proportionate to the amount of oxygen absorbed. But if, as Regnard [6] asserts, the respiratory quotient is always very markedly reduced in fever, and a larger amount of oxygen is available than in health for the oxidation of hydrogen, the increment of heat-production should be still greater; for a greater amount of heat is produced by the same amount of oxygen, when employed for the oxidation of hydrogen, than when it combines with carbon. And another source of variation lies in the fact that the same quantities of hydrogen and carbon, in their oxidation, yield varying amounts of heat, according to the chemical compounds in which they are contained, and we cannot say positively that the compounds oxidized are the same in fever as in health under like conditions of nutrition (Welch).[7]

Ord [8] has given us yet another, and a very ingenious, hypothesis in reference to a source of at least a part of the fever-heat. He suggests that chemical processes occur in the body by which, in health, heat-energy is stored up or rendered latent, as in the up-building of tissues. Since, therefore, tissue-formation is in abeyance during pyrexia, he argues that the heat of the body may be increased not only by processes of disintegration, but as well by the persistence, in the form of heat, of energy which, under normal conditions, would have taken another form. But, as Welch remarks, the amount of energy appropriated in the form of heat by these constructive processes bears only a very small ratio to the total heat-energy set free by heat-producing processes, so that their cessation would not bring a very large increment to the heat of the body. Welch,[9] while he does not attach much importance to figures purporting to express the actual heat-production in fever, believes that we are justified in drawing one conclusion from the results of direct and indirect calorimetric observations: "This is, that while an individual in fever produces more heat than he would in health under similar conditions as to food and muscular movements, he does not produce necessarily in fever more heat than he would in health on a full diet. And it is certain that he usually produces far less heat in fever than he often does under circumstances which normally increase heat-production, such as a cool environment and muscular exercise. . . . That in health vastly increased heat-production may occur with comparatively little change of temperature, is, of course, due to the fact that the dissipation of heat is proportionately increased. It is self-evident, and, so far as I know, has never been disputed, that in fever the equilibrium is so disturbed that heat-loss does not correspond to heat-production, as it should in health."

Many very interesting experiments have been made with a view to determine the relation, if any, which exists between heat-production and work-production in the muscles. It has been found that a muscle stimulated to action by an electric current produces both motion and heat, but that under long-continued stimulation the muscle becomes fatigued as a heat-producer much sooner than as a work-producer. The heat-producing function may even be abolished through fatigue without total or even very marked loss of the power of work-production. Cold is also capable of depressing or abolishing thermogenesis without notably affecting the motor function. The two functions are further distinct as to time, for while muscle-action causes heat-production, it is not necessary to it. A muscle which is at rest, so far as motion is concerned, continues to be a heat-producer so long as its nutrition and innervation remain intact. In other words, heat-production is constant, work-production intermittent. There cannot, therefore, be any constant relation between muscle-force and heat-production. Drs. Mead Smith, Macalister, and Lukjanow [10] conclude, from their experiments in Ludwig's laboratory, that the two processes are independent of each other in nearly all features, and in all such external relations as fatigue, exhaustion from inanition, rest, and temperature.

Macalister, basing his conclusions on his own experiments and those to which reference has just been made, says: "The conclusions I have adduced, and especially those relating to the power of recovery in a fatigued muscle, under the influence respectively of rest and of the blood-supply, point to the conclusion that the two metabolisms are in some way different; in other words,

that the 'contractile stuff' in the muscle is not the same as the 'thermogenic stuff.' Both of them are stored up in the muscle; so far as function is concerned they *are* the muscle. The store of each can be exhausted by repeated stimulation, but in some cases the thermogenic store sooner than the other. Both can be upbuilt again by the circulating blood, but in some cases the contractile store sooner than the thermogenic. Both the metabolisms are affected by cold, but the thermogenic much more intensely than the contractile. We know little of the chemical changes involved in either form of metabolism. Oxygen is taken up in each and carbonic acid is discharged, but the processes passed through between these terminal stages are much more complex than mere oxidations. The evidence rather goes to show that it is the living substance, as a whole, contractile stuff and thermogenic stuff, which is continually being decomposed and as continually recomposed by the blood."

The independent character of these two functions of the muscles has suggested the probability of an independent nervous control over each function, but no separate nerve-supply for the government of them has yet been discovered. It is believed by some investigators that thermogenesis is under a motor and inhibitory nervous mechanism similar to that which governs the thermolytic and so many other mechanisms with which we are familiar; but nothing is known of the path by which these motor and inhibitory impulses reach the muscles, unless they are conveyed by the same nerve-trunks which carry the impulses for the control of the work-producing function. Probably they are in some manner transmitted by the motor fibres, or if a special nerve-channel exists, it may probably be so associated with the former as to be undistinguishable from it. Mead Smith attempted to demonstrate the existence of separate fibres for thermic and motor impulses by means of the injection of curare, but without success. Mosso,[11] however, found that by the administration of moderate doses of this drug the motor nerve-endings may be completely paralyzed without obliterating the sensibility of the thermic nerves; he also found that the injection of strychnia into animals thus moderately curarized produced elevation of temperature, but no excitation of the motor function of the muscles. The centre which controls thermogenesis has been located by nearly all investigators in the corpus striatum. The evidences which have led to this conclusion have been both clinical and experimental, the former class beginning with Sir Benjamin Brodie's case of fracture of the cervical vertebræ and spinal-cord injury; the latter class with Bernard's experimental sections of the sympathetic in the necks of animals with resultant rise of temperature. Subsequent experimenters, among whom none have been more painstaking and conscientious than H. C. Wood, of our own country, have arrived at fairly uniform results, although differing widely as to details. Following up the experiments of Tscheschichin, this investigator found, by calorimetric experimentation, that an actual increase of heat-production occurs after section of the nerve-matter at the junction of the pons and medulla. From this he concludes that there are situated above this point thermo-inhibitory centres. More definite conclusions have been arrived at in regard to the location of these centres by Ott, Aronsohn and Sachs, Baginsky, and others. Ott[12] concluded that there are four heat-centres in the cerebrum, one in the vicinity of the corpus striatum, one in the caudate nucleus, a third in the anterior inner end of the optic thalamus, and the fourth near the median line between the optic thalamus and corpus striatum. Injury of the centre in the optic thalamus caused the most pronounced rise of temperature. Aronsohn and Sachs[13] found that puncture of the anterior part of the caudate nucleus, near its median convexity, causes rapid rise of temperature, amounting to three or more degrees, and continuing for two or three days, and that electrical stimulation of the same region causes a similar rise of temperature. This was accompanied by increased absorption of oxygen and elimination of carbonic acid and nitrogen. They, therefore, conclude that there is here located a thermo-excitory centre. As further evidence of the existence in the corpus striatum of a nervous mechanism intimately connected with the production of heat, White[14] cites the fact that this body is larger in warm-blooded animals than in cold, and largest in those which are subject to the highest rise of normal temperature, especially birds.

Thermotaxis.—The thermotaxic mechanism to which reference has been made has for its office to maintain a balance between thermogenesis and thermolysis, probably by causing modifications in the action of one or other of these mechanisms, or both. It is supposed to reside in the nervous system, but its precise location is not known. Ott locates it in the cortex in the vicinity of the fissure of Rolando, with some fibres at the base of the brain in some way connected with it; but Corin and Van Benedin[15] deny that any cortical centres are in any way connected with the heat-mechanism, since they were able to remove the hemispheres in pigeons without causing any change of temperature. Probably absent altogether from cold-blooded animals, the thermotaxic mechanism is much better developed in man than in the lower warm-blooded animals, a fact supported by the much greater stability in man of normal temperature. That it is but poorly developed in infants is indicated by the ease with which trifling causes produce marked disturbances of temperature, depressions on exposure to cold, and elevations on the occurrence of slight functional disturbances, as of the digestive organs. White believes that the human embryo is, until quite the late months of intra-uterine life, a cold-blooded animal, depending for its warmth upon that of surrounding media. Welch[16] believes that fever-producing agents must act directly or indirectly upon the mechanism which regulates the harmonious relation of heat-loss to heat-production. Macalister does not limit the production of fever to the disturbance of thermotaxis, but believes that there are three degrees of disturbance ordinarily produced. "Fever necessarily implies (1) a disorder of the thermotaxic mechanism; (2) an excessive production of heat, associated with excessive chemical changes in the tissues, the excessive production being more or less than that of a normal patient in full diet (perhaps oftener less than more), but more than that of a normal patient on fever diet; (3) that the body temperature depending upon the balance between production and discharge, fluctuates as the one or the other is in the ascendant, and is not, *per se*, a true measure of either, or of the consumption of tissue that may be going on. When thermotaxis alone is disturbed, the result is a peculiar rising and falling of the temperature, depending upon variations of production and loss, without the normal controlling influence of the affected centre. This has been termed thermal ataxia. The next degree of disturbance is that which is probably present in ordinary fever, namely, a disturbance of thermotaxis and thermogenesis, resulting in a loss of the controlling influence and an increase of heat-production. With this is associated, as a rule, a stimulation of thermolysis, an increased dissipation of heat. When, however, we have, in addition to the disturbance of thermotaxis and thermogenesis, a diminution of the dissipation of heat, the result is hyperpyrexia. The reduction of heat-dissipation thus produced is supposed to be in great measure a result of the action of high temperature, and to denote an exhaustion of the nervous mechanism controlling thermolysis; it is in part also, no doubt, a result of the action of the toxic matter which is the cause of the increased temperature." Fever, in other words, according to Macalister, is a process of dissolution from above downward, affecting first the centres most recently evolved and therefore most liable to disturbance, and last, those which are most stable (White). In recovery, too, this author maintains, with apparent correctness, that control is regained from below upward. First the thermolytic mechanism is incited to action, which is frequently indicated by the occurrence of more or less profuse sweating. As thermogenesis becomes more and more inhibited the temperature rises less and less high on succeeding days; but until thermotaxis becomes fully established the rhythm of thermogenesis and thermolysis is easily disturbed by such

trifling causes as errors in diet, fatigue, etc., the condition of the convalescent in this regard resembling somewhat that of the infant.

Wood [17] maintains that the cerebral centre is inhibitory in character, its disturbance permitting rather than producing increased thermogenesis. Heat-dissipation he places under control of the vaso-motor centres. In a contribution to the American Association of Physicians he thus recently summarized his theory of pyrexia:

First. "Fever is a disturbance of calorification in which, through the nervous system, heat-dissipation and heat-production are both affected. If there be a fever which is produced by the direct action of a poison, independent of the nervous system, we have at present no proof of its existence.

Second. "Heat-production is regulated by a nervous apparatus of which the knowledge is still imperfect. There is certainly an inhibitory centre which depresses or controls the production of heat. It probably does this by acting on the trophic cells of the gray matter of the spinal cord. It is possible also that there is a centre which, when excited, increases tissue-change, but its existence has not yet been proved.

Third. "Heat-dissipation is regulated through the vaso-motor system, so that vaso-motor paralysis is followed by an enormous loss of animal heat, and, under favorable conditions, by death from cold." [17]

Hanfield Jones [18] adopts a yet simpler view in the supposition that elevation of temperature is a paralytic phenomenon due, as is also the increased heart action and rapid respiration, to a toxic depression of nerve-centres similar in character to the depressant action more easily recognized in the clouding of the intellect and impairment of muscular mobility.

Immediately after the lectures of Macalister, Maclagan [19] published a series of articles on pyrexia and hyperpyrexia. He considers these not as different degrees of the same condition, but as essentially different in their causation. He states two theories of fever, first the combustion theory, according to which there is abnormal activity of the heat-producing process; a second, the neurotic theory, according to which the elevation of temperature is due to the impairment of the inhibitory force which keeps heat-production within normal bounds. He does not regard the two theories as antagonistic, but believes that each has its sphere of applicability. The combustion theory applies to all such specific fevers as malaria, rheumatism, and pneumonia—to all, in short, in which the poisons may be supposed to be micro-organisms, whose morbific action depends upon their organic development. He thinks it probable also that the fever of all inflammations is thus produced, not that all are necessarily due to foreign organisms, but because excessive activity of the minute cellular elements of the tissues may have the same effect on their metabolism as the propagation in them of foreign organisms. The neurotic theory explains probably all cases of hyperpyrexia resulting from non-inflammatory lesions in the nerve-centres, and probably most forms of so-called ephemeral fever.

Austin Flint [20] believes that the cause of fever is twofold, the more important factor being an exaggeration of the chemical changes taking place within the organism which generates the animal heat within normal limits, the other factor being a disturbance of the process of equalization of temperature, which acts mainly through the skin. He believes that the original cause of most, if not of all, the essential fevers is a micro-organism, different in character in different forms of fever. The author does not, however, in this connection enter into a discussion of the theory of nervous supervision over the heat-mechanism.

Causes of Fever.—The study of the etiology of fever has confined itself for the most part to the investigation of the action of ferments and putrid matters when introduced into the circulation, and to the effects produced by the entrance into the organism, experimentally or otherwise, of the micro-organisms of disease and their products. Fever sometimes undoubtedly occurs, however, which is due to the direct impression on the nerve-centres of influences arising in the body, even in the nervous system itself, quite independently of the action of chemical products of any kind.

The chemical agents which produce fever are of two kinds, namely (*a*) those which are a result of metabolisms going on in the organism independently of micro-organisms, and (*b*) those which result from the action of micro-organisms. The former bear close resemblance, if not relationship, to the physiological ferments, or are identical with them. Instances of their action are believed to be seen in the so-called aseptic fever following the receipt of severe injuries and the fracture of large bones, which are removed from infection or are cared for in the most rigidly antiseptic manner. Some of these agents are supposed to exist in small amount in the healthy organism, others to result from the decomposition of extravasated blood or other tissue. The fever of anæmia is also supposed to be, in some instances at least, a result of this kind of intoxication.

The second class of fever-producing agents, resulting from the action of micro-organisms, are of two kinds, agreeing with the pathogenic or non-pathogenic nature of the organisms of which they are the products. The term non-pathogenic is here used in its usual signification, designating micro-organisms which are not capable of propagation within the human body, although in some instances capable of producing disease when introduced into it. Large numbers of these organisms, for the most part saprophytes, reside at times in the body. They exist in great numbers and in great variety in the alimentary canal, into which they gain entrance with the food. The products of their metabolism alone gain access to the circulation, and the fever thus produced, as also its degree and the character of the accompanying symptoms, depend in part upon the amount and the character of the substance absorbed and the character of the organisms producing them, and in part upon the nature of the soil on which the organisms have grown, the character of the environments, etc. Examples of the pyrexia thus induced are abundantly seen in the fever caused by digestive disorders, particularly in children; in the fever which results from the absorption of toxic matters deposited by micro-organisms upon the surfaces of the mucous membranes of the fauces and tonsil, including perhaps some cases of diphtheria; in the elevation of temperature which follows wound-infection; and in many of the cases of poisoning which follow the eating of such unsound food as decayed meat or fish.

Most, if not all, the acute infectious diseases are now attributed to the presence and growth within the body of micro-organisms, the so-called pathogenic bacteria. Fever in these diseases is believed to be due to the chemical products of these organisms, and therefore we attribute the symptom to the organism which produces the poison. Although the organisms exist and grow within the blood-vessels, spleen, lymph nodes, and other glandular organs, few symptoms ever, and fever probably never, result from the direct action of the bacteria. Their chemical products, carried by the circulating blood, act directly upon the centres governing the heat-mechanism in the manner that has already been described.

Comparatively little is known concerning pyrexia resulting from the disturbance of the thermotaxic mechanism by any other than chemical irritants. Instances of it are, however, supposed to be presented in the elevations of temperature occurring in hysteria, in pronounced nervous excitement, particularly of children, and in convalescence. The elevation of temperature which sometimes occurs in convulsions may be regarded as of this character only when the convulsive phenomena are due entirely to nervous excitation in the absence of any toxic influence.

Effects of Fever.—The list of disastrous results which can be attributed to fever has been greatly shortened during the last few years. Formerly nearly all functional disturbances and all tissue-changes which occurred during the existence of a pyrexia were attributed to the elevation of temperature, and so great was the fear of fever that its reduction became almost the

sole object of treatment. A reversion from these views has occurred, however, which is so complete that we no longer look upon an occasional rise of temperature to 104° or 105° F. with much alarm, and there are those who maintain, with probable correctness, that elevation of temperature is one of nature's methods of combating disease—a *vis medicatrix naturæ*.

To determine the effects of high temperature many clinical observations and many experiments have been made by a large number of investigators. Probably the method which has yielded the most satisfactory results has been that of observing the effect of external high temperature on man and animals. By this means we have produced not only the desired elevation of internal temperature, but also the elimination of the influence of toxic elements which must always be taken into consideration when observations are made at the bedside. As a result of the observations referred to, all experimenters agree that a mammalian animal, artificially heated, dies when its temperature reaches 44° or 45° C. (111.2° or 113° F.). The death is preceded by convulsions, is quickly followed by rigor mortis, and is attributed to heart paralysis. Most of the animals experimented upon show signs of illness at a temperature several degrees below the lethal point, and it was inferred by most observers that toxic changes were produced by the increased temperature. But Naunyn reasonably attributes the cause of death, in many of the reported experiments, to the fact that the animals experimented upon were confined in small, ill-ventilated compartments, sufficient alone to cause their illness. By correcting these errors he succeeded in keeping a rabbit alive for thirteen days at an average temperature of 41.5° C. (106.7° F.). Welch,[21] by following Naunyn's suggestion, succeeded in keeping two black rabbits alive three weeks with an average temperature of 41.8° C. (107.3° F.) and 41.4° C. (106.6° F.), respectively. His observations are probably the most accurate that have yet been made. Although the animals lay most of the time stretched out, they took their food greedily and manifested no symptoms of illness. It was found essential to the success of the experiments, however, that the temperature be gradually raised. It was found that no factor is more important in determining the effects of external heat than the animal's power of temperature regulation. Failure of this power (paralysis of the thermotaxic mechanism) is followed by a sudden rise of internal temperature (hyperpyrexia) which may quickly attain a point incompatible with life. This point varies with different animals, and with the same animal at different times. The condition of the blood was found to affect the animal's resistance to a marked degree, a state of anæmia greatly reducing its power of resistance. The experiments of Maurel[22] are also of interest as indicative of the cause of death in high elevation of temperature. He found that a temperature of 44° to 45° C. (111.3° to 113° F.) destroys the vitality of the leucocytes within a few minutes, a temperature of 43° to 44° C. (109.4° to 111.3° F.) within an hour, and from 42° to 43° C. (107.6° to 109.4° F.) within three hours. But if the temperature be reduced, the leucocytes regain their vitality.

Welch concludes, from his own observations and those of Naunyn, that a considerable part of the current arguments based upon experiments concerning the injurious effects of high temperature, must be revised. "Because an animal may be killed by raising its temperature to 111° F. (43.9° C.), or 113° F. (45° C.), it does not follow that an increase of temperature up to within 4° or 5° F. of this fatal point involves danger to life, or even any serious disturbance of the functions of the body. Although experiments in hot-air chambers show that in man brusque elevations of the temperature by only a few degrees give rise to serious symptoms, Krishaber[23] found that by habituation his temperature could be raised to 106.5° F. (41.4° C.), or 107.2° F. (41.8° C.) without much discomfort." From a clinical stand-point, therefore, much depends upon the gradual accession of the fever and the intervals of depression between the maximal points of elevation.

One of the earliest and most striking symptoms of fever is an increased rapidity of respiration, a symptom which has been generally attributed to the direct action of the high temperature upon the respiratory centres. Sihler[24] has, however, shown that another factor, and probably a more important one in experimental pyrexia, at least, enters into its production, namely, the stimulation of the skin. Although it is probable that the stimulation of the skin by heated blood may in a measure influence the rapidity of respiration in man, it undoubtedly does so to a much less degree than in the animal; and the truth still remains that increased respiration is due chiefly to the direct action of the warm blood upon the respiratory centres.

The heart is stimulated to increased action in pyrexia by the direct impression of the heated blood. Martin[25] has demonstrated that the heart beats quicker when supplied with warm blood than when supplied with cold blood, and that its rate of action depends much more upon the temperature of the blood in the coronary arteries than on that in the right auricle or ventricle. Although this fact has been demonstrated, we are not justified in supposing that the elevation of temperature is in a given case the only element in the production of the accelerated heart's action, for this may result in a great measure also from the action of the chemical irritants which are more or less directly the cause of the pyrexia.

Changes in the arterial tension and blood-pressure in fever have been attributed to the action of increased heat, but they are probably due, as Welch has shown, much less to increased temperature than to other causes, especially to the infectious agents which have induced the elevation of temperature.

Fatty degeneration of the heart, liver, kidneys, and other organs, and of some of the voluntary muscles, has been more or less generally observed as a consequence of continued high temperature; but there is not a unanimity of opinion as to how far these changes may be attributed to the elevation of temperature, and in how far they are the result of other causes. Heat is at least not the only element capable of producing the degeneration in these cases.

Many other phenomena, more or less generally attributed to the influence of high temperature, might be mentioned did space permit, and their importance justify. In many instances, however, the conclusions that would have to be drawn are more or less speculative in character. Among the phenomena referred to may be mentioned the almost universal wasting of tissues in fever, the reduction of digestive power, the constipation, the increased absorption of oxygen and increased discharge of carbonic acid to which reference has been made, the clouding of the intellect, the prostration, the coma-vigil, disturbances of tendon reflexes, muscular weakness and twitchings, and other manifestations of nervous disturbance. There can, however, be no doubt that in most of these instances the phenomena are attributable as much to the action of poisons circulating in the body as to the elevation of temperature. Flint[26] believes that while the special morbific cause of the disease in these cases is the cause of the delirium, etc., it is rational to suppose that it acts as a secondary cause of these phenomena, by virtue of changes induced directly by the prolonged elevation of body temperature. This statement is supported by the fact that the abstraction of heat, by means of cooling applications to the exterior of the body, is sufficient to arrest these nervous phenomena.

The leading premise from which certain writers have drawn their argument of the beneficial action of fever is the fact that the vitality of micro-organisms is destroyed by heat. Few of them can withstand a temperature of 40° C. (104° F.) except for a short time, the activity of their growth diminishing as the temperature approaches this limit. From this fact it is concluded that a moderate amount of fever is sanatory in its effects on the infectious diseases.

Treatment of Fever.—Fever being no longer regarded as of necessity an element of great danger, the

object of treatment is rather to exert a judicious control over it than to entirely overcome it. A reaction has set in against the too free administration of antipyretics, owing in great measure to the disappointment which has followed their universal adoption by the profession.

Liebermeister[27] has given us a judicious summary of the treatment of fever. He says that in many cases of febrile disease the height of the temperature constitutes a danger; that in these cases the therapeutic problem is to reduce the temperature. The basis of antipyretic treatment is the direct withdrawal of heat by means of cooling baths; yet in many cases the administration of antipyretic medicaments is at the same time necessary.

Flint's classification of the methods of treating fever is as follows:[26]

1. Reduction of the general temperature by the external application of cold.
2. Reduction of the temperature by the internal administration of antipyretics.
3. Promotion of general nutrition by alimentation.
4. Measures to supply to the system matters that can be consumed in the excessive production of heat, thereby retarding the destruction of tissues.

Directions for the reduction of temperature by means of the application of cold to the exterior of the body may be found in the REFERENCE HANDBOOK OF THE MEDICAL SCIENCES, Vol. III., p. 69.

Treatment by the internal administration of antipyretics has not proved so successful as was anticipated a few years ago, upon the introduction of the synthetically prepared agents of the coal-tar series. Although these remedies as a class have the power to promptly and completely overcome fever, it has been found that they otherwise exert no beneficial action on the course or duration of the disease. In some instances, too, peculiar to the case no less than to the antipyretic agent employed, their administration has been followed by phenomena of exceedingly unpleasant or even alarming character.

No definite statements can be made as to the manner in which antipyretics reduce the temperature. Many experiments have been made for the solution of this problem, but the results have not been altogether satisfactory. Lauder Brunton is doubtless correct in classifying all antipyretics under the two heads of those which lessen the production of heat and those which increase the dissipation of heat. It is maintained by some writers, however, that these agents act largely by stimulating the thermotaxic mechanism.

Acetanilide, antipyrine, and phenacetine fairly represent the synthetically prepared antipyretics, and are probably more frequently prescribed than any other at the present time. Acetanilide is not only frequently administered alone, but is the active ingredient in nearly all so-called antipyretic compounds which have been introduced by manufacturing pharmacists of this country. Antipyrine, once the most popular of its class, has suffered much on account of unfavorable reports of its action. Gastric irritation, occasionally persistent vomiting and diarrhœa, a depressant action on the heart, syncope, are among the evil results attributed to it; but they are doubtless in great measure the result of its improper administration, particularly the giving of unnecessarily large doses. Phenacetine by many is esteemed as the safest of the antipyretics, and few instances of ill effects have been recorded.

For a thorough consideration of the subject of antipyretics, the reader is referred to works on materia medica, and to the articles in the present volume which treat of the individual drugs belonging to this class.

James M. French.

[1] Macalister: Gulstonian Lectures on The Nature of Fever, 1887; also Lancet (London), 1887, vol. ii.
[2] Colasanti: Pflüger's Archiv, Bd. 14.
[3] Lilienfeld: Pflüger's Archiv, Bd. 32.
[4] Finkler: Pflüger's Archiv, Bd. 29.
[5] Regnault and Reiset: cited by Welch (see infra).
[6] Regnard: Recherches exp. sur les Variations pathologiques des Combustions respiratoires (Welch).
[7] Welch: Cartwright Lectures, 1888, Medical News, vol. lii.
[8] Ord: British Medical Journal, 1885, vol. ii.
[9] Welch: loc. cit., p. 370.
[10] Du Bois Reymond's Archiv, 1886.
[11] Mosso: Virchow's Archiv, Bd. 106.
[12] Ott: Journal of Nervous and Mental Diseases, vol. ii., 1884; Medical News, vol. xlvii., 1885; Therapeutic Gazette, September, 1885.
[13] Aronsohn and Sachs: Pflüger's Archiv, Bd. 37.
[14] White: American Journal of the Medical Sciences, 1890, vol. c.
[15] Corin and van Benedin: Archives de Biologie, 1887.
[16] Welch: loc. cit. (see 7, supra).
[17] Wood: Transactions of American Association of Physicians, Medical News, 1887, vol. l.
[18] Hanfield Jones: Practioner, 1887.
[19] Maclagan: Lancet (London), 1887, vol. ii.
[20] Flint: Address on Fever, General Session Internat. Med. Congr., 1887, Medical News, vol. li.
[21] Welch: loc cit.
[22] Maurel: La Semaine médicale, September 27, 1891.
[23] Krishaber: Gazette méd. de Paris, 1887. (Cited by Welch, loc. cit.)
[24] Sihler: Journal of Physiology, vol. ii.
[25] Martin: Philosophical Transactions of Royal Society, pt. 2, 1883.
[26] Flint: Medical News, 1887, vol. ii.
[27] Liebermeister: Deutsche Medizinische Wochenscrift, January 5, 1887.

FIELD SURGEONS AND MEDICAL DEPARTMENTS, UNITED STATES ARMY. Since the publication of the REFERENCE HANDBOOK, in 1886, the United States has participated in no great wars. Its experience, however, in Indian hostilities has been constant, and certain knowledge regarding the duties and responsibilities of the Field Surgeon of the Army has thereby been increased and perfected.

With a medical staff into which are constantly received young men representing the highest education and culture, whose predecessors, now older, have possessed the same qualities, and in addition now possess the enthusiasm springing from success, and the knowledge born of experience, it is manifest that progress was to have been expected.

Accordingly I shall attempt to indicate such differences as have arisen in the past six years in the administration of the Medical Department in the United States Army, especially as to those duties and conditions treated of in the article on the duties of Field Surgeons which was published in Vol. III. of the REFERENCE HANDBOOK.

ORGANIZATION OF THE MEDICAL DEPARTMENT OF THE ARMY.—For the single Assistant Surgeon-General, the Chief Medical Purveyor, and four Surgeons, with the rank of colonel, existing in 1886, have been substituted by law, six Assistant Surgeon-Generals, with the rank of colonel.

Rank of medical officers.

Instead of the eight Surgeons and two Assistant Medical Purveyors, with the rank of lieutenant-colonel, have been substituted ten Deputy Surgeon-Generals, with the rank of lieutenant-colonel. In consequence, a Medical Purveying Department, separate and distinct, has been abolished.

Purveying Department abolished.

The motives influencing Congress to legislate for the above changes were principally two. The first was to assimilate the titles borne by the higher officers of the Medical Department to the titles borne by the higher officers of some of the other staff corps of the army. Thus in the Quartermaster and Pay Departments the colonels were styled, respectively, Assistant Quartermaster-General and Assistant Paymaster-General, and the lieutenant-colonels were Depnties. But, besides this, it had become manifest that the best work in purveying could be accomplished by allowing the Surgeon-General to select for purveying duties, from time to time, such men as had shown aptitude and taste for this special and peculiar business.

The men hitherto who, in natural sequence under the law, had become medical purveyors, were not necessarily those the best fitted for or the most desirous of discharging the duties of a purveyor, nor had they always been able or willing to give the bonds required of medical purveyors by law.

It had therefore been found necessary, for the reasons above stated and other reasons, to obtain the interference of the President of the United States, by whom alone medical purveyors could be assigned under the law to other duties than purveying. To obtain such interference when suddenly required was not always easy or convenient, and the Surgeon-General therefore found it

necessary to recommend legislation on the subject. In future the most suitable medical officer will be selected and detailed as medical purveyor.

Number of medical officers.

The number of surgeons, with the rank of major, 50, remains unaltered; also the number of assistant surgeons, viz., 125; of whom those under five years in service have the rank of first lieutenant, and those of more than five years' service the rank of captain.

The full number allowed are not, however, actually in the service; that is, the casualties have been more numerous than the successful candidates who have passed the examination before the Medical Board, so that at the present writing there are thirteen vacancies among the assistant-surgeons. A less number, however, are on leave of absence than when the REFERENCE HANDBOOK, Vol. III., was published.

The strength of the army is unchanged, the last Army Register showing an aggregate strength of 28,526, so that the proportion of medical officers to the whole army is unchanged in the last six years. Certain changes in the army, however, have rendered medical administration somewhat easier.

The number of military posts has been sensibly diminished by the concentration of troops. Consequently it has been found possible, with the same number of medical officers in the army, to supply a greater number of military posts with more than one medical officer, and in consequence the additional medical officer has been found available to accompany detachments or larger commands for field service, when formerly the commands would have been obliged to proceed without a medical officer, and to have sent their sick and wounded to the nearest military post for treatment. Manifestly this course was only possible when, in consequence of operating in its own country, as the United States army has done, the moving troops were sufficiently near to military posts to send there the sick and wounded without too much inconvenience and suffering.

Regimental medical officers in the National Guard.

During the past eight years the National Guard of the different States have assembled at different and suitable places as camps for purposes of discipline and inspection. The surgeons and assistant surgeons have accompanied the various military organizations to these camps, but not always in the full numbers authorized by law. The most of these camps have been inspected by duly authorized inspectors; and without attempting to give the reports of all these inspectors (the great majority of which I have not seen) as to the medical organization and its fitness to bear the strain of a campaign, I may say that while none has been perfect, none has been found absolutely unfit for its work, and most have merited praise, while the medical officers have been of more than ordinary intelligence.

The allowance of medical officers to each regiment has been one surgeon and two assistant surgeons with the same rank as in the regular army.

Proper proportion of medical officers to army.

The experience of the past six years does not change our conclusion that the size of the medical corps of the United States army is not too large or too small in proportion to the size of the army; and that the most proper number of medical officers to a regiment of the strength now authorized by law, where the medical officers also are regimental, is one surgeon and two assistant surgeons.

A new law passed by the last Congress requires that assistant surgeons shall pass an examination before promotion to the grade of captain; this in addition to the examination required by former laws.

Qualifications and disqualifications for becoming soldiers.

RECRUITS.—Inasmuch as the necessity for soldiers is greater in time of war than in time of peace, the physical examination of recruits becomes more lax in the former period, and so it happens that in the army of the United States physical examinations have been more strict for soldiers, cadets, and officers in recent years. In regard to the examinations, the directions which appeared at the bottom of column first, page 106, Vol. III., of the REFERENCE HANDBOOK, are no longer issued, and the rules and entire system of examination have been arranged for the better.

So late as at the beginning of 1892, the adjutant-general of the army issued a memorandum of instructions practically forbidding the enlistment, save as musicians, of any persons under twenty-one years of age.

These instructions are in entire harmony with the views expressed, concerning the minimum age of enlistment, on page 106, Vol. III., of the HANDBOOK.

Intellectual and moral examination.

In the effort to raise the standard of examination, the present system gives much attention also to the *intellectual* and *moral*. On these subjects the Epitome (which is the standard of instructions for the army) uses the following language: "*Intellectually*, although no educational standard officially is established, a soldier should be able to read and write, and should also be quick and clear in his understanding. The advance in the science and art of war and the improvement in modern fire-arms call for a higher degree of intelligence than was required of the soldier in the past. This is recognized by the Government by establishment of schools and libraries, by providing reading-rooms that are liberally supplied with periodicals and newspapers, and by opening the way for promotion to all who avail themselves of these opportunities for advancement. The care and attention that the soldier is required to give to his weapon and ammunition, the drill which its use entails, and the skill which may be attained by the practice of rifle-firing develop individuality, excite interest and ambition, and tend to make the profession attractive. It is therefore desirable that men should be selected who can appreciate this life and who have the mental capacity to profit by it. The *moral* character should be scrutinized with care in order that enlistments from the vagrant and criminal classes may be avoided. The recruiting rendezvous is a favorite haunt for these men, and a study of their personal characteristics will well repay the recruiting officer for his labor. The vagrant seeks admission to the army, usually at the beginning of winter, for shelter, food, and clothing, without any intention of completing his enlistment or of performing any more service than he is compelled to perform. The criminal seeks to bury his unsavory history under an assumed name, and, by service in distant stations, to escape the observation of those who know him. The evil influence in a company of even one of this class cannot be over-estimated, and no degree of physical perfection or soldierly bearing should induce a recruiting officer to accept his service. Happily, as a rule, the evidence of a life of debauchery is so plainly marked in the features and in the person that an ordinary observer is able to estimate the true character of such an applicant without difficulty."

This is almost an ideal picture, and it is to be desired that the candidates for enlistment may all be scholars and Christian gentlemen. But it has been found in the past that the degree of education and virtue is not always to be discovered and measured by the appearance of the subject, and both uneducated criminals and vagrants are often able to elude the examination of surgeon and recruiting officer combined.

Further remarks concerning the physical examination of recruits will be here omitted, as it is understood that the subject will be fully treated elsewhere in this volume.

STANDARD SUPPLY TABLE OF THE MEDICAL DEPARTMENT, UNITED STATES ARMY.—In the course of the past six years, from time to time as occasion demanded, various articles have been added to the army list of medical supplies and various articles dropped therefrom.

Various officers contributed their views on what was needed and not needed, for the medical supplies of the army in field and garrison, and finally a Board was ordered to convene in New York City for the purpose (among others) of revising the Standard Supply Table of the Army Medical Department.

The result of all the consideration of the subject has

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been that the following articles have been dropped from the Supply Table, page 108, Vol. III., REFERENCE HANDBOOK.

ARTICLES DROPPED FROM OLD SUPPLY TABLE.

Medicines.

Acacia (Gum Arabic).
Iron, solution of tersulphate.
Morphine, acetate of.
Oil, olive.
Pepsin, lactated.
Pills, mercury, green iodide of.
Potassium bichromate.
Acid hydrobromic.
Arsenic and mercury, solution of iodide of.
Brayera.
Bromine.
Cinchona, pulv.
Codeine.
Extract castanea, fluid.
Extract eucalyptus, fluid.
Extract glycyrrhiza, fluid.
Extract Indian cannabis.
Extract pilocarpus (jaborandi).
Extract physostigma (calabar bean).
Extract taraxacum, fluid.
Mercury, metallic.
Oil of lemon.
Oil of rosemary.
Pills, arsenic.
Pills, arsenic, iodide of.
Potassium, cyanide of.
Potassium, nitrate.
Strychnine, sulphate
Tar (wood).
Tincture cimicifuga.
Tincture sanguinaria.
Tincture serpentaria.
Wax, white.
Zinc, solution of chloride of.
Zinc, oleate.

Hospital Stores.

Arrow-root.
Chocolate.
Cinnamon.
Corn starch.
Farina.
Gelatine.
Ginger.
Meat-juice, Valentine's.
Nutmeg.
Pepper, black.
Pepper, cayenne.
Tapioca.
Tea.
Wine.

Instruments, Expendable.

Nipple-shields.

Dressings.

Antiseptic dressings for use with spray apparatus.
Cotton wadding.
Splints in sets.
Stenta book.

Stationery.

Blocks, memorandum.
Sealing-wax.

Miscellaneous, Expendable.

Mugs, delft.
Spoons, medicine, delft.

Instruments, Non-expendable.

Atomizer, steam.
Meteorological instruments.
Ophthalmoscope.
Speculum for ear.

Clothing and Bedding.

Bedsacks.
Blankets, gray.
Blanket cases.
Counterpanes, striped.
Mattresses, felt.
Pillow-cases, linen.
Pillow-ticks.
Sheets, linen.
Drawers.
Gowns, dressing.
Socks, woollen.

Miscellaneous, Non-expendable.

Bed-pans, metal.
Bed-ticket, frames.
Clothes-pins.
Clothes-wringers.
Hatchets.
Medical saddle-bags.
Medicine-cases.
Medicine-panniers.
Medicine-wagons.
Pails, chamber.
Pitcher, britannia.
Sad-irons.
Saw, wood.
Washboards.

This list of articles dropped is not as extensive as the list of articles which have been added to the old Supply Table and which follows.

In a certain number of cases a certain preparation of medicine is dropped from the old table, and a different preparation of the same medicine appears in the list of articles added, so that it is merely a case of a substitution.

ARTICLES ADDED TO SUPPLY TABLE.

Articles.	Allowance for posts having official population of:					
	100	200	400	600	800	1,000
Medicines, Expendable.						
Acetanilide, 3-gr. tablets (500 in bottle), bottles.	4	6	8	10	12	14
Acid, boracic, powdered, in 1-lb. bottles, ounces	16	16	16	32	32	32
Acid, lactic, concentrated, in 2-oz. g. s. bottles, ounces	2	2	4	6	8	8
Antipyrine, 5-gr. tablets (200 in bottle), bottles.	1	2	3	4	5	6
Asafœtida, in 8-oz. tins, ounces	8	8	8	8	8	8
Atropine sulphate, hypodermic tablets, $^1/_{100}$ gr., tubes	5	5	10	15	20	25
Atropine sulphate, ophthalmic disks, $^1/_{600}$ gr. (50 in box), boxes	1	1	1	2	2	2
Benzoin, compound tincture, in 1-lb. bottles, ounces	16	16	32	32	48	48
Caffeine, hypodermic tablets, 1 gr., tubes	1	1	2	3	4	5
Calabar bean, tincture, tablets, 1 m. (100 in bottle), bottles	1	1	1	2	2	3
Cannabis indica, tincture, tablets, 1 m. (100 in bottle), bottles	1	1	1	1	2	2
Cardamom, compound tincture, in 1-lb. bottles, ounces	16	16	16	32	32	32
Cerium oxalate, in 1-oz. bottles, ounces	1	1	1	2	2	2
Cocaine hydrochlorate, in drachm vials, ounces	¼	½	¾	1	1½	2
Cocaine hydrochlorate, hypodermic tablets, $^1/_6$ gr., tubes	2	4	6	8	10	12
Coniine, hydrobromate, hypodermic tablets, $^1/_{80}$ gr., tubes	2	2	3	3	4	4
Conium, tincture, tablets, 2 m. (100 in bottle), bottles	1	1	2	2	3	3
Cubebs, oleoresin, in 2-oz. bottles, ounces	2	2	4	4	6	8
Digitaline, hypodermic tablets, $^1/_{100}$ gr., tubes	1	1	2	2	3	3
Elaterine, tablets, $^1/_{20}$ gr. (50 in bottle), bottles.	1	1	1	1	1	1
Ergotine, tablets, 2 gr. (100 in bottle), bottles.	2	3	3	4	4	5
Eserine sulphate, hypodermic tablets, $^1/_{60}$ gr., tubes	1	1	2	2	3	3
Eserine sulphate, ophthalmic disks, $^1/_{2000}$ gr. (50 in box), boxes	1	1	1	1	2	2
Eucalyptol, in 2-oz. bottles, ounces	4	6	8	10	12	14
Gentian extract, in 4-oz. jars, ounces	4	4	8	8	8	16
Glycyrrhiza, fluid extract, in 1-lb. bottles, ounces	16	32	48	64	96	128
Glycyrrhiza, powdered extract, in 1-lb. bottles, ounces	32	32	64	96	96	128
Grindelia robusta, fluid extract, in 8-oz. bottles, ounces	8	8	8	16	16	16
Guarana, fluid extract, in 8-oz. bottles, ounces.	32	32	64	64	96	96
Hydrastis, fluid extract, in 8-oz. bottles, ounces	8	8	8	16	16	16
Hydrogen, peroxide solution,* pints	6	6	6	12	12	12
Hyoscine sulphate, hypodermic tablets, $^1/_{100}$ gr., tubes	1	1	1	1	1	1
Ichthyol, in 1-oz. bottles, ounces	1	2	3	4	4	5
Jalap, powdered, in 2-oz. bottles, ounces	2	2	2	4	4	6
Lavender, compound tincture, in 1-lb. bottles, ounces	16	32	48	64	80	96
Menthol, in 2-oz. bottles, ounces	2	2	4	4	6	6
Mercury protoiodide, tablets, $^1/_6$ gr. (200 in bottle), bottles	2	2	2	3	3	3
Morphine sulph., hypodermic tablets, $^1/_8$ gr., tubes	10	15	20	30	40	50
Morphine sulph., tablets, $^1/_8$ gr. (100 in bottle), bottles	2	4	6	8	10	12
Morphine sulph., $^1/_8$ gr. } hypodermic tablets, Atropine sulph., $^1/_{100}$ gr. } tubes	2	4	8	12	16	20
Nitro-glycerine, hypodermic tablets, $^1/_{100}$ gr., tubes	1	2	2	3	3	4
Nitro-glycerine, tablets, $^1/_{100}$ gr., (100 in bottle), bottles	1	1	1	1	2	2
Nux vomica, tincture, in 8-oz. bottles, ounces.	8	8	16	24	24	32
Oil, cotton-seed, in 1-quart bottles, bottles	24	32	48	64	80	96
Oil, sassafras, in 4-oz. bottles, ounces	4	8	8	16	16	20
Pancreatine, in 1-ounce bottles, ounces	1	1	2	2	3	3
Pepsine, pure, in 2-oz. bottles, ounces	4	4	8	12	16	20
Phenacetine, 5-gr. tablets (200 in bottle), bottles.	1	1	2	2	3	4
Pilocarpine hydrochlorate, hypodermic tablets, $^1/_8$ gr., tubes	2	4	6	8	10	12
Potassium carbonate, in 8-oz. bottles, ounces	8	8	16	16	32	32
Quinine bimuriate, hypodermic tablets, $^1/_2$ gr., tubes	2	2	3	3	4	4
Quinine bisulphate, in 1-oz. bottles, ounces	1	1	1	2	2	2
Salol, in 5-gr. tablets (125 in bottle), bottles	2	3	4	6	8	10
Senega, fluid extract, in 8-oz. bottles, ounces	8	8	8	16	16	16
Senna, fluid extract, in 8-oz. bottles, ounces	8	8	16	16	24	24
Sodium hypophosphite, in 8-oz. bottles, ounces	16	16	24	24	32	40
Sodium phosphate, in 8-oz. bottles, ounces.	16	16	24	24	32	40
Strophanthus, tincture, in 4-oz. bottles, ounces	4	4	4	8	8	8
Strychnine sulph., hypodermic tablets, $^1/_{60}$ gr., tubes	4	6	10	15	20	25
Sulfonal, 5-gr. tablets (200 in bottle), bottles.	1	2	4	4	6	8
Terebene, in 8-oz. bottles, ounces	16	16	32	32	48	48
Tragacanth, gum, in flakes, in 8-oz. bottles, ounces	8	8	16	16	32	32
Zinc phosphide, in 1-oz. g. s. bottles, ounces	1	1	1	1	1	1
Disinfectants, Expendable.						
Lime, chloride, in 25-lb. jars, pounds	12	24	48	72	84	96
Mercury, corrosive chloride, in 1-lb. bottles, bottles	1	1	2	3	4	5
Hospital Stores, Expendable.						
Beef peptonoids or meal, pounds	4	6	8	10	12	15
Gin, in 24 or 32-oz. bottles, bottles	2	2	4	6	8	10
Surgical Instruments and Appliances, not Expendable.†						
Apparatus, compressed air, number	1	1	1	1	1	1
" restraint, number	1	1	1	1	1	1
" steam sterilizing, number	1	1	1	1	1	1
Bags, rubber, hot water, number	1	1	1	2	2	2

* To be made as needed at post from special outfit furnished.
† See contents of cases of instruments, farther on.

Articles.	Allowance for posts having official population of:					
	100	200	400	600	800	1,000
Surgical Instruments and Appliances—(Cont.)						
Bags, rubber, ice spinal, number	1	1	1	2	2	2
Bougies, flexible, number	as req uir ed.					
Box, fracture, folding, number	1	1	1	2	2	2
Brush-holder for larynx, number	1	1	1	2	2	2
Case, aspirating,* number	1	1	1	1	1	1
" dental,† number	1	1	1	1	1	1
" emergency, number	as ne ed ed.					
" field, number	as ne ed ed.					
" field, operating, when specially approved, number	1	1	1	1	1	1
" forceps, hæmostatic, 12-inch set, number	1	1	1	1	1	1
" genito-urinary, number	1	1	1	1	1	1
" pocket, aseptic,‡ number	1	1	2	2	2	3
" trial lenses, number	1	1	1	1	1	1
Catheter box, number	1	1	1	1	1	1
" flexible, number	as ne ed ed.					
Curettes, number	as ne ed ed.					
Forceps, needle (Tiemann's), number	1	1	1	1	1	1
Inhaler and vaporizer, number	1	1	1	2	2	2
" ether, number	1	1	1	1	1	1
Lavage-tube, number	1	1	1	1	2	2
Microscope, number	1	1	1	1	1	1
Pouch, hospital corps, number	as ne ed ed.					
" orderly, number	as ne ed ed.					
Sprinkler, iodoform, h. r., number	1	1	1	2	2	2
Stethoscope, double, number	1	1	1	1	1	1
Surgical pump, number	1	1	1	1	1	1
Table, chair, or sofa, operating, as approved, number	0	0	0	0	1	1
Thermo-cautery (Paquelin's), benzine, s. g. not over 0.724, as needed, number	1	1	1	1	1	1
Surgical Dressings, etc., Expendable.						
Bandages, rubber (Martin's), 4 yds. × 2½ in., number	1	1	1	2	2	2
First-aid packets, number	12	18	24	32	56	70
Gauze, absorbent, plain, yards	5	10	15	20	25	30
" iodoform, 5 per cent., in 5-yd. tins, yards	5	5	5	10	10	15
Needles, surgical (Hagedorn's), assorted, set	1	1	1	1	1	1
Paper, dressing, oiled, in 25-yard rolls, rolls	1	1	2	3	4	5
Sponges, chloroform, number	1	1	1	2	2	2
Tents, laminaria or tupelo, number	6	6	12	12	18	18
Wire, suture, silver, in loops, loops	2	2	3	4	5	6
Stationery, Expendable.						
Blotters, hand, number	2	2	2	2	2	2
Letter-press, brushes, number	1	1	1	1	1	1
" cups, number	1	1	1	1	1	1
Pads, prescription, number	18	24	36	36	48	48
" letter, number	6	10	10	18	18	18
Paper-fasteners, box	1	1	1	1	1	1
Paper, writing, typewriter, quires	..	..	18	20	24	24
Ribbons, copying, for typewriter, number	as req uir ed.					
" record, for typewriter, number	as req uir ed.					
Bedding, Clothing, etc., not Expendable.						
Mattress covers, number	10	15	20	25	30	40
Quilts, colored, number	20	20	30	40	60	75
Furniture, etc., not Expendable.						
Baskets, letter, number	2	2	2	2	2	2
" waste-paper, number	2	2	2	2	2	2
Bed-cradle, number	1	1	2	2	3	3
Bed, invalid, number	1	1	1	1	2	2
Bedsteads, with woven wire mattresses, number	as req uir ed.					
Bedstead casters, rubber, number	as req uir ed.					
Bell, hand, number	1	1	1	1	1	1
Book-case, number	1	1	1	1	1	1
Cabinet for blanks, number	1	1	1	1	1	1
Chairs, arm, number	12	15	20	30	40	50
" invalid, rolling, number	1	1	1	2	2	2
" office, revolving, number	1	1	1	2	2	2
Cups, sponge, number	2	2	2	2	2	2
Desks, office, cloth top for, number	as req uir ed.					
Dish, soap, with cover, for office, number	1	1	1	1	1	1
Inkstands, number	3	3	3	4	4	4
Letter-press, number	1	1	1	1	1	1
" " copying-board for, number	1	1	1	1	1	1
Matting, cocoa, yards	as req uir ed.					
" " zinc ends for, number	as req uir ed.					
" rubber, yards	as req uir ed.					
Oil-cloth, for table, yards	as req uir ed.					
Paper-cutters, number	2	2	2	2	2	2
" weights, number	2	2	2	2	2	2
Pen-racks, number	3	3	3	3	3	3
Pitcher, ice, silver-plated, number	1	1	1	1	1	1
Safe, iron, number	1	1	1	1	1	1

* Will not be issued where surgical pump is supplied.
† Will not be issued where the services of a dentist can be obtained.
‡ This pattern of pocket-case will not be issued for post use until the supply of personal and post cases is exhausted.

Articles.	Allowance for posts having official population of;					
	100	200	400	600	800	1,000
Furniture, etc.—(Continued.)						
Screen, bed, folding, number	as req uir ed.					
Screens, door, wire, number	as req uir ed.					
" window, wire, number	as req uir ed.					
" wire netting for, yards	as req uir ed.					
Stamp, rubber, penalty, number	1	1	1	1	1	1
Tables, dining, extension, number	1	1	1	1	2	2
" plain, number	as req uir ed.					
Typewriter, number	..	..	1	1	1	1
Dispensary Accessories, not Expendable.						
Apparatus, distilling, 1-gal., if required, number	1	1	1	1	1	1
Bandage roller, number	1	1	1	1	1	1
Brushes, flesh, rubber, number	1	1	2	2	2	2
" nail, number	1	1	1	1	2	2
" " holder for, number	1	1	1	1	1	1
Dispensing set, labels for, set	1	1	1	1	1	1
Drawer-pulls, with labels, number	as req uir ed.					
Mortar and pestle, glass, 4-inch, number	1	1	1	1	1	1
Prescription file, number	1	1	1	1	1	1
Pus-basin, number	1	1	1	2	2	2
Stove, coal-oil, if required, number	1	1	1	1	1	1
Tape-measures, 100 feet, number	1	1	1	1	1	1
Tray, antiseptic, number	1	1	1	1	2	2
Twine-boxes, number	2	2	2	2	2	2
Dispensary Accessories, Expendable.						
Atomizers, hand, number	2	2	3	3	4	4
Boxes, ointment, impervious, dozen	12	15	20	25	30	35
Corks, large (No. 10), dozen	2	2	3	3	4	4
Envelopes for tablets, 2 × 2½ inches, dozen	20	25	30	35	40	50
Eye-shades, number	2	2	3	3	4	4
Glue, liquid, in ½-pint cans, cans	1	1	1	2	2	2
Measures, glass, graduated, 16-oz., number	2	2	2	2	2	3
Needles, sailmaker's, number	1	1	1	1	1	1
Paper, urinary test, assorted, packages	1	1	1	1	2	2
" wrapping, brown, quires	1	2	3	4	5	6
Percolator, glass, number	1	1	1	1	2	2
Test-tubes, stand for, number	1	1	1	1	1	1
Vials, 1-drachm, dozen	2	3	4	5	6	7
Kitchen and Mess Utensils, not Expendable.						
Eggbeater, number	1	1	1	1	1	1
Forks, table, silver-plated, number	24	36	48	56	72	72
Knives, table, silver-plated, number	24	36	48	56	72	72
Meat-covers, wire netting, assorted, number	6	6	9	9	12	15
" cutters, number	1	1	1	1	1	1
Pails, milk, with strainer, number	1	1	1	2	2	2
Pans, muffin, number	2	2	3	3	4	4
Potato-masher, number	1	1	1	1	1	1
Rolling-pin, number	1	1	1	1	1	1
Saw, butcher's, number	1	1	1	1	1	1
Sieves, flour, number	1	1	1	2	2	2
Skimmers, number	1	1	1	2	2	2
Spoons, basting, agate ware, number	2	2	2	2	3	3
" table, silver-plated, number	18	24	36	48	56	72
" tea, silver-plated, number	18	24	36	48	56	72
Trays, bed, with legs, number	2	2	4	6	8	8
Bowls, sugar, with lid, number	2	2	4	4	6	6
Dishes, vegetable, with covers, number	4	4	6	8	10	12
Gravy-boats, number	2	2	4	4	5	6
Pickle-dishes, number	2	2	4	4	5	6
Pitcher, sirup, glass, number	2	2	3	3	4	4
Plates, invalid, number	2	2	4	4	6	6
Miscellaneous, not Expendable.						
Blowers for insect-powder, number	1	1	1	1	2	2
Chart, anatomical, in case, set	1	1	1	1	1	1
Clothes-baskets, number	2	2	2	3	4	4
Crutches, pairs	4	6	6	10	10	12
Cups, spit, number	4	6	8	10	12	15
Grindstone, complete, number	..	..	1	1	1	1
Hose, canvas, feet	as req uir ed.					
" couplings, number	as req uir ed.					
" nozzles, plain and spray, of each number	1	1	1	1	1	1
" reel-cart for, number	..	..	1	1	1	1
Ladder, step, number	1	1	1	1	1	1
Lawn-mower, number	1	1	1	1	1	1
Litters, canvas for, pieces	as req uir ed.					
" straps for, number	as req uir ed.					
Litter-slings, pairs	as req uir ed.					
Manikin, physiological, or its equivalent, number	1	1	1	1	1	1
Oil-can, with pump, 5-gal., number	1	1	1	1	1	1
Pots, watering, number	1	1	1	1	1	1
Scissors, lamp, number	1	1	1	1	1	1
Settees for porch or hall, number	as req uir ed.					
Sickle, number	1	1	1	1	1	1
Skeleton, in cabinet, number	1	1	1	1	1	1
Stencil, with outfit, for marking hospital clothing, set	1	1	1	1	1	1
Trowel, garden, number	1	1	1	1	1	1

Articles.	Allowance for posts having official population of:					
	100	200	400	600	800	1,000
Miscellaneous, Expendable.						
Bath brick, number	2	2	4	4	6	6
Brooms, whisk, number	2	2	2	2	2	2
Crutches, rubber tips for, number	as req uir ed.					
Dusters, feather, long-handled, number	1	1	1	2	2	2
" " short-handled, number	2	2	3	3	4	4
Hand-grenades, number	12	18	24	36	48	48
Lamp chimneys, number	as req uir ed.					
" shades, number	as req uir ed.					
" wicks, number	as req uir ed.					
Lantern wicks, number	as req uir ed.					
Mousetraps, number	2	2	2	2	2	2
Naphthalin, in 10-lb. boxes, pounds	as req uir ed.					
Paper, tarred, in 100-ft. rolls, rolls	as req uir ed.					
" toilet, packages	10	15	20	30	40	50
Sapolio, pounds	6	8	10	15	20	25
Talcum (French chalk), 1-lb. packages, ounces.	as req uir ed.					

Some of the articles above named were habitually issued prior to this, but their issue being authorized since the former Supply Table, or never having been formally authorized at all, their names now appear for the first time in a Supply Table.

In looking over the names of the new medicines added to the list it will be noticed that a portion are:

1. New remedies, whose properties have been made public since the former Supply Table was published.

2. A certain portion are alkaloids and concentrated principles, a little of which goes a long way.

3. A very large portion, almost one-half, or twenty-seven out of sixty-four, are in the form of tablets or disks, convenient like Class 2 for transportation and use in the field. And

4. (It may seem a little strange), but a portion of the articles are the same as those which have been dropped from a Supply Table anterior to that published in this HANDBOOK.

This latter fact simply shows a change of fashion in medication, as well as the difficulty, and even impossibility, of any one man, or set of men, legislating or making rules that will be satisfactory and convincing to all others, or that should not be changed as time progresses. No differentiation has yet taken place of a Supply Table merely for the field, although, in all probability, ere many months one will be made out by competent authority. In the meantime, the surgeon must select from the table for field service such articles of medicine as may commend themselves to his taste, his experience, and his judgment.

Selection of medicines for field service.

For field service the Supply Table is largely redundant, and in selecting what he will take into the field—where transportation is scarce and hard to obtain—the surgeon must discriminate wisely, taking what he will need and use the most,—what is most concentrated and easy of transportation.

The same principle must guide him in the selection of his instruments and other surgical supplies, and he must bear constantly in mind that, after a battle, the wounded will ordinarily be cared for not by the regimental surgeon, but by other surgeons detailed for that purpose; and that ordinarily the cases of sickness, serious and of long duration, will be treated elsewhere than at the regiment.

Selection of instruments for field service.

The experience of the medical director will also come to the aid of the field surgeon, as by the first-named officer requisitions of regimental surgeons will be modified before they are sent to the medical supply depôt for issue; and it is the business of this officer to see that surplus supplies are at the depôt, to make good unexpected and unusual losses and deficiencies, by capture or otherwise.

By the regulations governing the issue of medical supplies heretofore, the fact that different medical officers might differ in their choice of medicines was more than recognized. In the first place, it was officially stated that a supplementary list of drugs and medicines had been published, to "permit the indulgence of individual preferences." In the second place, it was officially announced that "requisitions for articles not on the Supply Table, and which have been approved of as of value in the treatment and care of the sick, will be favorably considered by the Surgeon-General when the amount of appropriation for medical and hospital supplies will warrant."

The gratification of individual preferences has not been so fully provided for in the new Supply Table; but in view of the progressive and far-seeing policy which has characterized the official doings and utterances of the medical bureau for the past thirty years, it can hardly be believed that a liberal spirit will not guide it in its action in the future, regarding the issue of articles not in the Supply Table. Certainly all tools are not equally fit for the same purpose, and equally truly different men use with differing skill the same tool and different tools.

Property Accountability.—Medical officers receiving and receipting for medical and hospital property are held strictly accountable therefor, and should fully acquaint themselves with the regulations on the subject. In consequence of their failure to obtain this knowledge, or their neglect, for any reason, to comply with those regulations, it has happened very frequently that young or inexperienced medical officers of the regular army, the volunteer forces, or the militia have found (and hereafter are in grave danger of finding) themselves confronted with considerable pecuniary losses, to meet which their pay is stopped. Medical property is not difficult to account for if properly cared for. It is divided into expendable and non-expendable, and in reference to the latter the greatest losses to the medical officer occur, but are unnecessary.

Property non-expendable must be either accounted for by the receipt of some one else, or, if worn out, broken, or destroyed, evidence of such fact must be presented to the proper person, sometimes called an inspector, sometimes a board of survey, sometimes the accounting officer, who receives the returns of property, which have elsewhere been named as required of officers accountable for property.

Remembering these simple facts, medical officers will see the necessity of familiarizing themselves with the regulations on the subject, which can easily be complied with, and thus will save themselves the annoyance of pecuniary loss.

In one special case the military surgeon may destroy property in his discretion, for the regulations of the Supply Table provide that tents, clothing, hospital furniture, and other articles used in the treatment of contagious diseases, will be disinfected or burned under the supervision of a medical officer; and the articles destroyed to prevent contagion must be accounted for by a certificate of the officer responsible, setting forth fully the circumstances necessitating such destruction.

"The medical officer has discretionary powers, which are based on his knowledge of specific contagions and methods of disinfection. The efficiency of many of these methods is now so well established that they supersede the necessity for burning."

Since the publication of the Supply Table in Vol. III., the medical department has assumed the charge of supplying disinfectants for general post sanitation, and directs post surgeons as follows:

"(*a*) Chloride of lime should be used only as a disinfectant, properly so called, the cheaper sulphate of iron being used as an antiseptic and deodorant in privies, slop-barrels, etc. When a jar of chloride of lime has been opened, and a part of the contents removed, it should be sealed again with plaster of Paris. Solution of chlorinated soda will be issued in small amounts only for special personal disinfection.

"(*b*) The selection and use of proper disinfectants and deodorants will be determined by the senior medical officer, who should not issue them unless, in his opinion, their use is necessary and proper. He will give explicit instructions as to the quantities to be used, strength of solutions," etc.

Sterilized dressings, etc., will be supplied in small quantities only for post use. Their preparation is so simple and so well understood that they should be prepared as needed.

Meteorological instruments will not, in future, according to the new Supply Table, be issued by the medical department. When required for use at designated posts, they will be obtained by application direct to the Chief of the Weather Bureau, Department of Agriculture.

As will appear further on, meteorological reports by medical officers are discontinued. It is not clear that this new rule is wise, and many medical officers will regret that they are deprived of their meteorological instruments.

In this country the army surgeon has been the pioneer in weather observations, which, for many years, have been taken by them at every military post and forwarded to the War Department when, of other observers, there were none on the unsettled frontier. The familiarity with hygrometric and temperature conditions thus acquired by the military surgeon accustomed him to see relations and connections between these conditions and certain coincident pathological conditions, and often much to the advantage of the patient and the community—an advantage not precisely to be defined sometimes, and therefore properly to be called immeasurable.

It is not to be denied that, for the community at large, the meteorological observations regularly taken by the skilled observers of the Agricultural Bureau will take the place of those formerly taken by the military surgeon. Still, it would seem that it might be to the advantage of all concerned, were medical officers to continue to make such observations regularly at their hospitals.

No list of medical books for issue is included in the present Supply Table, and the reason given therefor is that, owing to the rapid advances in medicine, a large part of any fixed literature soon becomes obsolete. To a certain extent this is true, but the truth is only on the surface. The Table further provides that such new books as may be selected by the Surgeon-General will be furnished without requisition, and nothing is said concerning the issue of any other books than those so selected.

This provision seems also unwise. In the first place, there are a certain proportion of books on medicine and surgery published that are standard, and that every medical man feels the need of, and this independently of their selection by any one man. In the second place, a large number of medical men have well-defined and considered preferenees for certain authors and certain books. Of these books none other will take the place, and it is hard to see why these preferences should be ignored, or how any Surgeon-General or other man could know them.

It is to be hoped that ere long this regulation may be changed, and a list of such books be published for issue as will meet the general consensus of the military surgeons, for whose study and information the books are issued.

It is important that the military surgeon of the National Guard and Militia, as well as of the Regular Army, should know precisely what tools will be presented to him to do his work with, both in field and garrison.

The new Supply Table divides the supplies under the following headings:

1. Medicines, expendable.
2. Disinfectants, expendable.
3. Hospital stores, expendable.
4. Surgical instruments and appliances, not expendable.
5. Surgical dressings, etc., expendable.
6. Stationery, expendable.
7. Bedding, clothing, etc., not expendable.
8. Furniture, not expendable.
9. Dispensary accessories, not expendable.
10. Kitchen and mess utensils, not expendable.
11. Miscellaneous, not expendable.
12. Miscellaneous, expendable.

Some notice is now required of some of those articles included in Class 4.

1. Dispensing set (bottles and jars).
2. Apparatus, spray-producing, (for petrolatum).
3. Case, aspirating.
4. " capital operating, No. 1.
5. " capital operating, No. 2.
6. " eye and ear.
7. " field operating.
8. " genito-urethral.
9. " urethal.
10. " minor operating.
11. " obstetrical and gynecological.
12. " pocket personal.
13. " post-mortem.
14. " dissecting.
15. " stomach-pump.
16. " tooth-extracting.
17. Inhaler and vaporizer.
18. Microscope and accessories.
19. Surgical pump.
20. Syringe, hypodermic.
21. Thermo-cautery, Paquelin's.
22. Type-writer.
23. Vision-test set.
24. Amputating case.
25. Exsecting case.
26. General operating case.
27. Trephining case.
28. Chemical set with measuring apparatus.
29. Tool-chest.
30. Commode chest (No. 3).
31. Pack-saddle for medical and surgical chests.
32. Folding field furniture.

No. 1. The dispensing set consists of a suitable and sufficient number of bottles and jars.

Nos. 4 and 5. The contents of these cases vary but little from each other.

No. 6 contains all that is needed, save by the advanced specialist, for ordinary eye and ear surgery.

Nos. 8 and 9. The latter does not differ much from the genito-urinary case, whose contents are given farther on. The large-sized sounds in the genito-urinary case make it preferable to either 8 or 9 in certain cases where urethral dilatation is required.

Nos. 13 and 14. The issue of No. 14 will cease when those now on hand are exhausted, as No. 13 can fully supply its place.

No. 18. The Medical Department have issued the "Universal" and the "Investigator"—two different patterns of mieroscopes—manufactured by the Bausch & Lomb Optical Company. Beck's Popular Binocular, also, has been issued to a limited number.

No. 28. This is supplied only in special cases where analytic and other chemical work is to be prosecuted.

No. 29 is a small set of carpenter's tools.

No. 32 comprises a few articles, such as folding chairs and tables, that may be easily packed and carried in the field.

Concerning the other articles in the above list it seems unnecessary to say more than that they do not materially differ from other similar cases and instruments with which every surgeon is familiar.

In regard to the list of cases, etc., which follows, it seems necessary to name the contents, either because they differ from the ordinary cases of the same name, or because they possess peculiarities due to their preparation for use in the military service.

1. Apparatus, compressed air.
2. " restraint.
3. Case, dental.
4. " emergency.
5. " field.
6. " forceps, hæmostatic.
7. " genito-urinary.
8. " pocket, aseptic.
9. " " post.
10. " of trial lenses.
11. Pouch, hospital corps.
12. Pouch, orderly.
13. Bacteriological set.
14. Medical chest, U. S. Army, No. 1.
15. Surgical chest, U. S. Army, No. 2.
16. Field-desk, No. 4.
17. Mess-chest, No. 5.
18. Food-chest, No. 6.
19. Reserve-chest, No. 7.
20. Ice machine.
21. Articles issued by the Quartermaster's Department.
22. Articles issued by the Ordnance Department.

Contents of foregoing:

Apparatus, Compressed Air.

Air-container, with gauge, number	1	Davidson's sprays, in set, viz:	
Force-pump, number	1	Atomizer-tubes, h. r., number	3
Tubing, thick rubber, silk covered, connecting container with cut-off, *exp.*, feet	8	Bottles with h. r. caps, number	3
Tubing, thick rubber, connecting container with force-pump, *exp.*, feet	4	Cut-off, metal, number	1
		Stand for bottles, number	1
		Tube connector, h. r., *exp.*, number	1
		Tube wires for cleaning, *exp.*	2

Apparatus, Restraint.

Anklets, pair	1	Strap, bed, as per circular, number	1
Keys to lock buckles, number	5	Strap, waist, number	1
Muff, leather, number	1	Wristlets, pair	1
In wooden box, with handle and lock.			

Case, Dental.

Burnishers (Nos. 3, 29, 36), number	3	Gutta-percha, *exp.*, ounce	1
Chisels (Nos. 77, 135), number	2	Handles for instruments, number	6
Explorer (No. 5), number	1	Hone, number	1
Excavators (Nos. 10, 14. 16, 21, 41, 82, 86, 141, 143, 145), number	10	Mirror, number	1
		Paper, bibulous. *exp.*, sheets	6
		Scaler (No. 3), number	1
Files (2 each of Nos. 00, 0, 1) number	6	Spatula (No. 1), number	1
Forceps, college, number	1		

In small morocco case.

Case, Emergency.

Tablets in half-ounce bottles:		Potassium bromide, gr.	10
Acetanilide, gr.	3	Potassium chlorate, gr.	5
Acid boracic, gr.	5	Quinine sulphate, gr.	3
Acid tannic, gr.	5	Sodium salicylate, gr.	5
Alum, gr.	5	Sulphonal, gr.	5
Ammonium chloride, gr.	5	Tincture aconite root, m.	2
Antipyrine, gr.	5	Tincture digitalis, m.	5
Calomel, gr.	2	Tablets, hypodermic, in tubes.	
Camphor, gr. 2, and opium, gr. 1	*	Apomorphine hydrochlorate,* gr.	1/10
Cathartic compound	*	Atropine sulphate, gr.	1/100
Colchicum, fluid extract, m.	1/2	Cocaine hydrochlorate, gr.	1/6
Cough	*	Digitaline, gr.	1/100
Diarrhœa	*	Ergotine,* gr.	1/10
Dover's powder, gr.	5	Morphine sulphate,* gr.	1/4
Ergotine, gr.	2	} Morphine sulphate,* gr.	1/8
Ipecac, gr.	1	} Atropine sulphate,*	1/100
Morphine sulphate, gr.	1/8	Pilocarpine hydrochlorate, gr.	1/6
Nitro-glycerine, gr.	1/100	Quinine bimuriate, gr.	1/2
Opium, gr.	1	Strychnine sulphate, gr.	1/60
Phenacetine, gr.	5		
Syringe, hypodermic, not expendable, number			1
Thermometer, clinical. (See par. 44), number			1

* Tablets marked thus are in the hypodermic syringe case.

Case, Field.†

Bistoury, curved, number	1	Ligature silk, *exp.*, cards	2
Catheter, silver, jointed, number	1	Needles, surgeon's, *exp.*, number	12
Director and aneurism needle, number	1	Probe (Nélaton's), number	1
Forceps, artery and needle, combined, number	1	Saw-blade, movable back, number	1
Forceps, bone, number	1	Saw-blade, handle, number	1
Forceps, bullet, number	1	Scalpel, number	1
Forceps, dressing, number	1	Scissors, straight, number	1
Knife, amputating, blade, number	1	Serre-fines (Langenbeck's), number	4
Knife, amputating, handle, number	1	Tenaculum, number	1
		Wax, *exp.*, piece	1
		Wire suture, silver, *exp.*, loops	3

In wooden case, with leather pouch and sling strap, with buckle and snap hooks.

† This is the case recently issued as "surgeon's field case."

Case, Forceps, Hæmostatic.

Halsted's straight, number	1	Little's fenestrated, number	1
Halsted's curved, number	1	Tait's long grip, number	1
Jones's angular, number	1	Tait's short grip, number	1
Jones's straight, number	1	Thornton's T, number	1
		Wood's [Pean's] large, number	2
		Wood's [Pean's] small, number	2

In morocco case.

Case, Genito-Urinary.

Bistoury for meatus (Otis's), number	1	Urethrometer (Otis's), hinged, number	1
Bougies à boule (Otis's), metal, nickel-plated, Nos. 8 to 40, inclusive, number	33	Urethrometer, rubber covers for, *exp.*, number	12
Endoscopes (Otis's, h. r.), Nos. 22, 26, and 32, number	3	Urethrotome, Maisonneuve's No. 8 (Otis's) gauge, with two blades, two filiform bougies and one extra tunnelled tip for whalebone guide, number	1
Gauge (Otis's) steel, number	1		
Guides (Otis's), whalebone, number	2	Urethrotome, dilating (Otis's), straight, with two blades, number	1
Sounds (Otis's), short beaked, steel, nickel-plated, Nos. 20 to 40, inclusive, number	21		

In mahogany case.

Case, Pocket, Aseptic.

Bistoury, curved, number	1	Needle, aneurism, number	1
Bistoury, curved, probe-pointed, number	1	Needle, aneurism, and grooved director, number	1
Bistoury, straight, number	1	Needle, exploring, number	1
Catheter, jointed, male and female tips, number	1	Needles, surgeon's, *exp.*, number	12
Caustic holder, number	1	Probe (Nélaton's), number	1
Forceps, needle and fenestrated, artery, number	1	Probe, silver, number	1
Forceps, long-jawed, number	1	Scalpel, number	1
Lancet, thumb, number	1	Scissors, number	1
Ligature silk, *exp.*, card	1	Tenaculum, number	1
		Tenotome, number	1
		Wax, *exp.*, piece	1
		Wire suture, silver, *exp.*, loops	3

In leather case, with metal clips and chamois cover.

Case, Pocket, Post.

This name will be used when reference is made to the red morocco pocket-case with chamois cover issued during the past few years for post use.

The list of contents is the same as that of the aseptic pocket-case, but the aneurism and exploring needles, knives, and tenaculum are detachable from the two hard-rubber or ivory handles. Some cases contain a combined needle and fenestrated artery forceps and a hæmostatic forceps; others a plain artery and a dressing forceps.

Case of Trial Lenses.

Bausch & Lomb.

Twenty pairs spherical convex lenses.
Twenty pairs spherical concave lenses, both from 2 to 160 English inches focus (D. 20–0.25).
Eleven cylindrical convex lenses.
Eleven cylindrical concave lenses, both from 8.888 to 160 English inches focus (D. 4.50–0.25).
Six prisms, 2°, 3°, 4°, 5°, 8°, 12°.
Five disks, one white and one ground glass, one plain metal, one metal with hole in centre, and one metal with stenopaic slit.
Four colored glasses—red, blue, green, and brown.
One graduated trial frame, No. 3, double cell.
One graduated trial frame, No. 2 (double cell, adjustable).
In mahogany case, with lock and two keys.

Queen.

Twenty pairs spherical convex lenses.
Twenty pairs spherical concave lenses, both from 2 to 48 inches focus.
Eight cylindrical convex lenses.
Eight cylindrical concave lenses, both from 9 to 72 inches focus.
Five prisms, 2°, 3°, 4°, 5°, 8°.
Three metal disks, one plain, one with hole in centre, and one with stenopaic slit.
Four colored glasses—red, blue, green, and brown.
One single lens-holder.
One trial frame.
In mahogany case, with lock and key.

Pouch, Hospital Corps.

Ammonia, aromatic spirits, *exp.*, oz	1	Petrolatum, carbolized, *exp.*, oz	½
Bandages, roller, *exp.*, number	4	Pins, common, *exp.*,* paper	1
Candle, in tin box, *exp.*, number	1	Pins, safety, *exp.*,* number	6
First-aid packet, *exp.*, number	1	Plaster, adhesive, *exp.*, spool	1
Forceps, dressing,* number	1	Scissors, medium,* number	1
Iodoform sprinkler, number	1	Splints, wire, number	2
Jackknife, number	1	Sponges, small, in bag, *exp.*, number	2
Lint, sublimated, *exp.*, oz	2	Thread, linen. *exp.*,* yds	20
Needles, medium, *exp.*,* paper	1	Tourniquets, field, number	2
		Wool, boracic, *exp.*, oz	2

* Articles marked thus are contained in special case.

Pouch, Orderly.

Ammonia, aromatic spirits, *exp.*, oz	1	Pins, common, *exp.*, paper	1
Bandages, roller, *exp.*, number	2	Pins, safety, *exp.*, number	6
Basin, pus, number	1	Scissors, medium, number	1
Case, medicine, with tablets,* number	1	Sponges, small, in bag, *exp.*, number	2
Catheter, elastic (No. 8), *exp.*, number	1	Syringes, hypodermic, with tablets, number	1
Chloroform, *exp.*, oz	4	Tags, diagnosis, *exp.*, with pencil, book	1
First-aid packet, *exp.*, number	1	Tourniquet, Esmarch, number	1
Glass, medicine, *exp.*, number	1	Lint, sublimated, *exp.*, oz	2
Petrolatum, carbolized, *exp.*, oz	½	Wool, boracic, *exp.*, oz	2

* The six half-ounce bottles in this case contains the following tablets:

Acetanilide, gr.	3	Cough	
Antiseptic		Diarrhœa	
Compound cathartic		Quinine, gr.	3

Bacteriological Set.

The following articles constitute the Bacteriological Set, which will be issued in special cases:

Apparatus:		Apparatus:	
Apparatus, filling, and stand, number	1	Flasks, graduated, with lip, 1,000 c.c., number	4
Bath, water, copper, number	1	Incubator, lead-lined, 40 × 25 × 25, number	1
Bath, tripod for, number	1	Micro-burner, 1 flame, number	1
Burner (Koch's) number	1	Paper, filtering, *exp.*, q	1
Burner and regulator (Bunsen), number	1	Paper, filtering (Swedish), *exp.*, q	1
Burner, stand for, number	1	Pipettes, 1 c.c., number	4
Dishes, double (Petri's), number	12	Pipettes, 2 c.c., number	4
Filters (Pasteur), mounted in flask, number	2	Pipettes, 5 c.c., number	4
Flasks (Erlenmeyer's), 8 oz., number	12	Pipettes, 10 c.c., number	2
Flasks, graduated, 500 c.c., number	4	Platinum wire, fine, 4-inch, pieces	3
		Platinum wire, medium, 4-inch, pieces	3

Bacteriological Set.—(Continued.)

Apparatus :	
Platinum wire, heavy, 4-inch, pieces	3
Regulator, gas (Reichert's), number	1
Rods, glass, ⅛-inch, *exp.*, lb.	⅛
Sterilizer, hot-air, 23 × 30 × 20, number	1
Sterilizer, steam (Arnold's) number	1
Stoppers, solid rubber, assorted, *exp.*, lb	⅛
Syringe, sterilizable (Koch's), 1 c.c., number	1
Test measures, footed, 5 c.c. number	1
Test measures, footed, 10 c.c., number	1
Test measures, footed, 100 c.c., number	1
Test measures, footed, 500, c.c, number	1
Test tubes, bath for, 1 × 6 inches, copper, with extra cover, number	1
Test tubes, thin glass, 6 × ¾ inch bore, *exp.*, number	300
Thermometer, 0–50° C., number	1
Thermometer, 0–200° C., number	1
Apparatus :	
Tubing, glass, ⅛, 3/16, ¼-inch bore, *exp.*, lbs	3
Tubing, rubber, *exp.*, ft.	12
Culture media and staining reagents :	
Agar-agar, lbs	2
Aniline oil, pure, lb	1
Bismarck brown, oz	1
Carmine, best, oz	1
Eosine, oz	½
Fuchsine, oz	1
Gelatine, best, lbs	2
Glycerine, c. p., lb.	1
Hæmatoxylon, dr.	2
Methyline blue, oz	1
Peptone (Wittles's), lb	½
Saffranine, oz	1
Zylol, pure, lb. (These are expendable.)	1
Bacteriological Technology (Salomonsen), copy	1
Bakteriologische Diagnostik (Eisenberg), copy	1
Die Mikroorganismen (Flügge), copy	1
Objective, oil immersion, 1/12 or 1/15 inch, number	1
Nose-piece, double or triple, number	1
Condenser (Abbe), number)	1

Medical Chest, U. S. Army, No. 1.

The contents of the medical and surgical chests are expendable with the exception of those to which an asterisk is prefixed.

Contents of Tray.

Left of tray—4-oz. bottles :	
Acetanilide, tablets, gr.	3
Camphor and opium, tablets	..
Cathartic compound, tablets	..
Cathartic compound, veg., tablets	
Copaiba compound, tablets	..
Cough, tablets	
Diarrhœa, tablets	..
Dover's powder, tablets, gr.	5
Liniment, tablets, gr.	20
Potassium bromide, tablets, gr.	10
Quinine sulphate, tablets, gr.	3
Sodium bicarbonate, tablets, gr	5
Sodium salicylate, tablets, gr.	5
Magnesium sulphate, oz. (And two empty bottles.)	4
Back of tray—8 and 16 oz. bottles :	
Alcohol, oz	16
Ammonia, stronger water, oz.	8
Brandy, oz.	16
Chloroform, oz.	8
Ether, oz.	16
Oil, castor, oz	8
Turpentine, oz.	8
Whiskey, oz.	16
Stoppers, rubber, for above, number	10
Centre of tray :	
Cotton-wool	q.s.
Envelopes, small, for tablets, number	100
Graduates, glass, 2-oz., number	1
Graduates, glass, minim, number	1
Labels for vials, number	50
*Links, split, for pack saddle, number	4
Ointment boxes, in nests of three, nests	4
*Pocket stove, number	1
Vials, 2-oz., number	10
Front of tray—½-oz. bottles:	
Acid, arsenious, tablets, gr.	1/40
Alterative, tablets	..
Capsicum, tablets, gr.	½
Colchicum, fl. ext., tablets, m.	½
Croton-oil, tablets, m.	1/10
Ergotine, tablets, gr.	2
Iodine, oz.	½
Nitro-glycerine, tablets, gr.	1/100
Podophyllin, tablets, gr.	¼
Santonin, tablets, gr.	¼
Silver nitrate, fused, oz.	½
Tr. digitalis, tablets, m.	5
Tonic, tablets	
Right of tray—2-oz. bottles :	
Acid boracic, tablets, gr	5
Acid tannic, tablets, gr	5
Alum, tablets, gr.	5
Ammonium chloride, tablets, gr.	5
Antipyrin, tablets, gr.	5
Bismuth subnitrate, tablets, gr	5
Blue mass, tablets, gr.	5
Calomel, tablets, gr.	2
Chloral, tablets, gr.	5
Ipecac, tablets, gr.	1
Lead acetate, tablets, gr.	3
Morphine sulphate, tablets, gr.	1/8
Opium, tablets, gr.	1
Peptic, tablets	..
Phenacetine, tablets, gr.	5
Potassium chlorate, tablets, gr.	5
Potassium iodide, tablets, gr.	5
Salol, tablets, gr	5
Tr. aconite root, tablets, m.	2
Zinc sulphate, tablets, gr.	5

Contents of Drawers.

Drawer No. 1.	
Hypodermic tablets : †	
Apomorphine hydrochlorate, gr. 1/10, bott.	1
Atropine sulphate, gr. 1/100, bott.	1
Cocaine hydrochlorate, gr. 1/6, bott.	1
Ergotine, gr. 1/10, bott.	1
Morphine sulphate, gr. 1/8, bott	1
Pilocarpine hydrochlorate, gr. 1/8, bott.	1
Qainine bimuriate, gr. 1/2, bott	1
Strychnine sulphate, gr. 1/60, bott.	1
Ophthalmic disks:	
Atropine sulphate, gr. 1/500, 50 in box, box	1
Eserine sulphate, gr. 1/2000, 50 in box, box	1
Miscellaneous :	
*Caustic holder, rubber, number	1
*Corkscrew, folding, number	1
Medicine-droppers, number.	2
*Pencil, indelible, number	1
Pencil, indelible, leads for, number	6
Pencils, camel's-hair, number	12

Medical Chest, U. S. Army, No. 1.—(Continued.)

Contents of Drawers.—(*Continued.*)

Drawer No. 1.—(*Continued.*)	
Miscellaneous :	
*Syringe, hypodermic, number.	1
Thermometer, clinical, number	1
*Tongue-depressor, number	1
Drawer No. 2.	
Bandages, suspensory, number	5
Flannel, red, yds.	1
Jute, salicylated, in 1/4-lb. pkgs., pkgs.	4
*Syringe, rubber, self-injecting, number	1
Drawer No. 3.	
Book, prescription, number	1
*Forceps, dressing,‡ number.	1
*Index of Medicine (Carpenter), copy	1
Plaster, blistering, yd.	1
Plaster, mustard, yds.	4
*Reagent case, § number.	1
*Scissors, number	1
*Spatula, number	1
Spoon, tea, number	1
*Stethoscope, h. r., number	1
Drawer No. 3.—(*Continued.*)	
Syringes, p. g., in wooden case, number	3
Syringes, p., h. r., number	5
Tags, diagnosis, 24 in book, book	1
*Towels, number	2
Drawer No. 4.	
Beef extract, in 4-oz. cans, lb.	1
Jute, salicylated, 1/4-lb. pkgs., pkgs.	6
Drawer No. 5.	
Bandages, roller, assorted, number.	30
Cotton, absorbent, 1/4-lb. pkgs., pkgs	4
Soap, castile, oz.	8
Drawer No. 6.	
Candles, number	18
Flaxseed meal, lbs.	2
Drawer No. 7.	
*Cupping tins, number	4
Gauze, sublimated, 1-yd. pkgs., pkgs	3
Lint, absorbent, 1/4-lb. pkgs., pkgs.	4
*Scarificator, number	1

With list of contents stamped on morocco pad which is carried, reversed, under the cover of chest.

† The contents of tubes of hypodermic tablets hereafter issued to replace those expended should be placed in the screw-cap bottles.

‡ For the convenient removal of cotton from tablet bottles.

§ Consisting of 1 tube citric acid ; 1 medicine-dropper : blue litmus paper ; 1 tube potassium ferrocyanide ; 1 tube sugar-test powder ; 1 test tube ; *1 urinometer. With circular of directions.

Surgical Chest, U. S. Army, No. 2.

Contents of Tray.

4-oz. Bottles :	
Acid boracic, tablets, gr. 5, bott	1
Antiseptic tablets, botts.	2
Compound cathartic tablets, bott	1
Opium, tablets, gr. 1, bott.	1
Potassium bromide tablets, gr. 10, bott	1
*Bucket, folding, canvas, number	1
*Catheters, flexible, number	1
Dressing paper, roll	1
Ether, lb.	1
Felt for splints, pieces	2
*Links, split, for pack saddle number	4
Muslin, yds.	3
8-oz. Bottles :	
Carbolic acid, pure, bott.	1
Chloroform, botts.	2
Glycerine, bott.	1
Laudanum, bott.	1
Whiskey, botts.	2
Stoppers, rubber, for above, number.	10
Petrolatum, lb.	1
*Pocket case, aseptic, number	1
*Pus-basin, number	1
*Razor, number	1
*Razor-strop, number	1
*Towels, number	2

Contents of Drawers.

Drawer No. 1.	
Bandage, rubber, number.	1
Brush, nail, number.	1
Gauze, sublimated, yds.	2
Goggles, number.	2
*Iodoform sprinkler, number	1
Ligature, catgut, carbolized, spools	3
Ligature silk, cards	5
Needle, thread, etc., in case, case	1
Pencil, indelible, leads for, number.	3
Pins, common, paper.	1
Pins, safety, assorted, doz.	4
Plaster, isinglass, yds.	10
*Speculum for ear and nose, number	1
Tape, piece.	1
*Tape measure, number.	1
*Tourniquet, Esmarch's, number.	1
Drawer No. 2.	
*Case, tooth-extracting,† number.	1
Cotton, absorbent, pkgs.	2
Drainage-tubes, rubber, yds.	3
Plaster, adhesive, 1-in., spools	4
Plaster, adhesive, 2-in., spool.	1
Sponges in bags, bags	2
*Syringe, fountain, number	1
Drawer No. 3.	
Bandages, suspensory, number	2
Beef extract, in 1-lb. can, can,	1
*Brush, shaving, number	1
Cotton, absorbent, pkgs.	2
Medicine measuring glass, number	1
Minim measuring glass, number	1
Needle, sail, number	1
Needle, upholsterer's, number	1
*Pencil, indelible, number	1
*Scissors, number	1
*Surgery, Operative, copy	1
Syringe, p. h. r., number.	2
Tags, diagnosis, 24 in book, book.	1
*Tool, universal, number	1
Drawer No. 4.	
Bandages, flannel, number	4
Bandages, roller, number.	6
*Emergency case, complete, number.	1
Drawer No. 5.	
Gauze, sublimated, yds.	4
Jute, salicylated, in 1/4-lb. pkgs., pkgs.	6
*Lantern, small, number	1
Soap, castile, ozs.	8
Drawer No. 6.	
Bandages, roller, assorted, doz	4

With list of contents stamped on morocco pad, which is carried, reversed, under the cover of the chest.

† This tooth-extracting case consists of: Case, leather, rolling, 1 ; lancet, gum, 1 ; elevator, 1 ; forceps, "half-curved root," 1 ; forceps, "lower wisdom," 1 ; forceps, "wisdom," 1.

Field Desk, No. 4.

With the exception of books and inkstands, the contents of this desk are expendable.

Books:
- Army Regulations, copy..... 1
- Epitome of Tripler's Manual, Greenleaf's, copy..... 1
- Handbook for the Hospital Corps, Smart, copy..... 1
- Information slip book, copy.. 1
- Manual of Drill of Hospital Corps, copy..... 1
- Morning Report, Hospital Corps, copy..... 1
- Morning Report, sick and wounded, copy..... 1
- Order and letter book, copy... 1
- Standard Supply Table, copy. 1
- Transfer book, copy..... 1

Stationery:
- Book, blank, 8vo, number.... 1
- Elastic bands, assorted, gross ½
- Envelopes, official, large, number..... 12
- Envelopes, official, letter, number..... 50
- Envelopes, official, note, number 25
- Eraser, steel, number..... 1
- Ink, black, bott..... 2
- Ink, red, bott..... 1
- Inkstands, number..... 2
- Mailing tubes, number 4
- Pads, prescription, number... 4
- Paper, blotting, sheets..... 4
- Paper-fasteners, number..... 12
- Paper, writing, legal cap, qr.. 1
- Paper, writing, letter, qrs..... 2
- Paper, writing, note, qr..... 1
- Pencils, lead, number... 4
- Pens, steel, number..... 12
- Pen-holders, number..... 2
- Portfolio for Medical Department blanks, number..... 1

Blanks:

Medical Department:
- Examination of recruits, monthly report, number 4
- Hospital fund statement, number 4
- Medical property, return of, number 2
- Medical supplies, invoice of, single sheet, number..... 6
- Medical supplies, receipt for, single sheet, number..... 6
- Medical supplies, special requisition for, number... 8
- Report of sick and wounded, number 12
- Report of completed cases, number..... 12
- Return of personnel, etc., H. C., number..... 6

Quartermaster's Department:
- Clothing and equipage, quarterly return of, number 2
- Clothing and equipage, requisitions for, number..... 4
- Fuel, forage, and straw, requisitions for, number..... 4
- Invoices, abstract "E," number..... 2
- Receipts, abstract "E," number..... 2
- Requisitions, special (No. 48), number 6
- Stores, quarterly return of, number..... 2

Subsistence Department:
- Ration returns, number..... 12

Ordnance Department:
- Invoices, number 2
- Quarterly statements, number 2
- Receipts, number..... 2

Adjutant-General's Department:
- Certificates of disability, number..... 2
- Descriptive lists, number..... 2
- Discharges, number..... 2
- Final statements, number.... 4
- Furloughs, number..... 2
- Inventory of effects of deceased soldiers, number.... 2
- Muster and pay rolls, hospital, number 8
- Outline figure cards, number.. 6
- Physical examination of recruits, form for, number.... 6
- Surgeon's certificate of disability for officers, number.. 2

Mess Chest, No. 5.
- Basin, wash hand, agate ware, number..... 1
- Boilers, double, agate ware, number..... 1
- Bowls, soup, agate ware, number..... 6
- Box for salt, number..... 1
- Box for pepper, number..... 1
- Brush, scrubbing, *exp.*, number. 1
- Can-openers, *exp.*, number 2
- Cleaver, number..... 1
- Cook-book, Army, number..... 1
- Cups, coffee, agate ware, number 6
- Cups, large, agate ware, number..... 1
- Dippers, agate ware, number... 1
- Graters, nutmeg, number..... 1
- Gridiron, number..... 1
- Hatchet, number..... 1
- Kettles, steel, nested, with covers, number..... 3
- Knife, butcher, number..... 1
- Knife and fork, carving, of each, number..... 1
- Knife and saw, combined, number..... 1
- Knives and forks, of each, number..... 6
- Ladles, agate ware, number.... 1
- Lantern, candle, number..... 1
- Matches, in waterproof case, *exp.*, boxes..... 12
- Meat-cutter, small, number..... 1
- Meat-dishes, agate ware, number..... 2
- Mill, coffee, number..... 1
- Nails, assorted, *exp.*, lbs..... 4
- Pan, frying, steel, number..... 1
- Pans, mess, agate ware, number 2
- Pans, sauce, steel, tinned inside, with cover, number..... 1
- Plates, dinner, agate ware, number..... 6
- Pot, coffee, agate ware, number..... 1
- Pot, tea, agate ware, number... 1
- Rope, ¼ inch, *exp.*, feet 50
- Sickle, number 1
- Spoons, bastiug, agate ware, number 1
- Spoons, table, number..... 6
- Spoons, tea, number..... 6
- Steel, number..... 1
- Towels, crash, number..... 6
- Tray, metal, japanned..... 1
- Tumblers, agate ware, number. 6
- Wire, *exp.*, coil..... 1

Food Chest, No. 6.

In this chest, as issued, considerable vacant space is left in order to allow latitude to each medical officer as to the exact character of the supplies he may wish to carry.

The printed plan inside the cover of each gives the general arrangement.

Tins labelled "corn starch," "chocolate," and "arrow-root" are included, although not mentioned in the official list of contents, as it is thought that they may contain articles of more general use.
- Beef extract or an equivalent preparation.
- Candles.
- Condensed milk, in original cans, 8 pounds.
- Soap.
- Vinegar, in 1-quart wicker-covered bottles, 2 bottles.
- Yeast powder, in ½-pound original cans.

Tins for the following articles:
- Beans.
- Butter.
- Coffee.
- Salt and pepper.
- Sugar (2 tins).
- Tea.

Reserve Chest, No. 7.

The contents of this chest will be stated subsequently.

Outfit of Schuehle Ice-Machine as per Latest Contract.

Ice-machine, complete, Jacob Schuehle's patent, capacity 3,000 pounds in 24 hours, consists of:
- 1 double ammonia compressor.
- 1 steam-engine.
- 1 boiler, 20-horse power, complete, with feed-pump.
- 1 ammonia condenser.
- 1 9/16-inch boiler-steel freezing-tank, encased in 1-inch pine flooring, with the requisite number of ice-cans.
- 1 steam condenser, capacity sufficient to furnish in 24 hours distilled water for 3,000 pounds of ice.
- 1 brine-pump.
- 1 patent oil eliminator.
- 1 side-feed lubricator.
- 300 fire-brick.
- Bedplate, necessary pipes, gauges, valves, connections, etc.
- Anhydrous ammonia and lubricating oil sufficient to run the machine for two years.

In most cases additional or improved parts have been purchased for these machines, and this list can be considered as approximate only. The ammonia drum, or cylinder, is a container of the ammonia furnished by contract, and unless purchased from the ice fund does not form a part of the Schuehle machine, being returned when a fresh drum of ammonia is received. The Wood-Bailie machine, of which four are now in use, has an ammonia drum as part of the original machine. See par. 48 and Circular S. G. O., June 13, 1891.

For convenient reference the following lists are appended, although the articles are not issued by the Medical Department:

Issued by the Quartermaster's Department (see par. 51).
- Ambulance.
- Ambulance, harness for.
- Axe.
- Clothing, uniforms, etc.
- Cooking utensils.
- Dippers.
- Flags.*
- Gas-fixtures.
- Hand-cart.
- Hatchet.
- Ladder.
- Lamps, bracket.
- Lamps, hanging.
- Lanterns.
- Lockers.
- Piping for ranges and stoves.
- Range and fixtures.
- Shovel.
- Shelter for meteorological instruments.
- Spade.
- Stoves, heating.
- Tentage, etc.
- Travois.
- Wheelbarrow.
- Wood-saw.

* See A. R. 1848, as amended by G. O. 83, 1880. Except guidons, these flags will rarely be issued.

Issued by the Ordnance Department.
- Blanket bag.
- Blanket bag, shoulder straps, pair.
- Blanket bag, coat straps.
- Canteen.
- Canteen strap.
- Cup, tin.
- Fork.
- Haversack.
- Haversack strap.
- Knife.
- Knife, hospital corps.
- Knife, hospital corps, scabbard.
- Meat can.
- Revolver.*
- Rifle, Springfield, muzzle loading.†
- Shot-gun, Springfield.‡
- Shot-gun, reloading, outfit.§
- Spoon.
- Sword-belt for hospital steward.
- Sword-belt plate for hospital steward.
- Sword frog for belt.
- Waist-belt.
- Waist-belt plate.

* Revolvers will be obtained from the Post Commander for service in an Indian country, when necessary. If it is impracticable to obtain them for temporary service in this way, they may be procured by requisition on the Chief Ordnance Officer of the Department.—Circular S. G. O., April 30, 1891.

† The issue of two Springfield muzzle-loading rifles to each military post for company-bearers' drill is authorized.—Decision Acting Secretary of War, 1888.

‡ "Upon requisition of the Post Surgeon (through the usual military channels), duly approved by the Surgeon-General, the Ordnance Department will issue, for use at posts west of the Mississippi River, a shot-gun with necessary appendages and ammunition for the use of members of the Hospital Corps."—Decision Chief of Ordnance, 1889.

§ The reloading outfit of the shot-gun consists of the following: The articles with * prefixed are expendable, and may be replaced by annual requisitions upon the Chief Ordnance Officer of the Department:
- Brush-wiper, number.. 1
- Canister, tin, for powder, 2-lbs., number..... 1
- Canister, tin, for powder, 5-lbs., number..... 1
- *Cartridge primers, number. 1,000
- *Cartridge shells, 20 gauge, number..... 50
- Charger, adjustable, number... 1
- *Cotton cloth, yard..... 1
- *Cotton waste, lbs..... 1¼
- Drift, number..... 1
- Funnel, number..... 1
- *Gun-wads, No. 18, pink edge, number.... 2,000
- Packing-box, number..... 1
- *Powder, musket, lbs..... 7
- Priming tool (Frankford), number 1
- *Shot, No. 8, lbs 50

Below follows the composition of the tablets, etc., which are referred to in the Supply Table.

Tablets, expendable.

The words tablets and pills are used synonymously throughout the Supply Table:

Alterative.
Mercury protiodide, gr..... 1/5
Opium, gr..... 1/12
Antiseptic:
Mercury bichloride, gr..... 7.7
Ammonium chloride, gr.... 7.3
One tablet to one pint of water makes a 1 to 1,000 solution.
Camphor and Opium:
Camphor, gr..... 2
Opium, gr..... 1
Compound cathartic:
Same as compound cathartic pill.
Compound cathartic, vegetable:
Ext. colocynth, compound, gr..... 1/3
Podophyllin, gr..... 1/4
Pulv. resin scammony, gr... 1/2
Pulv. aloes socotrine, gr.... 1 1/4
Pulv. cardamom, gr..... 1/9
Saponis, gr..... 1/2
Copaiba compound:
Balsam copaiba, gr..... 1 1/2
Resin guaiac, gr..... 3/8
Iron citrate, gr..... 3/8
Oleo-resin cubebs, gr 5/8
Cough:
Extract licorice, gr..... 1/10
Camphor, gr..... 1/25
Acid benzoic, gr..... 1/25
Oil anise, gr..... 1/25
Opium, gr 1/25
Tartar emetic, gr..... 1/60
Each tablet is the practical equivalent of one teaspoonful of brown mixture.
Diarrhœa:
Calomel, gr..... 1/8
Morphine sulphate..... 1/16
Capsicum, gr..... 1/16
Ipecac, gr 1/32
Camphor, gr..... 1/16
Liniment:
Camphor, gr..... 6 1/2
Capsicum, gr..... 6 1/2
Ext. belladonna, alcoholic, gr..... 6 1/2
Dissolve one tablet in one ounce of alcohol.
Peptic:
Pepsin, gr..... 2
Pancreatin, gr..... 2
Bismuth subnitrate, gr..... 2
Tonic:
Iron pyrophosphate, gr..... 1
Quinine sulphate, gr..... 1/2
Strychnine sulphate, gr..... 1/60

Vegetable ration.

DIET.—To the ration of the soldier as described, page 120, third volume of this HANDBOOK, Congress in 1890 added one pound of vegetables, which by decision of the War Department were to be issued as: 1, One hundred per cent. in fresh potatoes; or, 2, eighty per cent. in fresh potatoes, and twenty per cent. in fresh onions; or, 3, seventy per cent. in fresh potatoes, and thirty per cent. in canned tomatoes, or in such fresh vegetables as can be procured in the vicinity of the station, or which it may be practicable to furnish from a distance in wholesome conditions; such as onions, cabbages, beets, turnips, carrots, and squash.

It was further directed that in preparing requisitions for these things, the preferences of the troops will be considered as far as climate, resources of the vicinity, transportation facilities, and season may render practicable.

Under these instructions the food supplied the soldier has been increased by the amount of one pound of vegetables per man, and the Subsistence Department, in issuing, has been guided by the expressed preferences of the troops as to what particular vegetables were supplied, by far the greater proportion being Irish potatoes.

The Irish potato as vegetable ration.

The Irish potato is one of the most abundant of the vegetable foods raised in this country, and it is also one that can be readily transported, and with small danger of injury or loss, as compared with most other vegetables. It is, therefore, to be presumed that it will be largely selected and supplied as food; and concerning it as the vegetable component of the ration, I will principally make comment.

According to the Tables found in Parke's "Hygiene," about three-fourths of the potato consists of water, and one-fifth of carbo-hydrates. One-fiftieth consists of albuminates; one-sixth of one per cent. of fatty material; and one per cent. of salts; so that one pound of potatoes added to the ration adds 0.32 oz. of albuminates; 0.0256 of fatty material; 3.36 oz. of carbo-hydrates, and 0.16 of salts. Adding these amounts to the ration given on page 121–2, Vol. III., of the HANDBOOK, these rations will foot up as follows:

COMPOSITION OF U. S. RATION WHEN INCREASED BY ONE POUND OF POTATOES.

	Albuminates.	Fatty material.	Carbo-hydrates.
	Ounces.	Ounces.	Ounces.
Largest ration of U. S. Army in weight	5.966	1.684	19.296
U. S. Army salt beef ration	4.72117	1.2685	18.7512
Typical ration of U. S. Army	5.197	5.3848	18.872

These amounts may be compared with the amounts in the ration of Moleschott, Pettenkofer and Voit, Ranke, and of the English Army, which amounts were not given, however, in the previous article in terms as below.

	Albuminates.	Fatty material.	Carbo-hydrates.
	Ounces.	Ounces.	Ounces.
Moleschott	4.587	2.964	14.247
Pettenkofer and Voit	4.83	4.12	12.40
Ranke	3.52	3.52	8.46
English Army	3.736	1.44	12.71

Comparison with other rations; United States Army ration increased by addition of one pound potatoes.

If we contrast these figures, it appears that the heaviest ration of the United States Army, increased by the vegetable ration, exceeds in albuminates and carbo-hydrates each of the four rations given in the last table, but is exceeded by each of them in fats, except the ration of the English Army, the fat in whose ration is slightly less. The salt beef ration of the United States Army, also so increased, is in a trifling degree less than that of Pettenkofer and Voit in albuminates, but exceeds all the others in this ingredient; it is less than all the others in fats, but much larger in carbo-hydrates.

The ration given as typical for the United States Army, increased by the vegetable allowance, is much larger than any of the others in albuminates, fats, and carbo-hydrates.

In a paper on the best ration for the soldier, published in the "Transactions of the Ninth International Medical Congress," is found a table giving the mean proportion of the components of seven different rations, which mean is as follows: Albuminates, 4.37 ounces; fatty material, 2.74 ounces; carbo-hydrates, 13.4 ounces. Let us compare with these amounts, the amounts given for what I have termed the typical ration of the United States Army, when increased by one pound of vegetables. The composition of this ration thus increased is as follows:

	Albuminates.	Fatty material.	Carbo-hydrates.
	Ounces.	Ounces.	Ounces.
Meat, half beef	1.245	0.6972	
Meat, half bacon	0.53	4.40	
Bread, half flour	1.314	0.108	6.174
Bread, half hard bread	1.248	0.104	5.822
Beans	0.54	0.05	1.20
Sugar	.....	.....	2.316
Potatoes	0.32	0.0256	3.36
Total	5.197	5.3848	18.872

The increase of albuminates in this ration (5.197 ounces) over the amount contained in the mean of several rations before given (4.37 ounces), equals 0.827 ounce, or nineteen per cent.

The increase in the fatty matter (5.3848 ounces) over that of the mean ration as above (2.74 ounces), equals 2.6448 ounces, or ninety-six per cent., almost double. The increase in the carbo-hydrates (18.872 ounces) over the carbo-hydrates of the mean ration (13.4 ounces) equals 5.472 ounces, or forty per cent. Certainly there can be no doubt of the sufficiency of this last-named ration.

Considering the figures of the ration called the "Largest ration of the United States Army in weight," and the "United States Army Salt Beef Ration," on page 121, Vol. III., REFERENCE HANDBOOK, we find that, when added to the pound of potatoes as above, both of these rations much exceed the "Mean Ration" in the amounts of albuminates and carbo-hydrates, but are less in fats. But the addition or substitution of bacon or salt pork, for fresh or salt meat in almost any proportion that would presumably, or probably, be issued, would bring up the fatty constituents, and still leave the albuminates and carbo-hydrates largely in excess. It is quite certain that in actual service the contingency can never occur when

bacon or salt pork will be wanting as part of the ration, for any length of time.

If, then, the experiments of all students and observers in regard to diet are worth anything whatever, if the experience of feeding armies and large bodies of men teaches aught worthy of reliance, it may be affirmed that the present ration of the United States soldier is larger than is necessary. Manifestly the sin of excess in the ration is less to the disadvantage of the soldier than that of insufficiency; but the same cannot be affirmed as to its advantage to the tax-payer.

Present United States Army ration larger than needed for purposes of nutrition.

The first cost to the United States of a pound of potatoes will not average less than a cent. This alone, to an army of one hundred thousand men, will equal $1,000 per day. To this must be added the cost of transportation to and with the army, and the expenses due to loss. In time of war each of the above items of cost will be largely increased over time of peace, and the cost of transportation is one of the heaviest expenses of the campaign.

Unless it can be shown that the supplying or the eating of unnecessary food possesses certain advantages not due to the final consumption of the food in the processes of nutrition, it may well be doubted whether the legislation which added to each ration one pound of vegetables was wise legislation, even though liberal to the soldier.

Certainly, those who have accompanied an army through a campaign will appreciate the immense additional labor and expense which will be entailed on the Quartermaster and Subsistence Departments if the attempt be made to carry out the law in time of war and supply the vegetables which have been added to the ration. The title of the act giving a vegetable ration is, "An act to prevent desertions from the army and for other purposes."

The foregoing considerations are entirely independent of the question of the desirability and necessity of fresh vegetables as an article of diet. This desirability is undisputed.

On p. 103, Vol. III., REFERENCE HANDBOOK, it is stated that the "surgeon must insist that fresh vegetables be supplied." Although it is said that people have lived, and do live, on animal food alone, or animal food with the addition of food of vegetable origin, but not ordinarily considered as fresh vegetables (flour, etc.), it will not here be denied that green, fresh vegetables are, if not necessary, certainly very desirable as an article of diet.

Vegetables needed as food.

Vegetarians claim that they live on vegetable food, to the exclusion of animal food, with the maintenance of better health than belongs to the consumer of animal food; and green vegetables are beyond doubt often a luxury.

But in the study of the soldier's ration, economy is an important consideration, certainly when its practice cannot be shown to conflict with aught more important.

The nutritive power of vegetables is small in proportion to weight, and the large amount of water they contain (which in the cabbage is nine-tenths or over) will always interfere with their general use as a constituent of the ration of an army in the field.

In time of peace, by company and post gardens, and by the barter or exchange of other portions of the soldier's ration, as has been heretofore shown in this HANDBOOK, the soldier may always have, and does in general have, an abundance of vegetables.

In time of war I believe the *regular daily issue* of a fresh vegetable ration to be almost, if not quite, impracticable; but vegetables may and must be purchased, and issued from time to time, on the recommendation of the medical authorities, as the circumstances may favor their procurement, or as the need may become imperative. This issue should be a special issue to replace other articles of food or in addition thereto.

DRINK.—Not much on the subject of drink need be added to what was said on that subject, p. 123, Vol. III. of this HANDBOOK. It is proper to emphasize the importance of boiling as a purifying process for suspected water. A temperature of 212° F. and upward will destroy the life of the bacillus of cholera and of microbes generally, and this mode of purification is cheap and handy.

Boiling to purify water.

ICE MACHINES.—Since the REFERENCE HANDBOOK was published the Medical Department has supplied ice machines to such Southern posts as were unable to obtain, by purchase, ice for the use of the sick.

The Surgeon-General has announced that these machines "are furnished by the Medical Department to supply ice for the use of the sick in hospital, and not for the comfort or convenience of the garrison at large," and this because such supply for the well belongs to another supply department. Under the regulations issued by the Surgeon-General June 13, 1891, the ice machines are operated under the immediate direction of medical officers.

After the sick were furnished with the needed ice the surplus manufactured was sold to officers, soldiers, and civilians at prices fixed by the officer in charge, with the approval of the Medical Director, these prices being sufficiently high to create a fund from which were met the expenses of the ice manufacture, viz., such expenses as repairs, fuel, oil, ammonia and salt, wages, freight on supplies, etc.

Ice supply.

No action of the Medical Bureau has been more grateful or beneficent to the army than this issue of ice machines and the supply of ice which it has been found practicable to issue to the garrisons at an expense generally of half a cent or less per pound.

A description of the ice machine used will be found under the heading Supply Table in this paper.

CLOTHING.—The soldier's clothing allowance, according to the latest orders of the War Department, is as follows:

ALLOWANCE OF CLOTHING.

Articles.	Year. First. 1st 6 mos.	First. 2d 6 mos.	Second.	Third.	Fourth.	Fifth.	Total for five years.
Helmets and trimmings, complete, number	1	..	..	1	..	..	2
Forage-cap and trimmings, number.	1	1	1	1	1	1	6
Campaign hats, number	1		1	1	1	1	5
Uniform coats, number	1	..	..	1	..	..	2
Trousers, pairs	2	1	2	2	2	1	10
Canvas fatigue coat, number	1	..	1	1	1	1	5
Canvas fatigue trousers, pairs	1	..	1	1	1	1	5
Linen collars, number	4	2	6	6	6	6	30
Dark-blue flannel shirts, number	2	1	2	2	2	2	11
Knit undershirts, number	2	1	3	3	3	3	15
Drawers, pairs	2	1	3	3	3	3	15
Boots, for mounted troops, pairs	1	..	1	..	1	..	3
Shoes, for mounted troops, pairs	1	1	1	2	1	1	7
Shoes, for foot troops, pairs	2	1	2	3	2	2	12
Barrack shoes, pairs	1	..	1	1	1	1	5
Stockings, woollen, pairs	3	1	4	4	4	4	20
Stockings, cotton, pairs	3	3	6	6	6	6	30
Blouses, number	1	..	1	1	1	1	5
Overcoats, number	1		..	..	..	..	1
Chevrons, cloth, pairs	2	.	1	1	1	1	6
Chevrons, gold lace, pairs	1	..	..	1	..	..	2
Stripes for trousers, pairs	2	1	2	2	2	1	10
Stable-frock, for mounted troops, number	1	.	..	1		..	2
Overalls, for engineers and mounted troops, pairs	1	..	1	1	1	1	5
Blankets, woollen, number	1		..	1	..	..	2
Berlin gloves, for mounted troops, pairs	2	2	4	4	4	4	20
Berlin gloves, for foot troops, pairs	4	4	8	8	8	8	40
Leather gauntlets, pairs	1	..	1	..	1	..	3
Suspenders, pairs	1	..	1	1	1	1	5
Band musicians authorized by law are entitled to mounted helmets, and, in addition to the foregoing, to the following articles:							
Trousers, white, pairs	2	1	2	2	2	1	10
Aiguillette and shoulder-knots, number	1	..	..	1	..	..	2
Music pouch	1	..	..		..	..	1

To this allowance must be added canvas mittens and canvas lined caps, and also leggings and cravats.

Cork helmets are supplied to troops, in the first and

third years of their enlistment, in lieu of the campaign hats.

Arctic overshoes and woollen mittens, when issued, will be charged to the enlisted men at cost prices. The necessity for their issue must, however, be certified to by the department commanders. The allowance for these articles is as follows:

Arctic overshoes, one pair in each of the first and third years of enlistment, and woollen mittens, two pairs per annum.

Overcoats made of fur or other suitable material will be issued and accounted for in the manner prescribed by paragraph 1301 of the regulations.

One fur cap and one pair of fur gauntlets will also be issued annually to all enlisted men in the Departments of the Platte, Dakota, and the Columbia, and in other departments, when specially authorized by the department commander, at the prices established for such articles in the annual price-list.

Rubber blankets and ponchos may be issued gratuitously at the rate of one per annum to each enlisted man, until the stock on hand shall have become exhausted.

Enlisted men may draw, whenever in the opinion of the proper officer it may be necessary, during their first year's enlistment, the two woollen blankets to which they are entitled during their service of five years.

The full amount of the allowance as given in the above table the soldier is not obliged to draw, and of what he does not draw, the money value is placed to his credit, and paid to him in money at date of his discharge from the service or at other stated settlement.

The money value of clothing not drawn placed to soldiers' credit.

REPORTS AND RECORDS REQUIRED OF THE MILITARY SURGEON.—Of the reports and records named, page 128, Vol. III., REFERENCE HANDBOOK, the case, diet, and prescription book, No. 10; the register of patient's effects, No. 12; and meteorological reports, No. 13, are no longer required of the surgeon.

The form called "Consolidated Reports of the Medical Department," No. 18, has been done away with and a new form substituted, called a "Report of Sick and Wounded." In certain respects the latter is an improvement upon the former, but retains some of its defects.

To the author it seems that the effort is made to comprise in this report *too much*, and it is to be hoped that some day a simpler form of report of sick and wounded may be adopted for the army. The writer of this paper has had occasion during the past thirty years to pay very much attention to this especial report.

Report of sick and wounded.

Since the remarks were printed concerning said report (page 127, Vol. III., of this HANDBOOK), a paper was read on the subject before the Section of Military and Naval Medicine and Surgery of the Ninth International Medical Congress, and published in its "Transactions." For more detailed arguments on the subject the reader is referred to that paper.

The report of sick and wounded of an army should be as brief as possible, consistently with its useful purpose, because the officer making it must be often, if not always, without the clerical help or the time needful to prepare an elaborate paper.

It is an *army* report, and not a paper specially prepared for the Census Bureau, for the Pension Bureau, or the general statistician, to the aid of all of whom, however, it should come, but solely within its own sphere; not pretending to give information so special in its kind as to be almost certainly inaccurate and unreliable when reported by any other than a skilled observer or student of the specialty.

No one can well do amateur work which interferes with his proper legitimate work if he is interested in that legitimate work and if that work occupies his time. Accordingly it seems wisest to require from the military surgeon, as part of his military duty, such reports only as grow out of and belong to his place as a military surgeon.

The following propositions, which were adopted, and reported by the Section of Military and Naval Medicine and Surgery of the Ninth International Medical Congress to the Congress itself are here again enumerated:

1. The main object of a report of sick and wounded for an army is to give the diseases and injuries, their number, their proportion occurring among the troops and the results thereof, all other objects being incidental and secondary, or better effected in certain cases by special reports.

2. For purposes of convenience this report should be monthly.

3. It is desirable that, for comparison and study, the form of this report should be uniform for all armies and as simple as may be.

4. No nosological arrangement can now be made which commends itself to everyone, and which all will agree on as the only one compatible with scientific knowledge; and, therefore, *that* nomenclature and arrangement of diseases should be adopted which is most convenient for use in the exigencies of military service.

5. In view of the great desirability of an uniform "report of sick and wounded" by all armies, and in the absence of any other form better fitted to fulfil the ends for which this report is made, this Section recommends the adoption of the subjoined "form" in the medical departments of all armies.

The "form" which followed contained the date, place, and mean strength; a list of diseases, by name, occurring, with their result, cure, death, etc.; a report of vaccinations; of discharges on certificate of surgeon, and of deaths, by name; and "directions" how to make out the report.

The nosological table recommended was that of the Prussian army, arranged in fourteen divisions, as follows:

First Division.—General diseases (poisoning).
Second Division.—Diseases of the nervous system.
Third Division.—Diseases of respiratory organs.
Fourth Division.—Diseases of circulatory organs.
Fifth Division.—Diseases of organs of assimilation.
Sixth Division.—Diseases of urinary and sexual organs (excluding venereal).
Seventh Division.—Venereal diseases.
Eighth Division.—Diseases of the eye.
Ninth Division.—Diseases of the ear.
Tenth Division.—Diseases of integument.
Eleventh Division.—Diseases of organs of locomotion.
Twelfth Division.—Mechanical injuries.
Thirteenth Division.—Other diseases, including in the order here named, self-mutilation, attempted suicide, simulation, general debility of body, debility from old age.
Fourteenth Division.—Under observation.

Concerning this form the author remarked that "it is not claimed that this 'form' is perfect, but it is simple, compact, easily understood, easier to make out than any form known to the writer, and contains all the data necessary to determine the proportion of cases of disease or injury occurring in an army, and the results thereof, besides all the data needed to enable proper conclusions to be reached in regard to pensions and similar allowances."

I add that no questions regarding doubtful pathology are involved, and that careful reconsideration leads me to here urge this form upon the favorable consideration of the military surgeon.

In addition to the new Report of Sick and Wounded a few stated reports and records have also been added, to wit: a Monthly Statement of Ice Fund from surgeons in charge of ice machines (to the Surgeon-General); a Semi-annual Return of Record Books (to the Surgeon-General); a Morning Report Book of the Hospital Corps (to the commanding officer); a Monthly Return of Hospital Corps (to the Surgeon-General); a Clothing Account Book of the Hospital Corps; a Descriptive Book of the Hospital Corps.

The last four books and reports have been rendered necessary by the organization of a separate Hospital Corps, under the command of the surgeon. Concerning this corps and its necessity to the field-surgeon further remarks will be made.

HOSPITAL CORPS.—On pages 132 to 139 inclusive, Vol. III., REFERENCE HANDBOOK, under the heading "Care and Removal of the Wounded in Battle," a somewhat extended notice is given of the ambulance corps of various armies, including that of the United States Army.

The ambulance corps of the United States Army as described, *loc. cit.*, had done good service during the great War of the Rebellion, and its operations were a great improvement upon the modes of caring for the wounded and sick in the field in previous wars. Still it had manifest imperfections, the most vital being that it really only existed during war, and that its organization only included, besides its officers, the litter-bearers and drivers.

The most progressive military surgeons of our army, and those whom they could influence to co-operate, did not fail, during the years following the war, to represent to those whom they thought could and would aid them, the necessity of a more comprehensive and permanent organization of a body of men whose sole duty should be the care of the sick and wounded at all times, and particularly their first aid when wounded, and their transportation after injury. Finally, March 1, 1887, an act passed by Congress was approved by the President and became a law.

This law establishing the Hospital Corps is the most important legislation for the Medical Department which has taken place since the Medical Department was reorganized. Upon page 222, Vol. VII., REFERENCE HANDBOOK, appears quite a full article by Pilcher upon the transportation of the disabled on land. This article is mostly devoted to the handling of the wounded in a systematic manner, and the drill of the organized body by whom the wounded must be handled. Incidentally a few words are said concerning the Hospital Corps, independent of its drill, and a few words only, and it seems proper to here treat more fully of that corps, its organization, and its duties other than that of transporting the wounded. The law organizing the Hospital Corps, is textually as follows:

An act to organize the Hospital Corps of the Army of the United States, to define its duty and fix its pay.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Hospital Corps of the United States Army shall consist of hospital stewards, acting hospital stewards, and privates; and all necessary hospital services in garrison, camp, or field (including ambulance service) shall be performed by the members thereof, who shall be regularly enlisted in the military service; said corps shall be permanently attached to the Medical Department, and shall not be included in the effective strength of the army nor counted as a part of the enlisted force provided by law.

Sec. 2. That the Secretary of War is empowered to appoint as many hospital stewards as, in his judgment, the service may require; but not more than one hospital steward shall be stationed at any post or place without special authority of the Secretary of War.

Sec. 3. That the pay of hospital stewards shall be forty-five dollars per month, with the increase on account of length of service as is now or may hereafter be allowed by law to other enlisted men. They shall have rank with ordnance-sergeants and be entitled to all the allowances appertaining to that grade.

Sec. 4. That no person shall be appointed a hospital steward unless he shall have passed a satisfactory examination before a board of one or more medical officers as to his qualifications for the position, and demonstrated his fitness therefor by service of not less than twelve months as acting hospital steward; and no person shall be designated for such examination except by written authority of the Surgeon-General.

Sec. 5. That the Secretary of War is empowered to enlist, or cause to be enlisted, as many privates of the Hospital Corps as the service may require, and to limit or fix the number, and make such regulations for their government as may be necessary; and any enlisted man in the army shall be eligible for transfer to the Hospital Corps as a private. They shall perform duty as wardmasters, cooks, nurses and attendants in hospitals, and as stretcher-bearers, litter-bearers, and ambulance attendants in the field, and such other duties as may by proper authority be required of them.

Sec. 6. That the pay of privates of the Hospital Corps shall be thirteen dollars per month, with the increase on account of length of service as is now or may hereafter be allowed by law to other enlisted men; they shall be entitled to the same allowances as a corporal of the arm of service with which on duty.

Sec. 7. That privates of the Hospital Corps may be detailed as acting hospital stewards by the Secretary of War, upon the recommendation of the Surgeon-General, whenever the necessities of the service require it; and while so detailed their pay shall be twenty-five dollars per month, with increase as above stated. Acting hospital stewards, when educated in the duties of the position, may be eligible for examination for appointment as hospital stewards as above provided.

Sec. 8. That all acts and parts of acts in so far as they contravene the provisions of this act are hereby repealed.

This law remains unchanged to the present time, with the one exception that the pay of the private, Hospital Corps, has been increased from thirteen dollars to eighteen dollars per month, because it was found difficult to procure for the first named pay men of the acquirements demanded. Immediately after the passage of the law it became necessary to establish the regulations provided for in its fifth paragraph, and the Secretary of War ordered for that purpose a Board consisting of the late Adjutant-General of the army, and three army medical officers, of whom the writer was the senior.

The Board, after a month's consideration, reported a system of regulations which were approved by the Secretary of War, and published to the army. They were incorporated in the new Army Regulations with such changes as from time to time were demanded to facilitate their operation.

Condensed, the points of these regulations important to be here made known are as follows:

Qualifications necessary for privates of the Hospital Corps.

Privates of the Hospital Corps may be enlisted from civilians, or transferred from soldiers of the line of the army. The latter will be the chief source of supply. The transfer will be made on the application of the post-surgeon, which application must show: 1st, That the man must desire to transfer; 2d, that he has served already one year or more; 3d, that he is not married; 4th, his age, and if over forty, his special qualifications as nurse or cook; 5th, his character; 6th, his physical condition; 7th, his habits as to temperance; 8th, whether for existing or prospective vacancy; 9th, the date of expiration of his present enlistment; 10th, his ability to read and write; 11th, his general intelligence and aptitude for the duties of a private of the Hospital Corps.

Neither artificers nor musicians must be recommended for transfer.

In time of peace recruits for the Hospital Corps who have not previously received at least one year's military instruction in the army shall be attached to a company stationed at Fort Monroe, Virginia; Fort Leavenworth, Kansas; or Fort Riley, Kansas, and shall perform all the duties and be subject to all the drill and discipline required of privates in the organizations to which they are attached. After one year's service in the line they may be assigned to duty in the Hospital Corps. The number of privates so enlisted and undergoing instruction shall at no time exceed ten, unless otherwise specially authorized by the Secretary of War.

Qualifications for appointment as acting hospital stewards.

Privates who have served one year or more in the Hospital Corps, and have displayed particular merit, will be recommended to the Surgeon-General for promotion, by the senior medical officer of the command; from those thus recommended acting hospital stewards will be appointed. The candidate for promotion as *acting hospital steward* must pass a satisfactory examination as to his physical condition, moral character, and general aptitude, and in the general prin-

ciples of arithmetic, including decimal fractions and the rules of proportion; in orthography and penmanship; the Articles of War and the regulations affecting enlisted men; pharmacy; care and use of meteorological instruments and hospital and field appliances furnished by the Medical Department; the methods of rendering first aid to the sick and wounded; the ordinary modes of cooking.

To be appointed *hospital steward* the candidate must have served at least one year as acting hospital steward.

Qualifications for the position of hospital steward.

He must then pass an examination, oral and written, on the branches named above, and also in the elementary principles of hygiene, including ventilation, heating, and disinfecting; the principles of materia medica, therapeutics, and minor surgery; the administration of anæsthetics. He must also possess a thorough knowledge of the regulations of the Medical Department.

These examinations must be conducted by commissioned medical officers.

Hospital stewards cannot be reduced to the ranks, but acting hospital stewards may. Their duties are, under the direction of the medical officer, to look after and distribute hospital stores and supplies; to care for hospital property; to compound and administer medicines; to supervise the preparation and serving of food; to maintain discipline in hospitals and watch over their general police; to prepare the hospital reports and returns; to supervise the duties of the members of the Hospital Corps in hospital and in the field; and to perform such other duties connected with their positions as may, by proper authority, be required of them.

Duties of hospital stewards.

From each company in the army four men shall be selected as *litter-bearers*, to be known as *company bearers*.

Litter-bearers, or company bearers.

These men, together with all available men of the Hospital Corps, are to be instructed at least four hours in each month under supervision of the medical officer, in the duties of litter-bearers and the method of rendering first aid to the sick and wounded.

During an engagement, or in an emergency, the company bearers shall, under the orders of their commanding officers, and the supervision of the regimental surgeons, if any are present, give first aid to the wounded or carry them to the rear until relieved by members of the Hospital Corps; when so relieved they shall immediately join their companies. In active service company bearers shall wear as a distinguishing mark a red brassard around the left arm.

Members of the Hospital Corps will be instructed by the senior medical officer of the post at such times (in addition to those previously prescribed) as he may deem necessary. This instruction shall consist of lectures and demonstrations in the methods of rendering first aid to sick and wounded, and of drills in the ambulance service, and as litter-bearers, in accordance with the prescribed manual.

Litter drill and instruction in first aid to wounded.

Members of the Hospital Corps shall not be required to perform any military duties other than those pertaining to their corps. They shall not be required to attend reviews, parades, or other military ceremonies.

Hospital stewards will be assigned in the proportion of one to every post; two, if the post equals six companies; and an additional steward for each additional six companies. An acting hospital steward is allowed also to every post save the smallest. Privates of the Hospital Corps are allowed in the proportion of three to every post; four, if the garrison consists of two companies, and an additional private for each additional two companies.

Members of Hospital Corps, how assigned.

In the field troops shall be accompanied by such number of men of the Hospital Corps as may be determined by the post commander on the recommendation of the post surgeon.

Field Service.

Upon the march or in battle medical officers shall, habitually, be attended by a mounted private of the Hospital Corps, carrying a medical officer's orderly pouch. Hospital stewards, acting hospital stewards, and at least one private of the Hospital Corps in each separate company shall be mounted when serving in the field; and all privates of the Hospital Corps shall be mounted when serving with mounted commands. The Quartermaster's Department will furnish the necessary mounts.

Each private of the Hospital Corps shall carry a canteen of water, a knife of approved pattern, and a simple package of dressings; and, except when serving as an orderly, a Hospital Corps pouch.

In time of war ambulance and field hospital services will be performed by members of the Hospital Corps. The privates of the corps, to perform the duties of litter-bearers, service with the ambulances, and at dressing and ambulance stations, should number at least two per cent. of the aggregate strength of the command. To every ten privates there should be an acting hospital steward, and to every thirty privates a hospital steward.

Hospital and ambulance service in war.

The allowance of ambulances, stretchers, and horse and mule litters are the same as fixed in the law published, p. 137, Vol. III., REFERENCE HANDBOOK, and the medical director of the army and each army corps is also given the control in the terms of that law. The wording of that law is also used in prohibiting the use of ambulances save for the transportation of sick and wounded, and in urgent cases for medical supplies, and all persons save the proper medical officers, the officers, non-commissioned officers, and privates of the ambulance service, or others specially assigned by competent authority, are prohibited from taking or accompanying the sick and wounded to the rear.

Ambulances, stretchers, horse and mule litters.

The medical director or chief medical officer is also again directed, previous to a march or battle, to cause the ambulances to be distributed and managed for the collecting the sick and wounded and conveying them to their destination, and to provide, under the general instructions of the commanding general, for the care of the wounded at dressing and hospital stations, when taken possession of by the enemy, by deciding in advance what medical officers and members of the Hospital Corps shall remain with a dressing or hospital station in case it is abandoned or captured by the enemy.

Medical director manages ambulances and provides for care of wounded after battle.

Privates of the Hospital Corps in the field in time of war will be organized into a company for each brigade, with their hospital stewards and acting hospital stewards, under command of an officer of the ambulance service or a medical officer detailed for that purpose, and will habitually camp near the division hospital, or, if there be none, the brigade or field hospital, to give such assistance as may be needed.

Privates of Hospital Corps organization in field.

They will be assigned, by order of the commanding general or the senior medical officer, to such duties connected with their corps elsewhere as may be required; but on the completion of such duty, or after an action, they will rendezvous at their camp, unless otherwise ordered. In time of action, in the absence of specific orders from the commanding general or proper medical officer, the officer in charge of the company will, under the general instructions which he may have received, himself issue the necessary orders to proceed to the dressing stations, or to the relief and care of the wounded.

For the care and treatment of the sick while in hospital or in transport, members of the Hospital Corps should be allowed as follows:

To general and division hospitals, six privates to every thirty beds, with such number of hospital stewards and acting hospital stewards as the Surgeon-General, with the approval of the Secretary of War, may direct. To a railway hospital train of twenty cars, carrying six hundred sick and wounded, two hospital stewards, six acting hospital stewards, and one hundred privates; and to trains of a greater or less capacity the number should be in the same proportion, to vary, however, at the discre-

Allowance of Hospital Corps in the field or war.

tion of the medical director, according to the distance to be travelled and the character of the cases to be transported. To a hospital boat of three hundred beds, three hospital stewards, six acting hospital stewards, and sixty-five privates; or in like proportion to hospital boats of a greater or less capacity.

DEFINITION OF TERMS.—Treating of the terms used in connection with the Hospital Corps, the Surgeon-General defines them as follows:

Wardmaster.—A private in charge of a ward or wards, wherein are other privates of the Hospital Corps on duty as nurses. This term is usually employed only in general hospitals.

Nurse.—A private who is in charge of patients in a ward. In the ordinary post hospital where but one private is on such duty he may also be in charge of the ward.

Cook.—A private who is in charge of the kitchen and preparation and cooking of the food.

Attendant.—A private who performs other duties than those heretofore enumerated.

Orderly.—A mounted private who habitually attends a medical officer "upon the march or in battle." The employment of an orderly in garrison is not contemplated by existing regulations, and the use of the term must be restricted to service in the field.

A description will here be given of certain articles which are either a part of the outfit of the soldier of the Hospital Corps or ordinarily used by him, and of which the Field Surgeon should have knowledge.

Uniform and Dress.—The uniform is to be almost the same as that of an infantry soldier, with modifications as hereunder.

Trousers for all Enlisted Men of the Hospital Corps.—Of dark-blue kersey, same quality as for non-commissioned officers of the other arms of the service.

Stripes for Trousers for Enlisted Men of the Hospital Corps.—Of emerald green piped with white. Hospital steward's to be one and one-quarter inch wide; acting hospital steward, one inch wide; privates, to be one-half inch wide.

Forage-cap Ornament for Hospital Stewards.—A cross in white metal, inclosed by a wreath in white metal; for acting hospital stewards and privates of the hospital corps, a cross in white metal.

Helmets for Enlisted Men of the Hospital Corps.—Same as for infantry, save that the side buttons shall be of yellow metal with a Geneva cross of white metal. *Device*, a Geneva cross.

Uniform Coats.—Same as for enlisted men of infantry except that the facing shall be of emerald green piped with white; that for acting Hospital Stewards to have a red cross on each side of the collar in front. The uniform dress-coats for all non-commissioned officers shall be made of dark blue cloth of finer quality than for privates.

Chevrons for Uniform Coats.—For a hospital steward, three bars and an arc of gold lace; for an acting hospital steward, same as for a hospital steward, omitting the arc.

Cloth Chevrons for Overcoats and Blouses.—For a hospital steward, three bars and an arc of one bar of emerald green cloth, inclosing a red cross; for an acting hospital steward, the same as for a hospital steward, omitting the arc.

For a Private of the Hospital Corps and for all Persons Neutralized by the Terms of the Geneva Convention.—A brassard of white cloth, sixteen inches long and three inches wide, with a cross of red cloth, two inches long and two inches wide in centre, to be worn on the left arm, above the elbow.

For a Company Litter-bearer.—A brassard of red cloth, to be worn on the left arm above the elbow.

Equipment for a Private of the Hospital Corps.—A blanket-bag, blanket-bag shoulder-straps (pair), blanket-bag coat-straps (pair), canteen, canteen-strap, haversack, haversack-strap, waist-belt, waist-belt plate, meat-can, tin cup, knife, fork, spoon, knife and scabbard (Hospital Corps), package of dressings, and Hospital Corps pouch.

Brassards.—The brassard of the red cross was adopted by the Geneva convention as a badge of neutrality, to be worn by all persons authoritatively serving with the medical department of belligerents. It is therefore of no use in time of peace. It was adopted by the War Department as the distinctive badge for *privates* of the *Hospital* Corps, and being a part of their uniform is to be worn at *all* times.

The duty of the company bearer is defined in Army Regulations, par. 1575, and is limited, except for purposes of drill, to "active service," during which he should wear the badge of his special duty.

As the *company bearer* is merely an official emergency man, he should, when serving in the field, be equipped as is any other soldier of the line, plus a field tourniquet and a package of dressings.

ARMS FOR HOSPITAL CORPS.—The Surgeon-General informs medical officers that when on service in an Indian country they should take steps to arm members of the hospital corps for self-protection against a savage enemy.

The Acting Chief of Ordnance concurs "in the views of the Surgeon-General as to the necessity of arming the members of the Hospital Corps for self-protection when on field service in an Indian country. Post commanders will arm the medical enlisted men when necessary. This will meet the case and relieve the medical officers from making returns for fire-arms when use by their men will only be occasional."

Contents of Knapsack.—One rubber blanket, one woollen blanket, one undershirt, one pair of trousers, two pairs of socks, two pairs of Berlin gloves, one pair of drawers, one blue flannel shirt, one towel, one pair of shoes, toilet articles, tin cup (suspended underneath).

Litter and Sling.—The regulation hand-litter consists of a canvas bed, six feet long and twenty-two inches wide, made fast to two poles seven and a half feet long, and stretched by two jointed braces. The ends of the poles form the handles, nine inches long, by which the litter is carried. The fixed iron legs are loop-shaped, four inches high and one and three-quarter inches wide.

On the left front and right rear handles a half round iron ring is fixed, four and a half inches from the end; between this and the canvas plays the movable ring of the sling.

A cross strap with ring and snap is permanently fastened to the bottom of each pole near the handles, the free (ring) end passing through a staple under the opposite pole. When the litter is open the straps lie transversely under the canvas; when the litter is closed they are passed around it through the free loop of the sling and fastened to the snaps, thus securely closing the litter.

One pair of regulation slings is permanently attached to each litter. They are made of gray woollen webbing, two and one-half inches wide, with a leather-lined loop at one end and a leather strap (with buckle) at the other, the strap passing through a steel swivel, itself attached to the movable ring on the handle.

Hospital and Ambulance Flag.—In November, 1889, it was published to the army in regulations, that:

The hospital and ambulance flags of the army are as follows: For general hospitals, white bunting 9 × 5 feet, with a cross of red bunting 4 feet high and 4 feet wide in the centre; arms of cross to be 16 inches wide.

For field hospitals, white bunting, 6 × 4 feet, with a red cross of bunting, 3 feet high and 3 feet wide in the centre; arms of cross to be 12 inches wide.

For ambulances and guidons to mark the way to field hospitals, white bunting, 16 × 28 inches, with a red cross of bunting 12 inches high and 12 inches wide in the centre; arms of cross to be 4 inches wide.

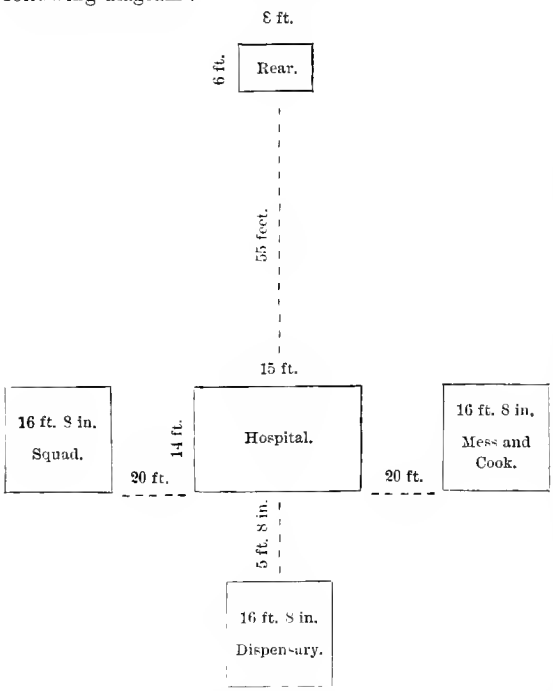
It will be remembered that Article VII. of the Geneva Convention declares that the flag adopted for hospitals, ambulances, and evacuations shall be distinctive and uniform.

Travois.—The travail or travois was briefly treated but not described, page 142, Vol. III., REFERENCE HANDBOOK, and is spoken of by Pilcher in his article on the transportation of the wounded, Vol. VII. As adopted

by the United States Army Medical Department the travois consists of two jointed side-poles seventeen feet long (when extended) connected by two cross-bars, one . . . feet long, placed . . . feet from the front ends, the other . . . feet long, placed six feet behind the first, and of a regulation litter, suspended from the cross-bars by straps provided for the purpose. For transportation, the litter and cross-bars being removed, the poles are closed, the bars laid alongside them and the whole secured by the bar-straps into a package nine feet long which may be carried upon the brackets of the ambulance. A breast-strap and traces accompany the travois. It is drawn by one animal, the rear ends of the poles trailing on the ground.

The service of the travois requires three men, one to lead the animal, the others to watch the litter and be ready to lift its rear poles when passing over obstacles, crossing streams, or going up hill.

Field Hospital.—As adopted by the United States Army Medical Department the canvas of a *regimental field hospital* consists of two hospital tents, and three hospital tent flies, three conical wall tents, one common tent. The hospital tents to be used as a ward; the conical wall tents as dispensary, squad, and mess tents respectively; and the common tent as latrine cover. The tents are most conveniently pitched in cross-shape as per following diagram:



When desired, a fly is pitched over the space between the dispensary and ward, thus affording shelter for those reporting at "Surgeon's Call."

A regimental detachment of the Hospital Corps consists of two non-commissioned officers and eight privates. One army wagon is required to transport a regimental field-hospital complete.

Canvas for a *battalion field hospital* consists of one hospital tent and two hospital tent flies; two conical wall tents; one common tent.

The battalion detachment of the Hospital Corps consists of one non-commissioned officer and four privates. One escort wagon is required to transport a battalion field-hospital complete.

Tentage for medical officers is not included in that for the field hospital. Each medical officer is allowed one wall tent complete.

A hospital tent is fourteen feet long, fifteen feet wide, and eleven feet to ridge, the wall being four and a half feet high; it furnishes comfortable accommodations for six patients, and requires to pitch it a ridge pole and two upright poles, seven long tent pins on each side for the guy ropes, and two on each side for the long guys, eighteen in all. Twenty-four small pins are needed for the front, rear, and walls. The hospital tent should always be pitched first in the field hospital.

Geneva Convention.—Reference to the Geneva Convention has been made in the foregoing, and it particularly behooves the field surgeon to be familiar with its provisions.

During the War of the Rebellion the War Department published to the army "Instructions for the Government of Armies of the United States in the Field," prepared by Francis Lieber, LL.D., and revised by a board of officers.

Therein were contained the following paragraphs particularly interesting to the field surgeon:

35. Classical works of art . . . *as well as hospital*, must be secured against all avoidable injury, even when they are contained in fortified places while besieged or bombarded.

49. A prisoner of war is a public enemy, armed or attached to the hostile army for active aid, who has fallen into the hands of the captor, either fighting or *wounded*, on the field *or in the hospital*, by individual surrender or by capitulation. . . .

All soldiers, of whatever species of arms; . . . *all disabled men* . . . if captured . . . are prisoners of war, and as such exposed to the inconvenienees, as well as entitled to the privileges, of a prisoner of war.

53. The enemy's chaplains, officers of the medical staff, apothecaries, hospital nurses, and servants, if they fall into the hands of the American army, are not prisoners of war, unless the commander has reasons to retain them. In this latter case, or if, at their own desire, they are allowed to remain with their captured companions, they are treated as prisoners of war, and may be exchanged if the commander sees fit.

79. Every captured wounded enemy shall be medically treated according to the ability of the medical staff.

115. It is customary to designate by certain flags (usually yellow), the hospitals in places which are sheltered, so that the besieging enemy may avoid firing on them. The same has been done in battles when hospitals are situated within the field of engagement.

116. Honorable belligerents often request that the hospitals within the territory of the enemy may be designated, so that they may be spared.

An honorable belligerent allows himself to be guided by flags or signals of protection as much as the contingencies and the necessities of the fight will permit.

117. It is justly considered an act of bad faith, of infamy, or fiendishness, to deceive the enemy by flags of protection. Such act of bad faith may be good cause for refusing to respect such flags.

Early in the war, in 1861, and for some time thereafter, captured medical officers were considered prisoners of war the same as the combatants, but later action in regard to captured medical officers was in accordance with the above paragraphs.

The Geneva Convention modifies the above quoted paragraphs slightly in certain directions, which will be patent on reading the original Convention with the articles additional thereto to which it appears the United States have aeceded. The importance of this Convention is such as to demand its appearance in this place.

General Orders, No. 3.

Headquarters of the Army,
Adjutant-General's Office,
Washington, January 14, 1892.

The Convention between the United States, Baden, Switzerland, Belgium, Denmark, Spain, France, Hesse, Italy, Netherlands, Portugal, Prussia, Würtemberg, Sweden, Greece, Great Britain, Mecklenburg-Schwerin, Turkey, Bavaria, Austria, Russia, Persia, Roumania, Salvador, Montenegro, Servia, Bolivia, Chili, Argentine Republic, and Peru; with additional articles: For the

amelioration of the wounded in armies in the field; concluded August 22, 1864; acceded to by the President March 1, 1882; accession concurred in by the Senate March 16, 1882; proclaimed as to the original convention, but with reserve as to the additional articles, July 26, 1882; commonly known as the Geneva Convention, is as follows:

ORIGINAL CONVENTION.

Article 1. Ambulances and military hospitals shall be acknowledged to be neuter, and, as such, shall be protected and respected by belligerents so long as any sick or wounded may be therein.

Such neutrality shall cease if the ambulances or hospitals should be held by a military force.

Art. 2. Persons employed in hospitals and ambulances, comprising the staff for superintendence, medical service, administration, transport of wounded, as well as chaplains, shall participate in the benefit of neutrality, while so employed, and so long as there remain any wounded to bring in or to succor.

Art. 3. The persons designated in the preceding article may, even after occupation by the enemy, continue to fulfil their duties in the hospital or ambulance which they serve, or may withdraw in order to rejoin the corps to which they belong.

Under such circumstances, when these persons shall cease from their functions, they shall be delivered by the occupying army to the outposts of the enemy.

Art. 4. As the equipment of military hospitals remains subject to the laws of war, persons attached to such hospitals cannot, in withdrawing, carry away any articles but such as are their private property.

Under the same circumstances an ambulance shall, on the contrary, retain its equipment.

Art. 5. Inhabitants of the country who may bring help to the wounded shall be respected, and shall remain free. The generals of the belligerent powers shall make it their care to inform the inhabitants of the appeal addressed to their humanity, and of the neutrality which will be the consequence of it.

Any wounded man entertained and taken care of in a house shall be considered as a protection thereto. Any inhabitant who shall have entertained wounded men in his house shall be exempted from the quartering of troops, as well as from a part of the contributions of war which may be imposed.

Art. 6. Wounded or sick soldiers shall be entertained and taken care of, to whatever nation they belong.

Commanders-in-chief shall have the power to deliver immediately to the outposts of the enemy soldiers who have been wounded in an engagement, when circumstances permit this to be done, and with the consent of both parties.

Those who are recognized, after their wounds are healed, as incapable of serving, shall be sent back to their country.

The others may also be sent back, on condition of not again bearing arms during the continuance of the war.

Evacuations, together with the persons under whose directions they take place, shall be protected by an absolute neutrality.

Art. 7. A distinctive and uniform flag shall be adopted for hospitals, ambulances, and evacuations. It must, on every occasion, be accompanied by the national flag. An arm-badge (brassard) shall also be allowed for individuals neutralized, but the delivery thereof shall be left to military authority.

The flag and the arm-badge shall bear a red cross on a white ground.

Art. 8. The details of execution of the present convention shall be regulated by the commanders-in-chief of belligerent armies, according to the instructions of their respective governments, and in conformity with the general principles laid down in this convention.

ADDITIONAL ARTICLES.

Article 1. The persons designated in Article 2 of the Convention shall, after the occupation by the enemy, continue to fulfil their duties, according to their wants, to the sick and wounded in the ambulance or the hospital which they serve. When they request to withdraw, the commander of the occupying troops shall fix the time of departure, which he shall only be allowed to delay for a short time in case of military necessity.

Art. 2. Arrangements will have to be made by the belligerent powers to insure to the neutralized person fallen into the hands of the army of the enemy the entire enjoyment of his salary.

Art. 3. Under the conditions provided for in Articles 1 and 4 of the Convention, the name "ambulance" applies to field hospitals and other temporary establishments, which follow the troops on the field of battle to receive the sick and wounded.

Art. 4. In conformity with the spirit of Article 5 of the Convention, and to the reservations contained in the protocol of 1864, it is explained that for the appointment of the charges relative to the quartering of troops, and of the contributions of war, account only shall be taken in an equitable manner of the charitable zeal displayed by the inhabitants.

Art. 5. In addition to Article 6 of the Convention, it is stipulated that, with the reservation of officers whose detention might be important to the fate of arms and within the limits fixed by the second paragraph of that article, the wounded fallen into the hands of the enemy shall be sent back to their country, after they are cured, or sooner if possible, on condition, nevertheless, of not again bearing arms during the continuance of the war.

[*Articles concerning the Marine.*]

Art. 6. The boats which, at their own risk and peril, during and after an engagement pick up the shipwrecked or wounded, or which, having picked them up, convey them on board a neutral or hospital ship, shall enjoy, until the accomplishment of their mission, the character of neutrality, as far as the circumstances of the engagement and the position of the ships engaged will permit.

The appreciation of these circumstances is entrusted to the humanity of all the combatants. The wrecked and wounded thus picked up and saved must not serve again during the continuance of the war.

Art. 7. The religious, medical, and hospital staff of any captured vessel are declared neutral, and, on leaving the ship, may remove the articles and surgical instruments which are their private property.

Art. 8. The staff designated in the preceding article must continue to fulfil their functions in the captured ship, assisting in the removal of the wounded made by the victorious party; they will then be at liberty to return to their country, in conformity with the second paragraph of the first additional article.

The stipulations of the second additional article are applicable to the pay and allowance of the staff.

Art. 9. The military hospital ships remain under martial law in all that concerns their stores; they become the property of the captor, but the latter must not divert them from their special appropriation during the continuance of the war.

Art. 10. Any merchantman, to whatever nation she may belong, charged exclusively with removal of sick and wounded, is protected by neutrality, but the mere fact, noted on the ship's books, of the vessel having been visited by an enemy's cruiser, renders the sick and wounded incapable of serving during the continuance of the war. The cruiser shall even have the right of putting on board an officer in order to accompany the convoy, and thus verify the good faith of the operation.

If the merchant ship also carries a cargo, her neutrality will still protect it, provided that such cargo is not of a nature to be confiscated by the belligerents.

The belligerents retain the right to interdict neutralized vessels from all communication, and from any course which they may deem prejudicial to the secrecy of their operations. In urgent cases special conventions may be entered into between commanders-in-chief, in order to neutralize temporarily and in a special manner the vessels intended for the removal of the sick and wounded.

Art. 11. Wounded or sick sailors and soldiers, when embarked, to whatever nation they may belong, shall be protected and taken care of by their captors.

Their return to their own country is subject to the provisions of Article 6 of the Convention, and of the additional Article 5.

Art. 12. The distinctive flag to be used with the national flag, in order to indicate any vessel or boat which may claim the benefits of neutrality, in virtue of the principles of this Convention, is a white flag with a red cross. The belligerents may exercise in this respect any mode of verification which they may deem necessary.

Military hospital ships shall be distinguished by being painted white outside, with green strake.

Art. 13. The hospital ships, which are equipped at the expense of the aid societies, recognized by the governments signing this Convention, and which are furnished with a commission emanating from the sovereign who shall have given express authority for their being fitted out, and with a certificate from the proper naval authority that they have been placed under his control during their fitting out and on their final departure, and that they were then appropriated solely to the purpose of their mission, shall be considered neutral, as well as the whole of their staff. They shall be recognized and protected by the belligerents.

They shall make themselves known by hoisting, together with their national flag, the white flag with a red cross. The distinctive mark of their staff while performing their duties shall be an armlet of the same colors. The outer painting of these hospital ships shall be white, with red strake.

These ships shall bear aid and assistance to the wounded and wrecked belligerents without distinction of nationality.

They must take care not to interfere in any way with the movements of the combatants. During and after the battle they must do their duty at their own risk and peril.

The belligerents shall have the right of controlling and visiting them; they will be at liberty to refuse their assistance, to order them to depart, and to detain them if the exigencies of the case require such a step.

The wounded and wrecked picked up by these ships cannot be reclaimed by either of the combatants, and they will be required not to serve during the continuance of the war.

Art. 14. In naval wars any strong presumption that either belligerent takes advantage of the benefits of neutrality, with any other view than the interest of the sick and wounded, gives to the other belligerent, until proof to the contrary, the right of suspending the Convention, as regards such belligerent.

Should this presumption become a certainty, notice may be given to such belligerent that the Convention is suspended with regard to him during the whole continuance of the war.

Art. 15. The present act shall be drawn up in a single original copy, which shall be deposited in the archives of the Swiss Confederation.

The additional articles have been acceded to by the United States, and signed on behalf of Great Britain, Austria, Baden, Bavaria, Belgium, Denmark, France, Netherlands, North Germany, Sweden and Norway, Switzerland, Turkey, and Würtemberg, but will not acquire full force and effect as an international treaty until the exchange of the ratifications thereof between the several contracting states shall have been effected.

II. The foregoing Convention and additional articles are published by the order of the President, who commands that the original Convention and the first five of the additional articles shall form part of the "Instructions for the Government of Armies of the United States in the Field," as published in General Orders, No. 100, 1863, from this office.

III. By direction of the Secretary of War the provisions of the Geneva Convention incorporated into the "Instructions for the Government of Armies of the United States in the Field" in the preceding paragraph will form part of the examination of captains of the line, Quartermaster's and Subsistence Departments, as prescribed under the head of "Military Law" in the Memorandum from this office dated October 5, 1891.

By command of Major-General Schofield:

Official. J. C. KELTON, *Adjutant-General.*

DRILL OF THE HOSPITAL CORPS.—In the past six years much attention has been given to the drill of the hospital corps. Several systems and manuals of drill have been prepared by different military surgeons, and more than one has been adopted by the medical department of the army, to be in its turn discarded, so that the whole subject may be considered as yet undecided and in a state of transition. The composite of all these efforts of individuals, as well as those of a Board convened by the War Department for the purpose of preparing a manual of drill for adoption in the United States Army, is about to appear in a new manual to be prescribed to the army as its official hospital corps drill. The writer has examined carefully every one of these systems of drill, and has found each to possess merit.

I propose to present some remarks pertinent to one phase of the subject, and that is the effect of drill on separate individual action. In so far as regards those duties of the hospital corps relating to the handling and first aid to wounded, the drill has acted unfavorably.

Since the presentation to the Hospital Corps of our army of its first manual of drill, the writer of this paper, in the discharge of his official duties as Medical Director, has made many formal inspections of the Hospital Corps and its drill, at between thirty and forty different military posts, extending from Pembina to San Diego, Cal. At these inspections a suppositious case has been presented at the drill to a set of "fours," in which a great emergency had occurred, a wounded man bleeding rapidly, or some other case demanding prompt and rapid action, and this view of the case was emphatically presented to the "fours" in words. In nearly every case the action of the "four" has been slow and deliberate, precisely as they had been drilled, while in the meantime the wounded man might have perished from lack of aid. In all these cases the officers under whom the men had been drilled informed me that they had not failed to impress, previously, on the men drilled the necessity of promptness of action in such emergencies, and further expressed surprise at the inappropriate action of their men of which I speak.

Now, it is quite apparent that nothing will account for the display of the want of judgment, and for the improper action in these cases but the *drill*. The men had been "drilled into" a certain routine, and so "drilled" that they were unable to depart therefrom when circumstances required that they should.

This view of the case acquires additional force when we consider what a drill is, and what for.

Drill seems to be the systematic instruction in certain acts which can be effected in different ways, but which should be always done in the same way, and in the one particular manner taught at the drill; or else acts that are performed by a number of persons together, and in harmony, and therefore best performed in a methodical, systematic manner.

Drill in general; what it is for.

Drill does not include the very large number of acts which are seldom best performed in one single way, or by a single person, but whose best manner of performance, in different cases, will vary widely, according to circumstances, and this best manner be selected by the exercise of individual judgment. This distinction clearly appears in early definitions of drill, though not made so prominent in some later definitions.

Wilhelm speaks of drill as in general the "exercises through which soldiers and sailors are passed to qualify them for their duties."

Webster's Dictionary gives the military meaning as "the act or exercise of training soldiers in the military art, as in the manual of arms, in the execution of evolutions and the like." Worcester's definition is, "the instruction of officers and soldiers in the exercise of

the firelock, and in the first principles of field movements."

Where men perform military exercises in masses, such as companies, platoons, or sets of fours, these exercises are best taught by drill and performed in an undeviating manner. Where the exercise, however, is to be performed individually, and demands individual judgment, as in sharp-shooting, or giving the first aid to a wounded soldier, it is best done independently of drill.

There is something very attractive about the drilling of men in a military manner—the giving them orders and watching them move in obedience thereto,—and any drill manual for the Hospital Corps must, of course, treat of the marching movements of the men and their handling of the litter, as well as of the first aid to the wounded, unless, as would be proper, the two subjects are embraced in different handbooks. Hence the danger, and the tendency which really has manifested itself, of making the military movements of the members of the Hospital Corps too important and conspicuous a part of their education, to the neglect of the most important part of their duty when in the field, viz.: the first care of the wounded, the carriage of whom, on a litter, does not constitute the greatest part of such first care, though one necessary portion.

Military movements made too conspicuous by the drill.

A certain amount of drill is necessary to a soldier of the Hospital Corps; but one of the qualifications for a private of the corps has already been stated to be service in the line of the army long enough for the acquirement of knowledge of the drill. Any subsequent drill can only serve to familiarize the man with concerted management of the litter, the ambulance, and the dummy, while in these directions it accustoms and prepares the squad of litter-bearers to act intelligently together.

But the first aid of the wounded is a very important part of the duty of the private of the Hospital Corps, and the drill is only one and not the most effective mode of teaching him any part of this. The regulations have attempted to guard against the promotion to undue importance of drill over teaching by their very terms. They say that the company-bearers, and men of the Hospital Corps, shall be "instructed" in "the duties of litter-bearers and the methods of rendering first aid to the sick and wounded." And "the instruction," in further terms, is directed to consist of "lectures and demonstrations in the methods of rendering first aid to the sick and wounded, and of drills in the ambulance service, and as litter-bearers, in accordance with the prescribed manual."

Importance of "first aid to sick and wounded," in the system in which Hospital Corps men should be instructed.

As, however, it became manifest that undue prominence was given to drill as compared with other instruction, the Surgeon-General last year issued the following judicious directions:

"As the object of this drill is the instruction of members of the Hospital Corps and company-bearers in the methods of moving, carrying, and otherwise handling the disabled, it should be conducted personally by a medical officer, who will combine with it instruction for rendering first aid in emergencies. While the military element in litter drill is desirable—and indeed essential—a knowledge of methods in rendering first aid is indispensable to practical efficiency in the corps. For this reason the hour devoted to drill should be largely given to object-lessons and demonstrations, especially in the methods to be used for the arrest of hemorrhage, the application of temporary dressings to fractures and wounds, methods of artificial respiration, etc., a dummy being used for this purpose whenever practicable.

"The object of instruction to company-bearers is 'to insure the constant presence, in each company, of a number of men who can, in emergencies, render temporary aid to the sick or wounded of their organizations;' and 'their duty during an engagement' . . . is to 'carry them to the rear until relieved by the members of the Hospital Corps.' They should, therefore, be instructed primarily and by object-lessons, as far as practicable, in first aid, litter-drill being subordinate to this important knowledge."

I have thus endeavored to impress upon the reader the view that, while instruction of the litter-bearer and private of the Hospital Corps, in all the subjects named in the regulations is of the utmost importance, yet the drill in military movements is of less importance than, and should be subordinated to, instruction in succor and first aid to the sick and wounded. *Joseph R. Smith.*

FLUORESCEÏN (Resorcin-phthalein Anhydride). This is one of the numerous coal-tar products. It results from the union of resorcin and phthalein when heated to the melting-point in equal parts by weight. The chemical formula is $(C_6H_3)(OH)_2(CO)_2$. It is a yellowish-red crystalline powder, sparingly soluble in water, more soluble in an alkaline solution, showing a beautiful green fluorescence.

It possesses the property of adhering to the tissue beneath the epithelium of mucous membranes and imparting to it a deep green color, while the epithelial covering is in no way affected. Advantage was taken of this by Dr. Straub, a Netherlands army surgeon, to detect lesions of the eye, who found that the most minute destruction of tissue could be clearly defined. The value of this discovery was made known to the profession by Dr. Thomalla, of Friedland, *Centralblatt f. prak. Augenheilk.*, November, 1889. Dr. R. L. Randolph (*Johns Hopkins Bulletin*, April, 1890) reports his experience with it, for this purpose, with favorable results. A solution of ten grains of fluoresceïn, with fifteen grains of bicarbonate of sodium to the ounce of distilled water is prepared, and a few drops placed in the eye on the cornea. Where the membrane is intact no trace of the coloring matter is left, but where the slightest abrasion exists, the parts are impregnated with the stain and the injury distinctly mapped out. After washing the eye with water, whenever a discoloration exists, some lesion is present, and if any foreign body is present its size and extent is quite evident by a green ring formed around the substance. In ulcers of the cornea the same positive results were always obtained by Dr. Randolph. In simple superficial keratitis the color was made less distinct; in parenchymatous keratitis the results were negative. Dr. Thomalla had found that in acute glaucoma the disturbances of the cornea that attend this affection could be detected and the diagnosis confirmed. Dr. Randolph did not succeed in detecting any changes in two cases in which he used the solution.

The depth of the coloration depends upon the extent of the wound. When superficial, only the exposed tissue is affected, but when the destruction of tissue is deeper the coloring fluid is absorbed by the open vessels, and the staining radiates from the wound. In ulcers and minute abscesses the coloring matter is restricted by the walls of the diseased spots. Cicatricial tissue is not affected, and the opaque spots of old lesions may be distinguished from those of recent origin. Some experience is required to detect the slighter abrasions and estimate the various degrees of discoloration. Other observers have obtained the same satisfactory action without any unfavorable results. The application is perfectly unirritating, and may be used when the most acute inflammation exists. A potash solution may be prepared, and is preferred by some to that of soda. *Beaumont Small.*

FOOD AND DRUG INSPECTION. MODERN LEGISLATION RELATIVE TO FOOD AND DRUG INSPECTION.—In the third volume of the REFERENCE HANDBOOK articles were published on the subject of "Adulteration of Food and Drink," and upon "Legislation respecting Food and Drug Adulteration," which fully set forth the inspection upon those topics up to the date of their publication. The present article will, therefore, be chiefly devoted to the subject of the efficiency of such legislation to provide protection against this species of crime, and to the amount of work accomplished under such laws.

Popular knowledge upon the subject of food adulteration is undoubtedly derived to a great extent from the occasional publications of the daily press, which are

too often of a very sensational character, exaggerating not only the extent of adulteration, but also the comparative ratio of harmful adulteration to that which is merely fraudulent in its character. Fortunately these publications are not so common as they were a few years ago. It is but ten years since a public document, in commenting upon this subject, stated that "fraudulent adulteration is but little more common than injurious adulteration." An examination of the food supply of almost any community at the present day would undoubtedly show the incorrectness of this statement.

England.—The following statement from the Twenty-first Annual Report of the Local Government Board for 1891–92 shows the advantages of food and drug inspection in England and Wales since the beginning of operations under the Food and Drug Acts in 1876:

The total number of analyses of food and drug samples made in 1891 was 29,028, or about 1,600 more than in the previous year. The increase has been quite constant during the past twelve years. In the five years 1877–81 the average number of samples examined was 16,688, or one to every 1,520 of the population; in 1882–86 it rose to 21,772, or one in 1,237; in 1887–91 it was 26,846, or one in 1,060; while in 1891 it was 29,028, or one in 999. In London one sample was examined for every 580 persons, and in the provinces one for every 1,140. But in some quite populous districts the provisions of the Acts were not carried out, and in commenting upon the neglect of the authorities in these districts the Board says: "It is surprising that the local authorities in these and many other cases are content to leave the inhabitants without that protection against fraud by the sale of adulterated food, which the exercise of the statutory powers conferred on the authority would be likely to insure."

The following table shows that a decided improvement has taken place in England since the Food and Drug Acts went into operation:

RESULTS OF EXAMINATIONS MADE IN ENGLAND AND WALES BY THE PUBLIC ANALYSTS, UNDER THE FOOD AND DRUG ACTS, 1877–91.

Character of samples.	Number of samples examined in 1891.		Percentages of adulteration.				
					Five-year periods.		
	Total.	Adulterated.	1891.	1890.	1877–81.	1882–86.	1887–91.
Milk	12,151	1,633	13.4	12.8	21.1	16.7	13.2
Bread	799	8	1.0	0.7	6.6	3.4	1.4
Flour	427	1	0.2	0.6	2.5	0.5	3.0
Butter	3,558	551	15.5	11.5	13.9	17.9	13.4
Coffee	1,684	287	17.0	15.3	18.6	17.8	14.8
Sugar	171	8	4.7	13.8	1.2	.....	4.6
Mustard	689	60	8.7	7.1	17.4	14.5	9.2
Confectionery, etc	403	11	2.7	....	2.8	2.7	3.2
Pepper	1,452	41	2.8	5.6	.....	.....	7.5
Tea	412	....	....	....	.....	.....	0.1
Lard	1,107	26	2.3	4.0	.....	.....	7.9
Wine	51	2	3.9	7.7	14.2	4.4	4.7
Beer	268	11	4.1	2.0	5.4	3.0	2.6
Spirits	3,139	600	19.1	18.1	34.9	22.3	18.5
Drugs	740	121	16.4	14.5	22.0	13.6	13.1
Other articles	1,967	180	9.2	5.6	....	....	7.5
Total	29,028	3,540	12.2	11.2	16.2	13.9	11.7

The foregoing table shows a slight retrogression since 1890. But the three five-year periods show a decided improvement, comparing the earlier with the latter.

The comments of the Local Government Board show that the practice of milk adulteration in the cities of England differs but little from that which prevails in large cities of the United States.

The whole number of samples of milk examined in England in 1891 was 12,151, or about two-fifths of all samples of food examined. Of these 1,633, or 13.4 per cent., proved to be adulterated. As might be expected, the samples from cities were much more adulterated than those from the country districts.

In London the percentage of adulterated samples was 21.5, ranging from 0 in St. James, Westminster, and other districts, up to 47.2 per cent. in Lambeth. In other large cities the results of analysis were more favorable, Manchester having but 4.7 per cent., Leeds 4.2, and Salford 1.3; while Liverpool and Birmingham had, respectively, 17.6 and 17.9 per cent.

Part of this difference undoubtedly may be accounted for by diversities in the practice of the inspectors, for while one takes samples only from those retailers whom he suspects of adulteration, another may buy from all dealers in his district. Some, again, are not sufficiently careful to conceal their official character, and it is evident that an inspector who makes purchases himself, in a place where he is known, is much less likely to be supplied with adulterated milk than one who employs a deputy for the purpose.

Out of the 1,633 samples of milk reported as adulterated, 989 were the subjects of legal proceedings. In 866, fines were imposed amounting to £1,443 (about $7,025).

The percentage of samples of adulterated butter increased from 11.5 per cent. in 1890 to 15.5 in 1891, notwithstanding the existence of stringent laws similar to those in force in the United States.

The number of samples found to be adulterated was 551, and 394 penalties were inflicted, amounting to £630.

Of the 1,684 samples of coffee examined, 287, or 17 per cent., were adulterated, and of these the Board says: "The proportion of genuine coffee was in some instances as little as 30.15, or even 5 per cent. It is possible that, as is often asserted in defence of the practice of selling these mixtures, some persons consider that the flavor of chicory improves the coffee. But as no special skill is required to mix the two articles, it would certainly be more economical for the consumer to buy his chicory separately, at its market value of about twopence a pound, rather than to pay about six times that price for it under the name of coffee. The penalties were generally very low, occasionally as little as five shillings."

The use of poisonous pigments in England, as elsewhere, appears to have nearly or quite disappeared under the protective action of the Food and Drug Laws. The principal adulterant found in lard was cotton-seed oil.

About one-fifth of the samples of spirits examined were found diluted, but in very few instances had anything but water been added.

The amount of drug adulteration found was 16.4 per cent. (121 samples out of of 740), of which the Board says: "Considering that the difference between pure and adulterated medicine may conceivably be a matter of life or death to the patient, it is desirable that still more should be done in this direction."

The articles not specified were oatmeal, vinegar, arrow-root, cheese, cocoa, olive-oil, yeast, canned peas, ginger, etc.

Of 412 samples of tea examined, not one was found adulterated.

The report of the Public Analyst of Kent for 1891 is worthy of notice. He says: "The steadygoing practice of diluting milk and spirits by the addition of water probably will always continue more or less, as the law is put in force; but there are other often most ingenious forms of adulterations, introduced as special branches of industry, which arise anew, for a time flourish, and then gradually die out. This was the case with the addition of cotton-seed oil to lard, and the substitution of margarine for butter, of powdered olive-stones for pepper, the fact being that the practice of adulteration has become a fine art, scientific knowledge and technical skill being applied to the subject as perseveringly, and, indeed, as successfully, as the same things are being employed in other more legitimate connections. 'Works chemists' of the highest skill in each special department of the food trade are continually engaged in the endeavor to produce articles that can be sold at a greater profit than the things they resemble, at perhaps a less price. This gives rise to a perpetual conflict between the falsifier on the one hand, and the public analyst on the other, in which the latter, in some respects is placed at a great disadvantage, for whereas every move

and method on his part that is devised to advance the art of detection of adulteration is done openly in the face of the scientific world, the arts of the adulterator are practised and perfected in secret. In point of fact, the most refined and successful processes that have been introduced for the falsification of food have been devised in view of, and with the express design to elude, those means of detection which from time to time are discussed and published in the "Transactions" of our scientific societies. This will explain how it comes about that, from time to time, new methods of adulteration are sprung upon us, and for a while a new fashion in adulteration sets in, until in turn, by the invention of new processes or by the perfecting of old ones, detection of the new-fashioned mode of adulteration is made possible, and a check thereby put upon the evil practice, which in course of time dying out is followed by other perhaps more cunning devices, and so it goes on, year by year, an everlasting see-saw of attack and defence, from all of which it naturally follows that the pursuit of the public analyst, day by day, becomes more onerous and more exacting."

Paris.—The work of examining the food supply of Paris has been conducted at the Municipal Laboratory, on the north bank of the Seine, during the past twelve years. When the writer visited this establishment in 1891 it presented the appearance of a busy workshop in which is employed a large force of skilled chemists. Professor C. Girard is the chief chemist in charge. Two printed reports of this laboratory have been published, dated 1882 and 1885.

By decision of the Municipal Council gratuitous qualitative analyses are made at this laboratory of such articles of food and drink as are deposited at the laboratory for this purpose. The greater part of the articles examined is collected by inspectors authorized to visit shops and markets where food is sold, for the purpose of making collection of such samples. These inspectors also have authority to destroy unsound food. Their collections are generally made from such kinds of food preparations as are suspected of adulteration or are especially liable to this species of fraud. Hence the monthly bulletins issued from the laboratory do not represent the actual condition of the markets, since many articles of food are not liable to adulteration. The number of articles examined in each year amounts at present to more than 20,000 annually. The scope of the analyses embraces several articles in common use besides food, such as children's toys, wall-paper, cooking utensils, preparations used in embalming, coloring matter, cosmetics, and illuminating oils.

The following condensed statement, compiled from the monthly bulletins for the eleven months ending May 31, 1892, will give a fair illustration of the work accomplished in Paris during that period: Number of visits made to markets and shops, 45,394; amount of meat and fish destroyed, 327,025 kilogrammes, or about 360 tons; amount of vegetables and fruits destroyed, about 1,000 tons; amount of mushrooms, tomatoes, etc., destroyed, about 295 tons; amount of butter and cheese destroyed, about 1½ ton; complaints before justice, 200; number of articles submitted to examination, 19,928; of these 7,015 were samples of wine, more than half of which were found to be adulterated by the addition of water, alcohol, sugar, coloring matters, plaster, salicylic acid, or other articles.

The other articles were chiefly the following: 97 samples of vinegar, of which 36 were adulterated; 688 samples of beer, of which only 1 was adulterated; 109 samples of cider, of which 45 were adulterated, either by dilution, coloring matter, or other means; 410 of distilled liquors, of which 240, or 585 per cent., were adulterated in various modes; 639 samples of drinking-water, of which 173 were unfit for use, either in consequence of pollution by organic or mineral ingredients; 4,315 samples of milk, of which only 279, or but little more than six per cent., were found adulterated by skimming or watering; of 156 samples of syrup, 74, or nearly half, were adulterated with glucose or coloring matters; of 985 samples of butter, 241, or 24 per cent., were adulterated by the addition or substitution of other fats; of 260 samples of salad oil, 111, or 42 per cent., were adulterated; of 372 samples of flour, only 11, or 3 per cent., were adulterated; of 134 samples of bread and cake, 44 were condemned on account of being mouldy or badly baked; of 253 samples of sugar and confectionery, 26 were adulterated; of 24 samples of honey and preserves, 10 were adulterated with coloring matters; of 262 samples of chocolate and cocoa, 99 were adulterated with foreign fats and other substances; of 268 samples of coffee, chicory, and tea, 42 were adulterated; of 1,344 samples of spices, 83, or 6 per cent., only were adulterated; of 185 samples of preserved meats, 63 were adulterated; three children's toys, out of 13 examined, were condemned on account of dangerous coloring matter; of 346 cooking utensils, 110, or nearly one-third, contained lead; of 737 samples of illuminating oil, 88 were below the standard. Only 2 samples of drugs were examined and both were found good.

The chief difference in the experience of the Paris inspection and that of Massachusetts consists in the low ratio of adulteration in milk and in spices in Paris. The former is probably partially due to the existence of a lower standard of milk solids in Paris.

Hamburg.—The International Review of Food Adulterations (published at Amsterdam) reports that at Hamburg, in 1890, of 758 samples of butter examined, 282 were adulterated; 25 samples of milk out of 44, and 17 samples of coffee out of 27 were adulterated. Of the cases of butter adulteration 185 were convicted, 9 were acquitted, and the remainder were under consideration. The chemist characterizes the extent of butter falsification as "deplorable."

Liège.—M. de Molinari, Director of the Laboratory of Liège, Belgium, reports 2 samples of coffee adulterated from thirty to fifty per cent.; 7 samples of milk, 8 of butter, 2 of pepper, 4 of mustard, 2 of fruit syrup, 4 of liquors, and 4 of beer were adulterated. Fines were imposed from 5 to 100 francs each.

Constantinople.—M. P. Apéry, Government Chemist at Constantinople, reports, as the result of examinations from March to December, 1891: 4 samples of meat, damaged; 4 of fat, rancid and old; 8 of butter, mixed with foreign fats; 25 of coffee, mixed with roasted cereals; 1 of olive-oil, old and rancid; 13 of milk, watered; 2 of cheese, 1 of drinking-water, polluted and unfit to drink; 1 of vinegar, containing wood spirit; 2 of flour, mixed with bean flour; 1 each of cream of tartar, saffron, and glycerine, adulterated.

Strasburg.—Dr. Amthor, of Strasburg, reports for the year ending April 1, 1891: Of 27 samples of *suspected* milk, 16 were adulterated; of 32 samples of butter, 8 were spurious; of 26 samples of confectionery and chocolate, 8 were adulterated; of 37 samples of canned food, 19 were adulterated, chiefly with copper. In two of these fines amounting to thirty marks were imposed ($7.50). Of 12 samples of vinegar, all were good. No trichinæ were found in the hams. Of 59 fruit syrups, 18 were adulterated, the adulterants being chiefly coloring matter and glucose; some were entirely artificial. Four fines of 145 marks were imposed ($35). Of 92 samples of spices, 11 were adulterated; all samples of honey and of cheese were good; of 9 samples of olive-oil, one was adulterated, and a fine of 10 marks imposed. Of 58 samples of lard, 18 were adulterated with cotton-seed oil and stearine. Seven fines were imposed, amounting to 263 marks. Of 356 samples of wine, 32 were bad and 14 suspicious; the adulterants were mainly water and alcohol. Two fines were imposed, amounting to 2,600 marks! also six months in jail! Of 98 samples of sausages, 18 were adulterated with flour, for which 6 fines were imposed of 160 marks in all. For having the fittings of beer-pumps in bad condition, 13 fines were imposed of 50 marks. All samples of petroleum were found to be of good standard quality. Cooking utensils, examined under a law of 1887, were found to contain lead and zinc. Other articles examined were coloring matters injurious to health, cosmetics containing lead, tubes for conduct-

ing beer and wine, nipples of nursing-bottles, etc. The total number of samples examined was 1,322.

Austria.—The Director of the Laboratory at Vienna, Dr. M. Mansfeld, reports, for the year ending August 24, 1891, out of 447 specimens that 160, or 35 per cent., were adulterated. The samples examined were bread, milk, butter, liquors, tallow, cocoa-butter, vinegar, preserves, coloring matters, fruit-juice, spices, compressed yeast, honey, coffee, flour, and olive-oil.

Dr. M. T. Lecco, Official Government Chemist of Belgrade, reports upon the following analyses of food and other articles for the year ending October, 1892:

	Number of samples examined.	Adulterated or of bad quality.
Bread	21	1
Milk	571	39
Cream	42	20
Butter	8	1
Lard	23	1
Water	23	2
Salad oil	68	28
Sausages	15	4
Cake	4	1
Wine	138	10
Brandy	77	9
Vinegar	28	16
Ground coffee	5	5
Whole coffee	7	3
Pepper (ground)	85	29
Pepper (whole)	1	..
Cinnamon	47	28
Sugar	28	1
Crockery ware	8	6
Metallic faucets	4	2
Cosmetics	18	9
Miscellaneous	135	16

The chemist states that the greater part of these articles were falsified by the addition of substances which cheapened their value.

The articles which were harmful to health were adulterated wines, cake colored with chrome yellow, brandy containing an excess of amylic alcohol, cosmetics containing corrosive sublimate and compounds of lead; metal faucets containing twenty-five to thirty-three per cent. of lead.

Amsterdam.—Drs. Coster and Mazure, Government Inspectors at Amsterdam, reported, in 1890, that out of 31 specimens of dried apples examined, 24 contained zinc in variable proportions; dried pears also were found to contain the same; the supposed cause being the drying of these fruits in galvanized (zinc-coated) vessels. In mineral waters they found minute traces of metals, chiefly copper. Out of 804 samples, 577 had no metallic poison.

They examined 1,781 specimens of pork, and none of them contained trichinæ. Of this number 1,090 were from America.

Switzerland.—In Switzerland the work of examining articles of food and drink is well organized by the appointment of a competent chemist in each Canton, whose duties embrace the analysis of all articles in domestic use wherein a chemical analysis may be required.

In the summer of 1891, the writer visited the laboratories of the Cantons of Berne and Lucerne, and found them well equipped and intelligently conducted. The Swiss method of work would form a good model for conducting a laboratory for food analysis in any American city.

Dr. Ambühl, Canton Chemist of St. Gall, examined, in 1890, 1,269 samples of all sorts. Out of 96 samples of milk, 9 were diluted with water from 10 to 35 per cent. In his examinations of samples taken direct from the cow, he found one which contained only 0.45 per cent. of fat instead of 3 or 3.5, and 8.9 of total solids in place of 12.5, or 13 per cent., and says of this sample: "If I had not known that this milk was drawn directly from the cow, as such, I should have decided that it had been both skimmed and watered. Such milk should not be considered as an article of sale, but as a *pathological secretion.*"

In commenting upon the use of poisonous salts of copper as a coloring matter for preserved peas and other vegetables, he says, "Food should not be made to assume a good appearance to the injury of health."

The Canton Chemist of Geneva, in his quarterly report for the last three months of 1891, reports upon the analyses of 274 samples, 215 of which were of wine—165 red and 50 white; 49 were plastered and 147 not plastered. They were further classified as 87 good, 108 medium, and 20 inferior; 20 were reported as injurious to health. Of 10 samples of butter, 7 were good and 3 adulterated; of 14 samples of water, 7 were potable and 7 unfit for use; of 4 samples of milk, 2 were pure and 2 adulterated; of 13 samples of sausage-meat, 10 were good and 3 bad; of 6 samples of spices, all were pure.

Dr. Schaffer, Canton Chemist of Berne, Switzerland, reported upon the following articles in 1890 and 1891, from which it appears that the scope of the Canton chemist's authority extends to nearly all articles in domestic use as well as to food and drugs.

Articles examined.	Number examined.		Number found adulterated.	
	1890.	1891.	1890.	1891.
Ammoniac	....	2	....	....
Apples, dried	2	....	1	....
Axle-oil	....	9	....	....
Azurin	2	2	....	....
Beer	8	3	2	....
Beer faucets	....	1	....	....
Brandy and spirits	26	16	10	2
Bread and cake	8	3	2	....
Butter	7	9	3	2
Cloth and fabrics	....	4	....	1
Cloves	2	....	....	....
Coal	7	....	1	....
Cocoa	6	12	5	5
Coffee and coffee substitutes	7	15	2	2
Coloring matters	25	6	17	....
Confectionery	90	....	61	....
Cooking utensils	2	....	....	....
Cordials	7	14	2	8
Cotton yarn	....	2	....	....
Fertilizers	62	52	3	3
Fireworks	4	....	4	....
Fodder (for cattle)	16	28	1	1
Fruit	12	16	....	....
Hat linings	5	....	4	....
Maize	3	....	....	....
Meal	6	7	1	2
Milk	193	260	61	99
Paper	3	2	....	1
Peat	....	1	....	....
Pepper	37	33	16	17
Petroleum	4	2	....	....
Rum	13	32	6	11
Saffron	52	38	29	20
Sal ammoniac	....	2	....	....
Sausages	3	3	1	1
Soap	3	6	....	....
Soda	....	1	....	....
Stomach bitters	....	4	....	....
Sugar	2	7	....	....
Sulphate of copper	6	4	....	....
Sulphosteatite	1	1	....	....
Syrup	3	....	1	....
Tallow	....	3	....	....
Tea	11	3	....	....
Vaseline	3	4	....	....
Water, including mineral waters	123	110	24	28
Wine	353	388	78	74
Wool	3	....	3	....

In addition to the foregoing the chemist reports upon several proprietary articles, such as Putzwasser for cleaning brass; hair-dye, containing nitrate of silver; salve for burns; mixture for erasing writing; powder for removing acid taste from wine (carbonate of lime), and antidotes for erysipelas.

Massachusetts.—The following summary presents in a condensed form some of the results of the work of food and drug inspection in Massachusetts by the State Board of Health during the past nine years of its work in this direction :

Summary.	Years.									Total.
	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	
Number of samples of food examined	695	1,962	3,771	3,438	4,870	4,904	4,854	5,585	4,870	34,949
Number of samples found to be pure	363	779	2,180	2,186	3,163	3,385	3,213	3,771	3,206	22,246
Number of samples found to be adulterated, or not conforming to the statutes	332	1,183	1,591	1,252	1,707	1,519	1,641	1,814	1,664	12,703
Percentage of adulteration	47.8	60.3	40.3	36.4	35.1	30.9	33.8	32.5	34.2	36.3
Number of samples of milk examined (included above)	218	1,123	2,219	2,085	3,081	2,825	3,219	3,256	2,726	20,732
Number of samples above standard	35	347	1,297	1,323	1,900	1,705	1,971	1,858	1,629	12,065
Number of samples below standard	183	776	922	762	1,181	1,120	1,248	1,378	1,097	8,667
Percentage of adulteration	83.9	69.1	41.7	36.5	38.3	39.6	38.7	42.6	40.2	41.8
Number of samples of drugs examined	603	682	1,007	888	550	862	600	400	424	6,016
Number of samples of good quality	357	431	571	463	400	634	503	325	352	4,036
Number of samples adulterated, as defined by the statutes	246	251	436	425	150	228	97	75	72	1,980
Percentage of adulteration	40.8	36.8	43.3	47.8	27.3	26.4	16.2	18.7	17.0	32.9
Total examinations of food and drugs	1,298	2,644	4,778	4,326	5,420	5,766	5,454	5,985	5,294	40,965
Total examinations of good quality	720	1,210	2,751	2,649	3,563	4,019	3,716	4,096	3,558	26,282
Total examinations not conforming to the statutes	578	1,434	2,027	1,677	1,857	1,747	1,738	1,889	1,736	14,683
Percentage of adulteration	44.5	54.2	42.4	38.7	34.3	30.3	31.9	31.5	32.8	35.8
Expense of collection, examination, and prosecution	$2,931 56	$5,529 60	$8,557 43	$8,025 34	$8,803 62	$8,915 41	$10,356 28	$10,013 04	$10,019 41	$73,151 69
Expense of collection, and examination per sample	2 26	2 09	1 79	1 85	1 62	1 54	1 89	1 67	1 89	1 79

As is customary under the operation of all new laws of similar character, the first few months of work are usually devoted to an examination of the different sorts of food, in order to determine the extent and the character of adulteration. This preliminary examination established the fact that many staple products are not subject to adulteration, except in rare and exceptional instances. This applies, so far as Massachusetts is concerned, to sugar, flour, and the various other cereal products, so that it has not been deemed necessary to give much attention to these articles of food. Hence the figures in the foregoing table should not be understood as representing the actual amount of adulteration existing in the general food-supply, nor even in articles liable to adulteration, since special pains are taken at times to obtain only such articles as are known to be adulterated. Experience often shows an inspector where to find adulterated articles of food. The difference in the percentages of the first two years (1883 and 1884) and the last two (1890 and 1891) in the foregoing table may be taken as representing quite fairly the improvement, not in the general food-supply under the present inspection, but in those articles which are found to be liable to adulteration. Upon this point the Board published the following general statement in its Annual Report of 1884 :

"There can be no question as to the beneficial results of the law, as executed by the officers of the Board, in improving the quality of the food and drug supply of the State, especially in regard to milk and butter—in the former case as relates to the quality of the supply, and in the latter as relating to the proper branding and marking of spurious goods. The extensive correspondence of the Health Department with wholesale houses outside of Massachusetts also confirms their appreciation of the value of the work done in this State, and also the necessity of furnishing articles of undoubted purity for this market. This is especially true of all classes of drugs sold at wholesale by parties outside the State.

"The actual economic results obtained by the enforcement of the statutes relative to food and drug inspection cannot be stated exactly. The law is comprehensive and its provisions cover a great variety of articles. Its restraining influence extends outside of Massachusetts to manufacturers sending goods to this market. Such parties appreciate the value of the work done in this State, and also the necessity of furnishing articles of undoubted purity for this market. It is specially provided by the statute that at least three-fifths of the amount appropriated shall be expended in the enforcement of the laws relating to the adulteration of milk and its products. This provision has been carefully observed."

It was found convenient, after a year's work, to adopt a code of regulations for the government of its analysts and inspectors in the performance of their duties under the Food and Drug Acts. The following is a copy of these regulations. It is not thought necessary to repeat the laws in force in Massachusetts here, since the substance of them has been presented in the third volume of the REFERENCE HANDBOOK :

Rules and Regulations of the State Board of Health of Massachusetts Relative to the Inspection and Analysis of Food and Drugs.—1. The State Board of Health shall appoint analysts and inspectors, as provided in section 5 of chapter 263, Acts of 1882.

2. It shall be the duty of the inspectors to procure samples of drugs and articles of food at such times and places as the secretary shall direct, in the manner provided in section 6 of chapter 263 of the Acts of 1882, and in section 3 of chapter 289 of the Acts of 1884, and in all acts amendatory of said provisions.

3. Under the direction of the secretary, the inspectors shall, for the identification of samples, affix a number to each sample of food or drugs obtained by them, in such manner as may be prescribed. Under no circumstances shall an inspector convey any information to an analyst as to the source from which any sample was obtained.

4. The inspectors shall keep records of each sample, each record to include the following items : (*a*) The inspector's number ; (*b*) the date of purchase or receipt of sample ; (*c*) the character of the sample ; (*d*) the name of the vendor ; (*e*) the name of the city or town, and street and number where the sample is obtained, and in the case of a licensed milk pedler, the number of his license ; (*f*) as far as possible the names of manufacturers, producers, or wholesalers, with marks, brands, or labels stamped or printed upon goods.

5. It shall be the duty of the analysts so appointed to determine, under the direction of the secretary, by proper examination and analysis, whether articles of food and

drugs, manufactured for sale, offered for sale, or sold within this Commonwealth, are adulterated within the meaning of chapter 263 of the Acts and Resolves passed by the General Court of Massachusetts in 1882, and all acts amendatory thereof, adulteration being defined as follows, viz. .

In the case of drugs, (1) If sold under or by a name recognized in the United States Pharmacopœia, it differs from the standard of strength, quality, or purity laid down therein, unless the order calls for an article inferior to such standard, or unless such difference is made known or so appears to the purchaser at the time of such sale. (2) If when sold under or by a name not recognized in the United States Pharmacopœia, but which is found in some other pharmacopœia or standard work on Materia Medica, it differs materially from the standard of strength, quality, or purity laid down in such work. (3) If its strength or purity falls below the professed standard under which it is sold.

In case of food: (1) If any substance or substances have been mixed with it, so as to reduce or lower or injuriously affect its quality or strength. (2) If any inferior or cheaper substance or substances have been substituted wholly or in part for it. (3) If any valuable constituent has been wholly or in part abstracted from it. (4) If it is an imitation of or is sold under the name of another article. (5) If it consists wholly or in part of a diseased, decomposed, putrid, or rotten animal or vegetable substance, whether manufactured or not, or in the case of milk, if it is the produce of a diseased animal. (6) If it is colored, coated, polished, or powdered, whereby damage is concealed, or if it is made to appear of better or of greater value than it really is. (7) If it contains any added poisonous ingredient, or any ingredient which may render it injurious to the health of the person consuming it.

6. It shall also be the duty of the analysts to receive such specimens of food and drugs for analysis as may be delivered to them by the secretary, or by the inspectors, and to examine the same. To avoid, as far as possible, all suggestion or danger of specimens having been tampered with, each analyst shall keep each specimen in his possession in a suitable and secure place, labelled in such a manner as to prevent any person from having access to the same without the knowledge and presence of the analyst.

Analyses of perishable articles should be made promptly after they are received.

7. An analyst shall give no information, under any circumstances, regarding the result of any analysis, to any person except to the secretary of the Board, prior to any trial in court in reference to such analysis.

The analysts shall carefully avoid any error regarding the inspector's number attached to each sample, and shall report the results of their work in detail to the secretary.

In the case of all articles having a numerical standard provided by statute, the result of the analysis should show their relation to such standard.

8. Before beginning the analysis of any sample, the analyst shall reserve a portion, which shall be sealed, and in the event of finding the portion analyzed to be adulterated, he shall preserve the sealed portion, so that in case of a complaint against any person the last-named portion may, on application, be delivered by the secretary to the defendant or to his attorney.

9. Each analyst shall present to the secretary, on the Monday before the first Thursday of each month, a summary of the analyses made by him during the previous month.

Each analyst shall also present, on or before the first of January of each year, an annual report of the work done for the year ending on the 30th of September preceding.

10. The secretary shall have charge of the reports of analyses, and shall cause cases founded on such reports to be submitted to the courts for prosecution.

In each case of a retailer, and of every dealer not a manufacturer or producer, he may, if the party has not been previously complained of in court, issue a notice or warning of any violation of the law relative to the adulteration of food and drugs, and of the offender's liability to prosecution on a repetition of the sale.

11. Should the result obtained by any analyst be questioned in any given case, another analyst shall repeat the analysis, unless otherwise instructed by the Board, provided a sufficient sum to meet the expense of the analysis be deposited with the secretary by any interested party feeling aggrieved, which sum will not be returned unless the second analysis fails to confirm the first in essential particulars.

12. Any appeal from the decision of an analyst shall be filed with the secretary, who shall report it, and any matter in controversy to the Board, giving his judgment thereon, and the Board shall supervise and control the action of its officers in executing the law.

13. Where standards of strength, quality, or purity are not fixed by the act, the analysts shall present to the secretary such standard as in their judgment should be fixed, and the secretary shall report the same to the Board for its action. The standards set by the British Society of Public Analysts will be followed, as nearly as practicable, until otherwise ordered.

14. Whenever a drug or preparation, not prescribed in a national pharmacopœia or other standard work on Materia Medica, shall be manufactured, offered for sale, or used in this State, the standard of such drug, and the standard and proportion of the ingredients of such preparation, and the range of variability from such standard or standards, shall be ascertained by the analysts, who shall report the same through the secretary to the Board.

15. The analysts shall occupy such time in the performance of their respective duties as a reasonable compliance with the terms of the statute shall require, and shall be present one hour of each day, at such time of the day and at such place as shall be designated by the Board, to meet the convenience of interested parties and the public.

The following classified list embraces most of the examinations of articles of food examined in Massachusetts under the Food and Drug Acts up to October 1, 1891:

Articles examined.	Number examined.	Number adulterated or below standard.	Per cent. of adulteration.
Milk	20,732	8,667	41.8
Condensed milk	20	2	10
Butter	1,195	338	28
Cheese	130	1	0.8
Vinegar	1,146	652	57
Lard	173	74	43
Olive-oil	313	206	66
Spices and Condiments:			
Black pepper	997	331	33
White pepper	582	239	41
Cayenne pepper	146	33	23
Mustard	784	379	47
Cloves	737	154	21
Cassia and cinnamon	789	103	13
Pimento	18	2	11
Ginger	663	73	11
Nutmeg	18	1	6
Mace	179	69	39
Allspice	346	27	8
Curry powder	21	0	0
Coffee	296	97	33
Tea	352	5	1
Cocoa and chocolate	72	9	12.5
Wheat flour	22	0	0
Bread	24	1	4
Cake	3	0	0
Corn-meal, rye-meal, oat-meal, barley-meal	15	0	0
Sago, tapioca, and corn-starch	21	0	0
Buckwheat and cerealin	3	0	0
Cream of tartar	1,877	376	20
Baking powders	156	115*	74
Soda and saleratus	100	2	2
Molasses	1,165	212	18
Syrups	39	13	33
Maple syrup	210	89	42
Sugar	151	7	5
Maple sugar	118	44	37

* Containing alum.

Articles examined.	Number examined.	Number adulterated or below standard.	Per cent. of adulteration.
Glucose	4	2	50
Honey	266	118	44
Confectionery	285	52	18
Milk sugar	1	0	1
Pickles	29	2	7
Lime-juice	7	0	0
Lemon-juice	21	21	100
Horse-radish	20	8	40
Arrow-root	21	4	19
Gelatine	34	3	9
Salt	21	1	5
Canned foods †	203	133	66
Flavoring extracts	39	5	13
Sardines	5	4	80
Jellies and jams	61	12	20
Fig paste	2	1	50
Whiskey, wine, ale, beer, and cider ‡	17	7	41
Miscellaneous §	79	0	0
Drugs	6,016	1,980	33

† A considerable portion of these were French vegetables, which were examined for the presence of copper as a coloring agent.

‡ A large number of examinations of spirits and wines is included in the item of drugs.

§ Under this head are included samples of sage, marjoram, macaroni, vermicelli, poultry dressing, desiccated cocoa-nut, citron, compressed yeast, meat-extracts, etc.

A broad view of the subject of food inspection would include the examination of water as one of the necessaries of life, since it is essential to the preparation of most articles of food, and also a convenient vehicle for the administration of very many of them. It is also absolutely necessary to the healthy growth of the human organism.

The important work of water analysis has been conducted by the Engineering Department of the State Board of Health since 1887, and this work has been extended to the examination of the waters of the ponds, streams, springs, reservoirs, and wells used as public supplies by about one hundred and fifty cities and towns in the State. The total number of such examinations has been about ten thousand five hundred. Full reports upon this subject may be found in the reports of the Board for the years 1887 to 1892.

In addition to the regular routine mode of food and drug inspection in Massachusetts, much has been accomplished by work in special directions during the nine years since the work was begun. These may be enumerated as follows:

Investigations relating to the *quality of milk* as produced by the cow.

Analysis of injurious and other empirical preparations: Hair-dyes, cosmetics, bitters, and tonics; alleged cures for the opium and alcohol habits, etc.

Coloring-matters in food: Milk, butter, oleomargarine, preserved vegetables, salts of tin in molasses, etc.

Food Preservatives. — The quality of *wines and liquors;* report upon *oleomargarine;* the uses of *glucose* in food; the presence of *trichinæ* in pork products; the standard of *vinegar; baking-powders;* the use of the word "*compound.*"

The Standard of Milk.—For the purpose of determining the consistency of the existing standard of milk in Massachusetts, analyses were made in 1884 of the milk of six hundred cows, the samples being collected in different parts of the State, and from different herds of animals, of different ages, and in different seasons of the year. The average total solids of the entire number was found to be very nearly thirteen and one-third per cent. (the legal standard is thirteen per cent.). In later years these figures have been confirmed by further examinations upon the same point.

With reference to breeds of cows the results of analyses were as follows:

The average milk of	11	Jerseys	had	14.02	total solids	and	4.34	fat.
"	"	"	"	92	native cows	"	13.09	"	"	"	3.31	"
"	"	"	"	30	Ayrshires	"	12.97	"	"	"	3.35	"
"	"	"	"	51	Durhams	"	12.73	"	"	"	3.28	"
"	"	"	"	47	Holsteins	"	12.51	"	"	"	3.29	"

Artificial Coloring-matter in Food.—The practice of employing coloring-matters in connection with different articles of food is very common. The following may be named as very common examples:

Certain condiments, such as mustard, ginger and other spices, sugar, confectionery, preserved and canned goods (especially peas and beans), milk, butter, oleomargarine, pickles, cake, syrups, and various sorts of beverages.

The coloring-matters employed in connection with these articles of food may be classified as follows:

1. *Harmless Colors.*—These are usually made from some comparatively harmless organic products, such as annatto, caramel, turmeric, and cochineal.

2. *Injurious Colors.*—These are usually some of the metallic compounds, such as lead, copper, and tin.

It cannot be urged in regard to any of these colors, whether harmless or otherwise, that they have any true value as articles of food, and the demand for their use comes mainly from the trader, and not from the actual consumer, excepting, so far as the latter has been erroneously educated by the former as to color-standards in the matter of food. No good and useful end is attained by their use, so far as the question of nutriment is concerned, and not only may harm ensue, but also even fatal consequences, as in recent cases which occurred in Philadelphia from the use of poisonous compounds of lead.

The true use of artificial-food colors is usually a fraudulent one, and they are consequently employed mainly for the purpose of giving to an inferior article of food a fictitious value, and thus to imitate other articles of a similar character, but of better quality, at least so far as their actual cost is concerned. The difference in actual nutritive value as articles of food may, however, be but little or nothing.

When examinations of milk were made in Massachusetts soon after the enactment of the law of 1882, it was found that the addition of coloring-matter to milk was a very common practice in the cities. From the fact that colored samples of milk were almost invariably found to be adulterated in other ways, it was inferred that artificial coloring was practised for the purpose of concealing fraud, and of giving to milk which had been skimmed and watered the appearance of milk of good standard quality. Hence a vigorous warfare was made against the practice until it disappeared.

The question of the sale of preserved vegetables colored bright green by sulphate of copper came to the attention of the Board, and the safe ground was taken that the introduction of poisonous metallic colors in any amount whatever, should have no legitimate place in the food-supply of the people.

Trichinæ in Pork.—Among the many questions relating to the food-supply in Massachusetts the quality of the pork offered for sale has not been overlooked. Nearly thirteen thousand hogs have been examined under the direction of the Board for the presence of trichinæ. Of this number seven hundred and ninety-one, or 6.3 per cent., were found to be trichinous. Western hogs were found to contain less than Eastern, and of those raised in Massachusetts, those reared in public institutions and upon the refuse of cities were found to suffer the most. An examination was also made of sausages, and only one out of 365 was found to contain trichinæ.

Baking-powders. — No class of substances employed in the preparation of food has been the subject of so much discussion as these; and this is true notwithstanding the fact that, as elements in the matter of food economy, or as nutritive constituents of the necessary food of mankind, they have absolutely no value. Their use in the preparation of food was unknown until the early part of the present century, and for ages the human race has thrived without them. Whenever bread was desired which should possess the properties of porosity and lightness of texture, in early times, some sort of leaven or yeast was employed for the purpose.

The use of baking-powders at the present day is due, undoubtedly, to several causes, prominent among which is a demand for rapid and convenient methods of pre-

paring bread and pastry for cooking; and, also, to the stimulus of trade produced by excessive advertising.

If the statements of rival manufacturers as to the poisonous qualities of all other baking-powders except their own were to be credited, the use of these preparations would soon cease. Such false teaching does harm in misleading the community and creating a distrust. The fallacy lies in the want of discrimination between large and small doses of the ingredients of such powders. For example, common salt and mustard act as poisons in large doses and produce vomiting. In small doses, on the contrary, neither of them is harmful.

The same is also true, to a certain extent, of cream of tartar, alum, and other ingredients of baking-powders. Another property which is common to this class of articles is that of chemical reaction, which takes place when the different ingredients of these powders are brought in contact, and also into solution, in the process of preparation of bread. The resulting salts which follow this union may, and often do, have very different properties from those which were characteristic of the different ingredients of which such powders were originally composed. In one instance hydrate of alumina is the resulting salt; in another, a salt quite similar to Rochelle salts; and in another, the phosphate of alumina. It is therefore a misleading statement to call alum "a corrosive poison," or to assert the same property of cream of tartar or the acid phosphate of lime, since it is not in either of these forms that the baking-powder is ingested by the consumer. For the same reason it is also manifestly wrong to state that cream of tartar or phosphate of lime is healthful. Both of these are drugs, and as such have their proper uses. Their constant daily use is another question.

The singular claim has been made in behalf of the phosphate of lime that it "restores the phosphates lost by the removal of the bran." It may reasonably be asked whether, in the interest of public health, as well as economy, it would not be better to retain this valuable portion of the grain in preference to the attempt to substitute for the natural constituent an artificial representative. Flour made from the whole wheat, or other grains, while it may be less pleasing to the eye and possibly to the taste, has the advantage of producing wholesome bread.

Claims are made by the makers of baking-powders of purity for their own products, and also of impurity for the products of others. In whatever sense these terms may be regarded by the community at large, it should be remembered that the introduction of these articles is of comparatively recent date; that they are compounded of several ingredients; that different manufacturers employ different ingredients to attain the same object or end. No standard has ever been adopted by any government authority, so far as we can learn, for this class of preparations; hence the use of the terms *purity* and *impurity*, as applied to them, must be considered as arbitrary, or at least merely conventional. Experiments have been undertaken with the view of settling the question as to whether the ingredients of certain baking-powders were injurious to health; and, while positively harmful results have in some instances been reached by the ingestion of considerable doses of such ingredients, when taken singly, still, the question of actual injury to health, on the one hand, or of freedom from harm on the other, from the use of baking-powders in food, cannot be regarded as settled.

Mixtures or Compounds.—The work of inspection includes a careful examination of the methods in which food is offered for sale, especially with reference to the question of labelling and the agreement of the label with the actual contents of the package to which it is affixed, since the statute of Massachusetts provides that "mixtures or compounds" are not to be treated as adulterated in the eye of the law, "provided that the same are not injurious to health and are distinctly labelled as mixtures or compounds."

This provision of the law is frequently disregarded, especially in the case of spices; and while the term "compound" is to be found after prolonged search upon the label, it often occupies an obscure position, or is printed in extremely small type, so that the term "*distinctly* labelled" does not apply.

It is not always safe to infer that all parts or packages in a lot of spices or similar articles of food are pure, because a single sample or package proves to be pure. The following case is an illustration: Two packages of powdered cloves were obtained at a grocery. The packages were in unbroken tin boxes of one-quarter pound each, and were purchased at an interval of three weeks; each package was of the same size, and each had exactly the same brand or label. On inquiry of the retailer it was found that both of the packages came from the same lot. It appeared on examination that the first package was considerably adulterated and the second was pure. A notice of this fact was therefore sent as usual to the retailer, who transmitted the notice to the manufacturer, who lives outside the limits of the State; he denied the charge, and hence, as is customary in cases of disputed analysis, samples were sent to a second analyst, who confirmed the statement of the first; and finally, four analyses were made with the same result, neither chemist knowing anything of the source of the samples, nor did either know that a previous analysis had been made.

This circumstance shows that it is not always safe to judge of the character of any group or lot of articles from the examination of a single sample.

Gross Appearances.—It is evident that very little reliance can be placed upon the mere external inspection of articles of food, such as may be made by the employment of the senses of taste, touch, smell, and sight, since the principal object of the falsifier of food preparations is to deceive the senses of the consumer by every possible resource of his art. It is a common experience in this department of work to receive articles of food from various sources, which are believed by the persons presenting them for examination to be adulterated, but which the analyst finds to be pure. This experience is true in the case of many of the articles of food which are liable to adulteration, and also of some articles which are scarcely ever found to be adulterated. The same experience has been met by other authorities who have had charge of similar work ("Report of Commissioner of Internal Revenue, Washington, 1887," p. cxliii.). Among the various articles which have been thus submitted to the Board for examination (under the impression of the person submitting them that they were adulterated) were the following: Flour, sugar, molasses, vinegar, cream of tartar, honey, milk, butter, cheese, lard, salt, and several kinds of spices or condiments.

The reasons for these false notions with reference to the quality of articles of food are mainly the following: 1. A liability to mistake the deterioration of an article, or an inferiority in grade or quality, for an actual falsification or substitution. 2. A lack of familiarity with the true physical characteristics of the article in question.

Notices to Retailers.—It has been the custom of the Board to issue a warning notice to retailers selling articles found to be adulterated, in cases where there was a reasonable probability that the retailer was not aware that such articles were adulterated.

In certain articles of food which have been specially liable to fraud, such as the various sorts of spices, condiments, cream of tartar, etc., adulteration has been greatly diminished, and is in many instances limited to parties whose business is conducted outside of the State, and cannot therefore be easily reached except through the customary notice sent to the retailer who buys of such outside parties.

These notices have proved to be a very efficient mode of diminishing adulteration. It is not the retailer who is seriously affected by the receipt of such a notice, but the wholesale dealer or manufacturer to whom it is speedily forwarded by the retailer, and who finds that he cannot afford to continue a wholesale imposition.

Drugs.—The term "drugs" in the Massachusetts Act of 1882 embraces "all medicines for internal and external use, antiseptics, disinfectants, and cosmetics.

Hence the work of the State Board of Health, in this direction, has not been confined to the remedies defined in the United States Pharmacopœia, but has embraced many other articles, and especially empirical preparations of a more or less harmful character.

Of the drugs found to be of a specially inferior quality during the earlier investigations of the analysts in 1883 and 1884 were the following:

Tincture of opium (U. S. P., 1.20 to 1.60 parts per 100 of morphine), 144 samples out of 197 fell below the required limit of 1.2, and some had as little as .01, .14, .17, or a mere fraction only of the minimum requirement. Citrate of iron and quinine (legal requirement twelve per cent. of quinine), eighty-five per cent. of the samples had less than the required amount, and several had as little as three and 3.5 per cent., or but little more than a quarter of the requirement. Of powdered jalap only one sample out of twelve conformed to the pharmacopœial standard. Of 192 samples of powdered drugs, 39 were found to be adulterated in various forms. Of 19 samples of compound spirits of ether, 2 only contained the required amount of the ethereal oil required by the statutes. Of 23 samples of spirit of nitrous ether, scarcely any had the required amount of ethyl nitrite.

Twenty-two samples or lots of the quinine pills made by different manufacturers were examined. These were examined in two groups, at an interval of several months, during which time the manufacturers had become aware of the work of the Board in this direction. The analysis of the second group showed in nearly every instance an improvement. The following figures indicate the percentages of the required weight of the pills made by nine manufacturers, in the two series of analyses:

First Series.	Second Series.	First Series.	Second Series.
1. 93.5	97.9	6. 84.7	89.5
2. 86.6	97.3	7. 93.8	101.1
3. 93.3	99.6	8. 104.4	100.5
4. 93.8	100.7	9. 97.0	97.1
5. 107.6	76.5		

The foregoing list shows an improvement in each case except two. Of 106 samples of pharmacopœial spirits and wines, only 10, or 9.4 per cent., conformed to the legal requirements.

In proof of the improvement under the action of the statutes, very marked changes for the better have been found to have taken place in many of the foregoing articles.

Among the non-pharmacopœial preparations examined in 1885, were eleven hair-dyes, all of which contained lead in large amounts; also twenty different fraudulent nostrums advertised for the cure of the opium-habit, most of which were solutions of morphine. One of them was the so-called "Keeley gold cure," which was found to contain no gold whatever. In 1887 about fifty proprietary articles, sold as tonics and bitters (some of which were advocated as temperance drinks), were examined chiefly for their alcoholic contents. All were found to contain alcohol in the proportion of six to forty-eight per cent. by volume. One of these, which was advertised as a remedy for inebriety and the opium-habit, was the celebrated "Scotch Oats Essence," containing alcohol and morphine, the latter in varying proportions. This nostrum very soon disappeared after its analysis had been published.

Cosmetics for the complexion, termed face-bleaches, freckle-lotions, skin-tonics, have been examined and found to consist of strong solutions of corrosive sublimate. It was required that these, if sold at all, should be labelled as poisons, and sold under careful restrictions only. Seventeen complaints were made against parties selling these articles in violation of the statutes.

In the following brief table the ratio of adulteration found in articles of food and drugs in England and in Massachusetts, during the period of inspection and enforcement of the laws, is presented:

PERCENTAGE OF ADULTERATION AS GIVEN IN THE REPORTS OF EACH YEAR.

Year.	England and Wales. Ratio of adulteration. Per cent.	Average 5 years. Per cent.	Massachusetts. Ratio of adulteration. Per cent.
1877	19.2		....
1878	17.2		....
1879	14.8	....16.2	....
1880	15.7		....
1881	14.7		....
1882	15.1		....
1883	15.0		44.5
1884	14.4	.....13.9	54.2
1885	13.2		42.4
1886	11.9		38.7
1887	12.8		34.3
1888	10.8		30.3
1889	11.5	.....12.7	31.9
1890	11.2		31.5
1891	12.2		32.8

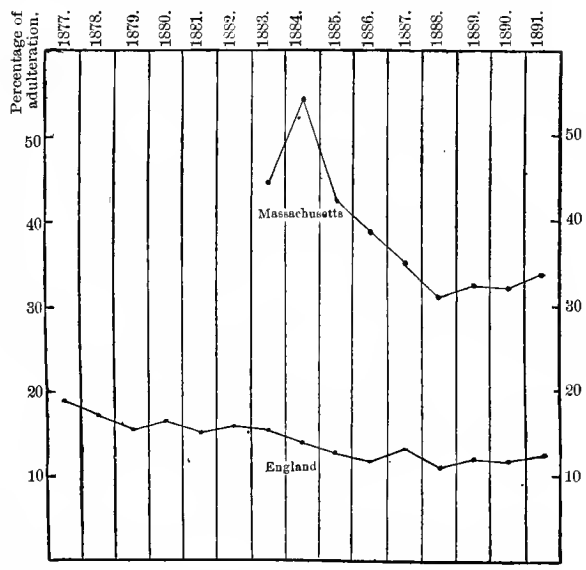


FIG. 160.—Diagram showing the Ratio of Adulteration in England, 1877–91, and in Massachusetts, 1883–91.

As a comment upon the foregoing table and diagram the following observations may be made:

First. The gradual lessening of adulteration under the action of judicious legislation.

Second. The much greater ratio presented in the column headed Massachusetts than in that of England and Wales.

The reason for this great difference may be found, *first*, in the fact that in conformity to the requirements of the statutes in Massachusetts more than half the samples examined were milk. The standard of milk in the State is unusually high as compared with that of other countries (thirteen per cent. of solids, except in May and June, when it is twelve per cent.). Hence it is the custom to report all samples as adulterated which are found to be below the foregoing limits. Now, there are many animals, especially those of the Holstein breed, which habitually produce milk having less than thirteen per cent. of solids. Hence it has not been deemed prudent to enter complaints at court to the full extent of the legal requirements. In the case of milk, therefore, the ratio of adulteration as reported is partially an apparent and not an actual adulteration. *Secondly*, the samples selected under the Massachusetts law are mainly such as are known or suspected to be adulterated, while in England many samples of such staple articles as bread, flour, sugar, and tea are annually examined, which are practically free from adulteration.

In the following table and diagram the articles exam-

ined are classified in three groups, by means of which this element of apparent adulteration in milk is separated:

PERCENTAGE OF ADULTERATION IN MILK, OTHER ARTICLES OF FOOD, AND DRUGS IN MASSACHUSETTS.

Years.	Milk.	Other articles of food.	Drugs.
1883	83.9	35.4	40.8
1884	69.1	48.5	36.8
1885	41.7	43.1	43.3
1886	36.5	36.2	47.8
1887	38.3	29.4	27.3
1888	39.6	19.2	26.4
1889	38.7	24.0	16.2
1890	42.6	18.6	18.7
1891	40.2	26.4	17.0

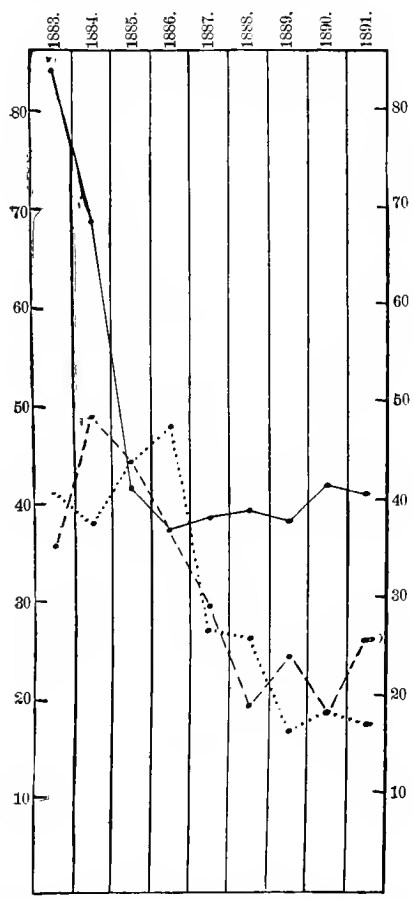


FIG. 161.—Diagram showing the Ratio of Adulteration of Drugs and Different Articles of Food in Massachusetts in the Years 1883-91. Milk, ——; other articles of food, – – –; drugs, ...

The ratio of samples of food collected for examination to the whole population for the past five years has been about as follows: In England and Wales, 1 to each 1,000 of the population; in the city of Paris, 1 to each 120 of the population; in Massachusetts, 1 to each 375 of the population.

The work of a food analyst embraces a variety of branches. In a recent monograph by two French army surgeons, Polin and Labit, the following classification of such work is presented. Three principal groups, as follows: 1. Examination of articles in which the alterations in character are either of a chemical or of a mechanical kind. 2. Those which are biological. 3. Those which are parasitic.

The first group is subject to the following subdivision. (*a*) Additions have been made to the food products either of a commercial or fraudulent nature, and of substances more or less harmful. (*b*) The vessel in which the food has been prepared or preserved renders the food poisonous. (*c*) The manipulation of food, or its surroundings, may expose it to harmful contamination. (*d*) It may be mixed accidentally with foreign substances.

The second group is subject to the following divisions: (*a*) An animal designed for food has been fed with food of a harmful or poisonous character; the poisons absorbed appear in the milk, or, not having had time to become eliminated, either the whole animal or some of its organs have become poisonous. (*b*) Recognizes the possibility of the formation of poisonous ptomaines in meat, under certain conditions. (*c*) In consequence of certain unknown conditions wholesome vegetable food occasionally becomes harmful.

Third group: (*a*) Animal, vegetable, and mineral food products may be invaded by parasites of the larger kinds. (*b*) Food may become the prey of micro-organisms of a parasitic nature, involving the processes of (1) fermentation, (2) putrefaction and (3) the development of infectious diseases, either of which may render the food harmful, either by infection, by ptomaïne poisoning or by the combined action of both. (*c*) Food contaminated by its surroundings, or by infectious contact, becomes the carrier of pathogenic germs.

This list is sufficiently ample to show that the food analyst has a wide field of investigation.

The following special regulations regarding food inspection were published by Dr. Schumacher Kopp, Canton Chemist of Lucerne, and also a member of the International Jury of Award at the Paris Exposition of 1889.

The following extract is taken from his report:

Collection of Food.—In collecting food the greatest cleanliness should be observed. Clean bottles, and, if possible, new ones, should be used in collecting fluids. Bottles should be closed only with new corks.

In collecting drinks, the local experts must be present, and the beverages should be drawn from the regular source of supply.

In collecting milk, fill the bottle to the cork; seal every bottle at once after corking it. If milk is collected in a stable, the cows must be milked quite dry, by a disinterested person, and in the presence of the local magistrate, or a policeman.

Strong glass, or porcelain, or crockery vessels should be used for the collection of butter.

For coffee, tea, and meal, boxes of clean wood or pasteboard should be used.

The use of paper bags for collecting samples is forbidden.

Bread and sausages should be wrapped in clean white paper; if possible, parchment paper.

The use of printed or colored paper for this purpose is forbidden.

Quantity of Food Necessary for Examination.—1. For the local health authority: Beer, one litre; bread, one whole loaf; brandy, 0.3 litre; butter, 50 grammes; vinegar, 0.2 litre; coffee, 30 grammes; meal, 200 grammes; milk, 0.5 litre; cider, 0.5 litre; tea, 10 grammes; drinking-water, 1 litre; wine, 0.5 litre; small sausages, one whole sausage; large sausages, 100 grammes; honey, 50 grammes.

For the Canton Chemist the quantities are nearly the same as the foregoing, but in most instances two samples are taken. When two samples are taken, for example, of water, two litres in one bottle are not meant, but two bottles each containing one litre.

Sealing.—The samples collected must be sealed at once upon the spot, with an official seal. This seal must cover the whole head of the bottle, in order to keep the air out, and to avoid leakage.

Marking.—The samples should be plainly marked in two different places immediately after collection, one on the neck of the bottle, and the other on the opposite side of the body of the bottle. Each marking must contain: 1, The number and name of the article collected; 2,

name of the jurisdiction authorizing the collection, and of the collector.

Provision is made for the collection of two samples when necessary, so that, in case of a dispute, the second may be examined under the auspices of a superior authority. The samples sent to the Canton chemist must contain no information as to their source. A report must also be sent to the Health Officer, stating the articles collected, the date of their collection, name of the dealer, his source of supply, and in every case his remarks upon the character of his goods. This report must be signed by the local expert and by the police assisting in the collection. All samples sent to the Canton chemist must be so packed with sawdust, paper, or wadding, that they may be transmitted without injury. The name of the sender must accompany all packages, letters, etc., and they must be prepaid; otherwise they will not be received.

In sending milk to the Canton chemist, observe especially: 1. That the milk is thoroughly cooled in cold water before it is forwarded. 2. (*a*) In the accompanying report mention must be made first of the number of cows from which a sample of mixed milk is taken; (*b*) how many cows, if any, are in the stable which have calved within fourteen days of collection of the milk; (*c*) how many cows, if any, are near the time of calving.

Food Standards.—*Bread.*—The water in a freshly baked loaf of bread should not be more than thirty per cent. of its weight, and the ash, after deducting the common salt, should not be more than one per cent.

Butter.—This name should only be associated with the fat which is made from milk only. Artificial butter must be properly marked as such, being designated as margarine, and packed in separate parcels. Such names as "cheap butter," "tub butter," and "Alpine butter," are forbidden, except as applied to pure butter.

Vinegar must contain four per cent. of acetic acid. The addition of other acids, flavoring matter, and aniline colors, is forbidden.

Honey must be called honey only when it is free from adulteration. Such terms as "table honey," "Swiss honey," and "Appenzell honey," etc., are forbidden, except when applied to pure honey. Substitutes for honey, such as syrups, etc., and also mixtures of these with pure honey, must be plainly marked as such.

Coffee must not yield more than four per cent. of ash (Mocha, eight per cent.). Artificial coloring is to be regarded as adulteration. Mixtures of coffee with other substances are not to be called coffee.

Rye-meal should not yield more than two per cent. of ash.

Wheat meal should not yield more than one and a half per cent. of ash. The water of rye- and wheat-meal should not be more than fifteen per cent. of its weight, and that of other meals eighteen per cent.

Milk.—Milk must be sold as drawn from the cow. Its specific gravity at a temperature of 15° C. (60° F.) before skimming should not be less than 1.029 nor more than 1.033, and when skimmed after twenty-four hours it should not be less than 1.033 nor more than 1.037. The chemical examination should show at least 11.5 per cent. of solid residue, and at least three per cent. of fat.* When taking milk at dairies for comparison, it is desirable to have examinations made within the shortest possible time, three days at the longest, and the cows should be milked dry by disinterested persons. "Centrifugal" milk should be marked as such, and when inspected at a temperature of 15° C. should have a specific gravity of from 1.034 to 1.037, and should have at least 8.4 per cent. of solids. The sale of the milk of sick cows is forbidden, as well as that of cows within eight days before and after the time of calving.

Cider, after fermentation, must not have less than three per cent. by weight, and 3.76 per cent. by volume of alcohol, and not less than 1.5 per cent. of solids, nor less than .15 of one per cent. of ash.

Tea must not have more than seven per cent. of ash.

Water for domestic use must neither have color nor sediment. Nor should it have smell or bad taste. Water containing infusoria and bacteria should be avoided.

Sausages should be made only of healthy, fresh meat, fat, and spices in general use. Any additions of starches are considered as adulterants.

Propriety of International Laws on the Subject of Food Inspection.—Dr. Von Hamel Ross expressed his opinion, at the International Congress of Hygiene at London, in 1891, that a *codex alimentarius* should be adopted for civilized nations, as agreed upon by a competent commission for general use. He commented upon the different standards of different countries, and as an example quoted the milk standard of Massachusetts, which is thirteen per cent. of solids (twelve per cent. in May and June), while milk having 11.5 per cent. solids is deemed to be pure in Holland.

At the International Congress of Agriculture at The Hague, in the following month (September, 1891), conclusions were formulated as to the need of uniform laws relative to food adulteration and the protection of food products. It was then voted "that each State should establish a commission of competent men, who should be charged with the duty of investigating the methods of analysis in use, and of determining the proper methods of such analysis, and that each State should publish an annual report of its proceedings and exchange reports with other States."

United States.—Recent attempts have been made to secure national legislation for the general prevention of food and drug adulteration in the United States, but thus far the only articles which have become the subjects of such legislation are butter and lard.

The following bill, usually known as the Paddock Bill, was reported to Congress in 1890, and in many respects resembles that which was reported in 1880. Its provisions are reasonable, and not as stringent as those which are in force in some of the States, since knowledge of the fact of adulteration on the part of the vendor must first be proven to secure conviction under this Act.

A Bill for Preventing Adulteration and Misbranding of Food and Drugs, and for other Purposes.—Be it enacted, etc. Section 1. That, for the purpose of protecting the commerce in food-products and drugs between the several States and Territories of this Union and foreign countries, the Secretary of Agriculture shall organize in the Department of Agriculture a division to be known as the food division, and make necessary rules governing the same to carry out the provisions of this act, and appoint a chief thereof, at a salary of $3,000 per annum, whose duty it shall be to procure from time to time, under rules and regulations to be prescribed by the Secretary of Agriculture, and cause to be analyzed or examined samples of food and drugs sold or offered for sale in any State or Territory other than where manufactured. The Secretary of Agriculture is hereby authorized to employ such chemists, inspectors, clerks, laborers, and other employees as may be necessary to carry out the provisions of this act.

Sec. 2. That the introduction into any State or Territory from any other State or Territory or foreign country of any article of food or drugs which is adulterated within the meaning of this Act is hereby prohibited, and any person who shall wilfully and knowingly ship, or deliver for shipment, from any State or Territory or foreign country, to any State or Territory, or who shall knowingly receive in any State or Territory from any other State or Territory or foreign country, or who, having so received, shall deliver, for pay or otherwise, or offer to deliver to any other person, any such article so adulterated within the meaning of this Act, shall be guilty of a misdemeanor, and for such offence be fined not exceeding $200 for the first offence, and for each subsequent offence not exceeding $300, or be imprisoned not

* The standard of whole milk in Paris is a minimum of 11.5 per cent. of solids and 2.7 fat. That of the British Society of Public Analysts is 11.5 total solids and 2.5 fat. That of the State of New York is 12 per cent. of solids and 3 per cent. of fat. Of New Jersey 12 per cent. of solids. Of Massachusetts and New Hampshire, 13 per cent. of solids.

exceeding one year, or both, in the discretion of the court.

Sec. 3. That the chief of said food division shall make, or cause to be made, under rules and regulations to be prescribed by the Secretary of Agriculture, examinations of specimens of food and drugs which may be collected from time to time, under rules and regulations to be prescribed by the Secretary of Agriculture under its direction in various parts of the country, and publish in bulletins the result of such analyses. But the names of manufacturers or vendors of such foods or drugs analyzed shall in no case be published in such bulletins until after conviction in the courts of violation of this Act. If it shall appear from such examination that any other provisions of this Act have been violated, the Secretary of Agriculture shall at once cause a report of the fact to be made to the proper United States District Attorney, with a copy of the results of the analysis duly authenticated by the analyst under oath.

Sec. 4. That it shall be the duty of every district attorney to whom the food division shall report any violation of this Act to cause proceedings to be commenced and prosecuted without delay for the fines and penalties in such case provided, unless, upon inquiry and examination, he shall decide that such proceedings cannot probably be sustained, in which case he shall report the facts to the food division.

Sec. 5. That the term "drug," as used in this Act, shall include all medicines for internal or external use. The term "food," as used herein, shall include all articles used for food or drink by man, whether simple, mixed, or compound.

Sec. 6. That for the purposes of this Act an article shall be deemed to be adulterated—

In case of drugs :

First. If, when sold under or by a name recognized in the United States Pharmacopœia, it differs within the knowledge of the seller from the standard of strength, quality, or purity according, to the tests laid down therein.

Second. If, when sold under or by a name not recognized in the United States Pharmacopœia, but which is found in some other pharmacopœia or other standard work on materia medica, it differs within the knowledge of the seller materially from the standard of strength, quality, or purity, according to the tests laid down in said work.

Third. If its strength or purity fall below the professed standard under which it is sold.

In the case of food or drink :

First. If any substance or substances has or have been knowingly mixed and packed with it so as to reduce or lower or injuriously affect its quality or strength, so that such product, when offered for sale, shall be calculated and shall tend to deceive the purchaser.

Second. If any inferior substance or substances has or have been knowingly substituted wholly or in part for the article, so that the product, when sold, shall be calculated and shall tend to deceive the purchaser.

Third. If any valuable constituent of the article has been knowingly wholly or in part abstracted, so that the product, when sold, shall be calculated and shall tend to deceive the purchaser.

Fourth. If it be an imitation of and knowingly sold under the specific name of another article.

Fifth. If it be knowingly mixed, colored, powdered, or stained in a manner whereby damage is concealed, so that such product, when sold, shall be calculated to deceive the purchaser.

Sixth. If it contain within the knowledge of the seller any added poisonous ingredient or any ingredient which may render such article injurious to the health of the person consuming it.

Seventh. If it consist within the knowledge of the seller of the whole or any part of a diseased, filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food, whether manufactured or not, or if it is the product of a diseased animal, or of an animal that has died otherwise than by slaughter : *Provided*, That an article of food or drug which does not contain within the knowledge of the seller any added poisonous ingredient shall not be deemed to be adulterated—

First, in the case of mixtures or compounds which may be now or from time to time hereafter known as articles of food under their own distinctive names, and not included in definition fourth of this section ;

Second, in the case of articles labelled, branded, or tagged so as to plainly indicate that they are mixtures, compounds, combinations or blends ;

Third, when any matter or ingredient has been added to the food or drug because the same is required for the production or preparation thereof as an article of commerce in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight, or measure of the food or drug, or conceal the inferior quality thereof ;

Fourth, where the food or drug is unavoidably mixed with some extraneous matter in the process of collection or preparation.

Sec. 7. That every person manufacturing, offering, or exposing for sale, or delivering to a purchaser any drug or article of food included in the provisions of this Act shall furnish such drugs or article of food to any person interested or demanding the same, who shall apply to him for the purpose, and shall tender him its value, of a sample sufficient for the analysis of any such article of food which is in his possession. And upon the presentation of such drug or article of food to the proper officer of the food division by a responsible person, with a request from such person for an official analysis of the same, the chief of such division shall make, or cause to be made, such analysis of the drug or article of food so presented, under rules and regulations to be prescribed by the Secretary of Agriculture.

Sec. 8. That whoever refuses to comply, upon demand, with the requirements of section seven of this Act shall be guilty of a misdemeanor, and, upon conviction, shall be fined not exceeding $100 nor less than $10, or imprisoned not exceeding one hundred nor less than thirty days, or both. And any person found guilty of manufacturing, offering for sale, or selling an adulterated article of food or drug under the provisions of this Act shall be adjudged to pay, in addition to the penalties heretofore provided, for all the necessary costs and expenses incurred in inspecting and analyzing such adulterated articles of which said person may have been found guilty of manufacturing, selling, or offering for sale.

Sec. 9. That in prosecutions for violations of this Act proof of the act done shall be held to imply knowledge and intent on the part of the accused, unless such knowledge and intent shall be disproved on the trial.

Sec. 10. That this Act shall not be construed to interfere with commerce wholly internal in any State, nor with the exercise of their police powers by the several States.

The English Food and Drug Act was quoted with sufficient fulness in the third volume of the REFERENCE HANDBOOK ; hence it is not repeated here.

Germany.—After the enactment of the English law, a demand arose in Germany for similar legislation, and a bill was introduced early in 1879, which became a law in May of that year.

A very complete inquiry had already been made, in anticipation of this Act, in the year 1878, embracing the examination of 231,478 samples of food, drink, and other articles coming under the proposed law. Of these, 3,508 proved to be adulterated, or 1.5 per cent. only ; 1,538 articles of food were decomposed and unfit for consumption, and 3,332 convictions of offenders were secured. Of the whole number, there were 152,043 samples of milk ; 17,628 of beer ; 21,380 of sausages and meat ; 17,203 of flour and bread, etc. A few glaring instances of the use of harmful ingredients were detected.

The following is the text of the Act in question :

Section 1. The sale of food and articles of consumption, as well as the trade in toys, paper-hangings, colors, eating, drinking, and cooking utensils, and petroleum, is to be regulated by this Act.

Sec. 2. The officers of the sanitary police are empowered to enter any rooms in which the articles coming under Section 1 are kept for sale, during the usual business honrs, or while the rooms are kept open for sale.

They are authorized to take, according to their choice, for the purpose of analysis, samples of the articles coming under Section 1, and which are kept in the sale-rooms, or which are sold in public places, upon market-places, squares, streets, or which are hawked about. If requested, part of the sample must be left with the vendor, properly secured or sealed. For the sample the usnal price is to be paid to the seller.

Sec. 3. The sanitary officers are empowered to make inspections of the premises of persons who have, according to Sections 10, 12, 13 of this Act, been sentenced to imprisonment, or of rooms in which articles specified in Section 1 are kept for sale, or in which such articles intended for sale are stored.

This power of inspection begins with the date at which the sentence takes force, and ceases after three years from the date on which the term of imprisonment ceases, or is remitted.

Sec. 4. Sanitary officers, in the meaning of this Act, are the medical sanitary officers, as well as those officers which are nominated as such by the Superior Court of Administration. The central authority of the empire will decide which court has to act as Superior Court of Administration.

Sec. 5. By imperial decree, with assent of the Federal Council, regulations for the protection of health may be framed to prohibit: 1. Certain modes of preparing, storing, or packing articles of food or consumption intended for sale. 2. The trade and offering for sale of articles of food or consumption, of certain conditions, or under a name not corresponding to their real condition. 3. The sale and offering for sale for slaughter of animals suffering from certain diseases, as well as the sale and offering for sale of the flesh of animals which are affected with certain diseases. 4. The use of certain substances and colors for the manufacture of wearing apparel, toys, paper-hangings, eating, drinking, and cooking utensils, as well as the sale and offering for sale of articles manufactnred contrary to this regulation. 5. The sale and offering for sale of petroleum of a certain nature.

Sec. 6. By imperial decree, with assent of the Federal Council, the manufacture, sale, or offering for sale, of articles intended for adulterating articles of food or consumption may be prohibited or limited.

Sec. 7. The imperial decrees, issued under Section 6, are to be laid before the next following session of Parliament. They are to be put out of force as soon as Parliament so requires it.

Sec. 8. Whoever acts contrary to the regulations of Sections 5, 6, is punishable with a fine up to 150 marks (about $35), or with imprisonment.

Sec. 9. Whoever, contrary to regulations of Sections 2 to 4, refuses entry to the rooms, the taking of samples, or inspection, is punishable with a fine from 50 to 150 marks, or with imprisonment.

Sec. 10. Liable to imprisonment up to six months, and to a fine up to 1,500 marks, or to either of these, is: 1. Whoever, for the pnrpose of fraud in commerce, imitates articles of food or consumption, or adulterates the same by deteriorating them by the subtraction or addition of substances, or gives them the appearance of a better quality. 2. Whoever knowingly sells articles of food or consumption, which are spoiled or imitated, or adulterated according to Section 1, without giving notice of these circumstances, or offers them for sale under a name liable to lead to deception.

Sec. 11. If offences mentioned in Section 10 have been committed by negligence, a fine up to 150 marks or imprisonment is to be inflicted.

Sec. 12. Liable to imprisonment, and to loss of civil rights, is: 1. Whoever prepares articles intended for the food of others in such a manner that their consumption is calculated to injnre health, also, who knowingly sells, offers for sale, or otherwise brings into circulation as articles of food or consumption such articles which are injurious to health. 2. Whoever intentionally manufactures wearing apparel, toys, paper-hangings, eating, drinking, and cooking utensils, or petroleum, so that the probable use of these articles proves injurions to health; also, who knowingly sells such articles, offers them for sale, or otherwise brings them into circulation.

The attempt is pnnishable—

If, through the action, grievous bodily injury, or the death of any person has been caused, penal servitude np to five years is to be inflicted.

Sec. 13. If, in the cases of Section 12, the consnmption or use of the articles was liable to destroy health, and if that circumstance was known to the vendor or manufacturer, penal servitnde up to ten years, or, if the death of any person was caused, penal servitude not under ten years, or for life, is to be adjndged. Besides the punishment, supervision by the police may be ordered.

Sec. 14. If any of the actions indicated in Sections 12 and 13 has been committed through negligence, a fine up to 1,000 marks is to be imposed, or imprisonment up to six months; and if, by the action, the health of any person shall have been injured, imprisonment up to one year; but if the death of any person shall have been caused, imprisonment from one month to three years.

Sec. 15. In the cases of Sections 12 and 14, besides the punishment, the confiscation of the articles which were made, sold, offered for sale, or otherwise brought into circulation, is to be caused, no matter whether the articles belong to the defendant or not; in the cases of Sections 8, 10, and 11, the confiscation may be caused.

If in cases of Sections 12 and 14 the prosecntion or punishment of any person is not practicable, confiscation of the articles alone may be caused.

Sec. 16. In the judgment it may be ordered that the sentence be made public, at the expense of the defendant.

On the motion of any defendant who has been found not guilty, the Conrt has to order the publication of the acquittal; the costs to be paid by the State, unless they are to be paid by the prosecutor.

In the order the mode of publication is to be stated.

Sec. 17. If, for the place where the offence was committed, a public institntion for the examination of articles of food or consumption be in existence, the fines imposed by authority of this law, and as far as the State can dispose of them, go to the fund which provides the cost of maintaining that institntion.

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Samuel W. Abbott.

FRIEDRICHRODA. A popular watering-place and climatic resort in Thuringia, Germany.

LOCATION.—Friedrichroda is charmingly situated in the "*Thüringerwald*," near the city of Gotha, and at an elevation of 1,300 feet above sea-level. The pure mountain-air, the attractive scenery, the saline waters, and facilities for brine, pine-needle, and other baths all contribute to make it a favorite resort in that section of the country.

ACCESS.—The place is now a station on the railroad running from Gotha to Eisenach.

INDICATIONS.—Friedrichroda is much frequented during the summer season (May to October) by those af-

flicted with minor neuroses, anæmia, bronchial and slight pulmonary affections, and scrofula. There are several bathing establishments, with facilities for massage, hydrotherapy, inhalations, etc. The place is also made use of as "*Terrainkurort*," for the Oertel system. Milk and whey cures are much employed there.

ACCOMMODATION. — There are hotels and numerous boarding-houses; also a *Kurhaus* where music and the usual entertainments are provided.

Edmund C. Wendt.

FRONTAL SINUSES, DISEASES AND INJURIES OF THE. OSTEOMA OF THE FRONTAL SINUS.—The statistics of operations for the removal of these growths continue to show a very high mortality. Thus out of fifty-four cases in which interference to the extent of the removal of the bone was carried out, thirty-three per cent. died of meningitis.[1] The serious nature of the operative procedure seems to be in direct proportion to the size of the tumor. Hence it is suggested that early interference should be practised.[2]

EMPYEMA OF THE FRONTAL SINUSES.—Intense catarrhal inflammation of the frontal sinus may give rise to an empyema of the cavity. This may be due to a primary inflammation, in which an acute or chronic obstruction of the infundibulum occurs, and consequent retention of pus. Of forty-eight cases collected and analyzed, in three acute obstruction occurred.[3] In four cases hypertrophied turbinated bodies and polypi were found. In fourteen cases injuries by blows, falls, etc., were the primary cause of the affection.[4] In one-half the entire number of forty-eight cases there was nothing in either the history or the condition to suggest the origin of the disease, although there are strong reasons for believing that it had its origin in some intra-nasal affection which blocked up the infundibulum.

The course of the disease may be exceedingly rapid or very slow. In the first instance the empyema is due directly to accumulation of pus. In the more chronic cases the distention is first caused by the presence of mucus, which afterward becomes changed into muco-pus by bacterial infection. Necrosis following periostitis may be one of the results of the diseased condition of the mucous membrane, or it may precede it and act as a cause of the disease.

The orbital plate of the frontal bone first yields to the effects of the pressure, and, from its comparative thinness, may give way. In this way a swelling at the root of the nose and at the upper and inner margin of the orbit is formed, which may be mistaken for an inflammation and distention of the lachrymal sac. Where necrosis is either the cause or the result of the disease, the swelling may be found at some other portion of the sinus wall. The swelling is usually one-sided, whatever be the situation of the diseased area, for the reason that disease of both sinuses is extremely rare.

The symptoms are—frontal headache, the pain frequently following the course of distribution of the supra-orbital nerve. Chills, rise of temperature, and a general malaise are also experienced. To these are to be added the symptoms of a severe coryza, with inability to respire through the nose, and discharge of mucus or muco-pus. Lachrymation may be present. Perforation of the sinus may occur posteriorly, in which event circumscribed or diffused septic meningitis may occur. The severity of these symptoms will vary with the acute or subacute character of the case.

The chronic cases come on insidiously, with moderate frontal pain and a feeling of distention in that region, and occasional discharge from the nose. As the fluid slowly accumulates there is a tendency to protrusion of the globe of the eye, due to the pressure from above downward and outward. As absorption of the bone proceeds, a sense of fluctuation, at first obscure and afterward more pronounced, is felt. In both the acute and chronic forms, as the contents approach the surface, there occurs infection of the structures overlying the bone; œdema and swelling, with an erysipelatous blush, are observed. In fact these cases may readily be mistaken for true infectious erysipelas. The tumor may vary in size by reason of an occasional partial emptying of its contents through the nose.

Among the complications of empyema of the frontal sinuses may be mentioned disturbances of the visual organs, brain symptoms, and those referable to the naso-pharyngeal cavity. Diplopia and ptosis are sometimes present. Variations in visual capacity may result from variations in the degree of pressure upon the globe, according as the neighboring swelling increases or decreases in size; even total loss of vision has been reported. The empyema, by perforating posteriorly, may give rise to secondary abscess of the anterior lobe of the brain. Cerebral involvement may be preceded by anosmia and symptoms of optic neuritis. As a result of the blocking up of the air-passages, mouth-breathing and a very distressing dryness of the pharyngeal cavity are likely to be observed. The sense of smell is lost, and frequently the sense of taste as well.

The treatment of empyema of the frontal sinus consists in gaining access to the cavity by making an opening into the anterior wall of the sinus, thoroughly cleaning the same, and then providing for efficient drainage. An exploratory puncture, in case of doubt, may precede the formal operation. In exposing the bone, the incision in the soft parts should commence at the inner extremity of the shaven eyebrow, where no supraorbital notch can be felt (a foramen existing instead), and should extend outward not more than an inch from the median line. By this means the vessels and nerves will certainly escape injury (Dawbarn). The opening through the bone may be made by the dental engine and trephine, but a small chisel and wooden mallet will be found to be the most generally available instruments for the purpose. The drainage through the nose is the most important part of the treatment. Soelberg Wells claims to be able to accomplish this without external opening by passing an instrument upward from the nose into the sinus. Save in favorable cases this will be found to be very difficult. In opening into the nose from the floor of the sinus, after the latter has been opened, the operator's little finger should be passed into the nostril of the same side to act as a guide. Through and through drainage, by means of a perforated drainage-tube of rubber, should then be instituted. Mild astringent and antiseptic solutions, such as boro-salicylic or Thiersch's, a saturated solution of boracic acid or pyoktan in (2 to 1,000), should be employed.[5]

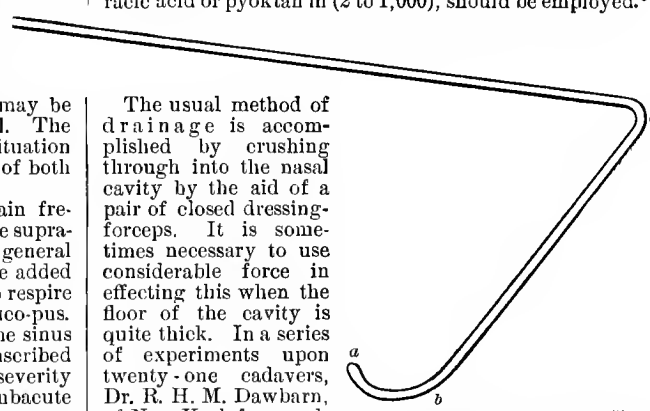

FIG. 162. — Dawbarn's Frontal Sinus Probe. The distance from *a* to *b* is about half an inch, and that from *b* to *c* should be the distance from the incision in the eyebrow to the nostril. The latter distance, therefore, will vary much, according to the length of the nose.

The usual method of drainage is accomplished by crushing through into the nasal cavity by the aid of a pair of closed dressing-forceps. It is sometimes necessary to use considerable force in effecting this when the floor of the cavity is quite thick. In a series of experiments upon twenty-one cadavers, Dr. R. H. M. Dawbarn, of New York,[6] succeeded, in all but one, in passing a peculiarly bent probe (Fig. 162) down the natural passage, through the middle meatus, and into the nose, and thence out of the nostril. A thread is then to be tied to the end of the probe as it projects from the nostril, and the probe is to be withdrawn. The operator now has a thread which passes from the nostril and nose through the middle

meatus and infundibulum into the frontal sinus. To this may be attached either a small drainage-tube or a strip of iodoform gauze, and by withdrawing the thread the drain is brought into position. The plan here suggested is worth a trial, for if the drainage can be efficiently applied by Dawbarn's method, it would be a barbarous procedure, in comparison, to crush through the outer plate of bone, as usually taught in the text-books.

In the series of forty-five cases collected by Richards, death occurred in six; one of these perished through albuminuria and another from meningitis. The remaining four died from secondary cerebral abscess.

George Ryerson Fowler.

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GALLACETOPHENONE. This substance has been introduced as a substitute for pyrogallic acid in the treatment of psoriasis and similar skin diseases. A commercial name for it is "alizarine-yellow C." Chemically it is a tri-hydroxy-benzene, in which a fourth hydrogen atom has been replaced by an acetyl group. Its formula is $CH_3CO.C_6H_2(OH_3)$. It is prepared by treating pyrogallic acid with acetic acid in the presence of chloride of zinc. It is a pale yellow powder, almost insoluble in cold water, very soluble in hot water, alcohol, ether, and glycerine. The presence of acetate of sodium increases its solubility in cold water: one drachm may be retained in solution in three and a half ounces of water by the addition of one ounce of sodium acetate.

It is a powerful antiseptic; a one per cent. solution will prevent the putrefaction of chopped meat for twenty-one days.

The chief advantage which is claimed for it, as a substitute for pyrogallic acid, is its freedom from irritating and toxic properties. Experiments on animals prove it to be non-poisonous. It has been shown that dogs will bear a dose of one drachm daily for a long time without inconvenience. This is due to the fact that it oxidizes very slowly. Pyrogallic acid is too rapid and energetic in its action: it has at times caused very serious disturbances, and fatal results have followed its external use, these ill effects being due to its intense reducing power, particularly in alkaline solution. Another advantage of the new drug is that it does not soil the linen when used.

The use of gallacetophenone in skin disease was introduced by Dr. L. von Rekowski, of Professor Nencki's Institute, at Berne (*Therapeutische Monatshefte*, September, 1891). It was used in psoriasis with very satisfactory results, the beneficial effects of the treatment being noticed within twelve hours. In a short time the patches become paler and thinner, and desquamation lessens. After ten or twelve days the patches have almost disappeared, and in two or three weeks a perfect cure is effected.

Dr. Hermann Goldenberg, in the *New York Medical Journal*, February 6, 1892, reports his success with it in several severe cases of long duration. He considers it much superior to pyrogallic acid or chrysarobin, and perfectly harmless. It also proved of service in some cases of eczema. There is no irritation of the skin, nor staining of the skin, hair, or clothing. The drug is used in the strength of ten per cent., as an ointment, with vaseline, or in solution. *Beaumont Small.*

GALL-BLADDER AND DUCTS, SURGERY OF. The domain of surgery has been extended during the last decade so as to include the disorders arising from biliary obstructions, which were formerly relegated to the list of irremediable cases. While Bobbs did an operation upon the gall-bladder incidentally, in seeking to remedy a trouble which was not clearly understood, Sims resorted to a measure subsequently, with a distinct object in view, which led to investigations by others, in connection with the gall-bladder, of vast importance. The experiments upon inferior animals, which were made by me, looked to a different result in the disposition of the bile from that which was contemplated, in the external discharge of it through a fistulous opening, by Sims. Winiwarter, without my knowledge, had sought to convey the bile into the intestinal canal, and had thus succeeded in relieving the troubles growing out of obstruction of the common bile-duct. On this line my efforts were directed to clearing up some of the difficulties in the accomplishment of a communication from the gall-bladder into the duodenum or the adjacent small intestines.

A careful examination of several articles contributed to the second volume of the HANDBOOK, entitled "Cholecystectomy, Cholecystotomy, and Duodenocholecystostomy," should premise a consideration of the data now presented to the profession. It will be learned that the principles and processes of the various operative procedures were fully elaborated, and the reader will be prepared to comprehend what advances have been made in the surgery of the gall-bladder and ducts since that period. There has been some modification of the different operations originally undertaken, but no material improvement in the steps inculcated for cholecystectomy and cholecystotomy; while new departures are noted principally in the excision of gall-stones from the ducts, and in the attachment of the gall-bladder to different portions of the intestinal canal, with a fistulous communication between the former and the latter. The use of gauze tamponage in operations involving the integrity of the gall-ducts, either around drainage-tubes or without them, has been attended with such favorable results as to commend this procedure to surgeons. While a case reported by Lane, and facts occurring in the experience of other operators, lead to the conclusion that the presence of freshly secreted bile in the peritoneum is not attended with any serious consequences, it is certainly very desirable to prevent its entrance into the cavity of the abdomen. It is principally with a view to circumscribe the collection of bile from lesions of the ducts, either accidental or in operations, that gauze packing in the immediate vicinity of biliary exudation has been resorted to of late. When the layers of iodoform gauze are extended from the site of an incised or lacerated duct to the external abdominal opening, it is claimed that it serves to carry out the bile by capillary drainage, even when no drainage-tube is employed. It is further held that by pressure upon the surrounding parts the extravasation of the bile into the structures is obviated, so that in suturing the ducts or the gall-bladder, with or without anastomosis with the intestinal canal, it is a wise precaution to fill up the intervening space with strips of iodoform gauze.

The operation of cholecystectomy, which was introduced by Langenbuch, has been practised eight times by Terrier, with seven recoveries. Michaux performed this operation in two cases, and both resulted in cure. Dawson reports a successful cholecystectomy for impacted gall-stones, which were faceted and weighed respectively 79, 80, and 81 grains. Czerny gives two cures by cholecystectomy, and this process affords highly satisfactory results. Other successful operations have been done in this country and in Europe, and the fatal results have been comparatively small. The number of operations reaches in all nearly one hundred, with a mortality of less than twenty per cent. This operation is contra-indicated in cases of obliteration of the ductus communis choledochus. But when this is patent, and there is occlusion of the cystic duct, with greater or less disorganization of the gall-bladder, so as to preclude its restoration, it is indicated. Biliary fistulæ, from the accumulation of gall-stones, would also warrant cholecystectomy. In view of the favorable results reported, surgeons will not hesitate to avail themselves of this recourse in suitable cases, notwithstanding the opposition of those who have no experience in its performance.

The operations of cholecystotomy and cholecystostomy have been practised extensively during the period which has intervened since the publication of my articles in the second volume of the REFERENCE HANDBOOK. The

former designation is applied to those cases in which the obstructions have been removed through an incision in the walls of the gall-bladder and afterward the opening is closed by sutures, when the viscus is either dropped or secured to the edges of the external wound. This last procedure, urged by Sanger and Wölfler, is intended to allow of the escape of bile externally, if the stitches yield, instead of being discharged into the peritoneal cavity. The term cholecystostomy is used for those cases having the incision in the gall-bladder left open and attached to the opening in the parietes, so as to allow of the flow of bile externally. This procedure has been adopted upon the supposition that eventually the bile would find its way through the common duct, and that the external opening might close, either spontaneously, or through the instrumentality of a plastic operation. The results of this procedure have not been always satisfactory, and it is not so free from risk as has been claimed by some who urge its adoption in preference to other measures. It cannot afford more than temporary relief in cases of occlusion of the common bile-duct, and entails upon the sufferer the very condition of a biliary fistula, which has furnished the reason, in many instances, for seeking surgical assistance. In two cases of pronounced cholæmia from the closure of the common bile-duct, which have come under my observation, a resort to the operation of cholecystostomy failed to arrest a fatal termination. Although in each case there was a free discharge of bile through the opening made by attaching the edges of the incision in the gall-bladder to the sides of the cut in the abdominal wall, no benefit was derived from either operation, and both patients (females) died in less than a week after undergoing the operation. It is proper to state, in this connection, that no gall-stones were found in the gall-bladder or in the ducts of either of these patients, and that the obstruction of the common bile-duct resulted from adhesive inflammation of its coats, by which the canal was reduced to a hard, dense cord. The previous history of clay-colored stools and profound jaundice, with distention of the gall-bladder, showed cholæmia in both.

The intermediate process of incising the wall of the abdomen only, and attaching the wall of the gall-bladder unopened to its edges, with gauze placed in the wound until adhesions have occurred, when an opening is made into the gall-bladder, has nothing whatever to recommend it. The most instructive digital examination of the gall-bladder and ducts is precluded by this procedure, and it affords no facilities for the removal of obstructions which may exist in the cystic or common ducts. Notwithstanding the endorsement by Riedel of the performance of this operation at two sittings, Körte, who has performed it in two cases, prefers the operation as performed at one sitting, when it is possible.

When the ductus choledochus is found free, and the cystic duct can be rid of obstructions, the most satisfactory proceeding is the immediate closure of the incision in the gall-bladder and its return into the abdomen, without any attachment to the parietes. This course has now been adopted in a sufficient number of cases, with a good result, to satisfy the profession of its efficacy in restoring the normal relations of the gall-bladder.

Catheterization of the cystic and common bile-ducts has been undertaken in a limited number of cases with satisfactory results. It is held by Terrier and Daily that it is easier under pathological conditions, but the catheterization should be undertaken with a clear idea of the normal relations for a guide to the operation.

The process of disintegration of biliary concretions by the introduction of a needle into the mass and breaking up its structure, has been found advantageous in dislodging obstructions of the ducts. In connection with this, the use of padded forceps or pressure with the thumb and index-finger for crushing the gall-stones, has been attended with good results in some cases.

In cases where it is impracticable to unite the gall-bladder with the intestinal canal, an attempt has been made in a few instances to bring about a communication, by incision and suture, between the ductus communis and the duodenum or a coil of the small intestine. A successful case is reported by Sprengel. But the difficulties attending this operation offer little encouragement to its repetition. The most striking developments in this department of surgery look to the restoration of the bile to the intestinal canal.

None of these procedures is adapted to relieve impaction of the ducts by gall-stones, or the agglutination of their walls from plastic inflammation of the tissues. Other measures have been resorted to within the past few years, which constitute the most notable advances in the surgery of the gall-bladder and ducts. The excision of biliary calculi, which are so hard as to resist crushing in the ducts, has been practised successfully. After incising the coats of the cystic or common bile-ducts and removing the concretions by forceps or other means, the opening has been closed by suture, and a satisfactory result has been obtained in a large proportion of the cases reported. Not only has the incision healed kindly, but the duct has conveyed the bile to its proper destination.

Incision and suture of the walls of the common bile-duct, with the removal of gall-stones, have been resorted to in thirteen cases, with two fatal results. Three of these operations have been done by Courvoisier, and one by each of the following: Kummell, Heusner, Kuster, Rehn, Braun, Frank, Hocheneg, Thornton, Marcy, and Vander Veer. A stone has also been successfully excised from the cystic duct by Ross.

There is a class of cases in which nothing can avail to remove the occlusion of the ductus communis choledochus, and the recourse for the surgeon is to secure a communication from the common duct above the obstruction, or from the gall-bladder, with the duodenum or some adjacent portion of the intestinal canal. The best efforts of operators have been directed to this end of late, and what was foreshadowed in my contribution on duodeno-cholecystostomy seven years ago, has now been realized in a sufficient number of cases to guarantee the future success of this operation. In nothing undertaken during the last decade has the triumph of intelligent effort been so marked as in overcoming the difficulties connected with complete obstruction of the common bile-duct. Temporary obstacles may yield to various devices which have been adopted, but the impermeable agglutination of the coats of the common bile-duct can only be remedied by opening up a new route for the passage of the bile into the intestinal canal. It is begging the question to allege that any process can restore the canal when it is permanently occluded by agglutination of its walls.

In my opening address, as chairman of the Surgical Section at the meeting of the American Medical Association in Detroit, some data upon the surgery of the gall-bladder and ducts were presented which may be appropriately incorporated in this paper. It was demonstrated that all cases of the obstruction of the cystic and common ducts by gall-stones call for their dislodgement by one or another procedure, to afford an outlet for the bile; and that the attachment of the incision in the gall-bladder to the opening in the wall of the abdomen for a discharge of the bile externally, should be regarded as a mere temporary recourse. In the event of failure to effect an outlet for the bile through the common duct, then cholecystenterostomy is clearly indicated. As to the portion of the intestine which should be selected for the attachment of the gall-bladder or the ductus choledochus, we have a definite guide in the entrance of the bile naturally into the duodenum; and the nearer to this an anastomosis can be effected, the better result may be expected. The relations of the duodenum and jejunum to the gall-bladder, ordinarily, are such as to facilitate their union, and I have given the preference to the duodenum from physiological considerations as well as from surgical convenience, while objecting to the colon.

It is, of course, presumed that there is such an occlusion of the common bile-duct as to prove irremediable by other means, before proceeding with an operation to effect an outlet for the bile by uniting the gall-bladder with the intestinal canal. A misunderstanding of this condition has led to misapprehension of the end to be

attained by duodeno-cholecystostomy or cholecystenterostomy; and let me say, once for all, it is only warranted by occlusion of the common duct.

In this connection the following pointed remarks of Greig Smith upon entero-cholecystotomy, in the last edition of his work on abdominal surgery, place my investigations upon this subject in a proper light before the profession:

"By this operation is meant the establishment of a fistula between the gall-bladder and the intestine. The operation is indicated only in cases of incurable biliary fistula; that is, in cases where there is insuperable occlusion in the ductus communis choledochus. The original operation of Winiwarter successfully established a communication between the gall-bladder and the colon. In this situation the physiological effects of the biliary secretion were lost. Dr. Gaston, of Atlanta, Ga., in a series of instructive experiments on dogs, showed how communication might be established between the duodenum and the gall-bladder, thus preserving in the system whatever value the bile may have. Gaston speaks of his operation as duodeno-cholecystostomy. Some misconceptions and misdirected criticisms of Gaston's operation have appeared in various journals; to those he has given satisfactory answers."

In the comprehensive and elaborate record by Courvoisier of what has been accomplished for the relief of biliary obstruction, he states that my experiments on animals were undertaken in the hope thereby of clearing up the way for a practicable future operation on man. His remarks on this point are quoted: "Gaston sought to utilize the elastic ligature. In five dogs he carried it through the approximated walls of the gall-bladder and duodenum, in such a way that one-half of the tightly drawn loop lay in the former, the other half in the latter. The loop was to cut through both walls at the same time and thus form a fistula between both cavities. At the close of his operations Gaston placed a catgut suture around the place where the walls of the organs lay in apposition. In one animal the adhesions were completed by the eleventh day, and in this case there was a beautiful fistula, while the ligature had passed off through the intestine. In 1884 Gaston also made an experiment on a young dog with a silk ligature, and obtained a good result. Later on, he repeated these experiments with ligation of the common duct, without satisfactory results."

Courvoisier further states that Golzi reports five experiments on dogs. The common bile-duct was ligated. Then, with a catgut suture, the surfaces of the gall-bladder and the nearest loop of the small intestine were stitched around a loop of suture, passed through each wall so as to cut through. It is stated that the animals bore the operations without material derangement of the digestion.

It is also noted by Courvoisier that Page operated in the same manner as Golzi did on three dogs, omitting, however, the ligation of the common duct. One dog survived, one sank with peritonitis, and the third died after six weeks, showing a considerable shrinkage of the gall-bladder, but without any fistula. The result is not known in the dog which survived.

The various procedures adopted by Golzi, Page, and myself were undertaken with a view to guide others in the performance of operations upon human beings. All must allow that the fruit of our experiences has thrown much light upon the intestinal labyrinth in which we groped without a guide to direct us at that period.

The difficulties encountered by me in ligating the common bile-duct subsequently, were the greatest obstacles to the final success of this operation, and would not be encountered in case of pre-existing occlusion, which is the occasion of performing an operation on the human subject.

These and other experiments, undertaken upon twenty-one dogs, are fully illustrated by the cuts accompanying my contribution upon "Duodeno-cholecystostomy" in the second volume of the REFERENCE HANDBOOK.

It may be stated that my conception of the procedures indicated was not limited to the means employed in these experiments, and it was distinctly set forth that some other process might be found preferable, and it rests with surgeons to adopt that which proves best.

To Nussbaum is attributed the first suggestion of relieving the occlusion of the common bile-duct, by discharging the bile into the intestinal canal through artificial openings in the adherent walls of the gall-bladder and the intestine. But the credit of having first accomplished this result upon the human being is undoubtedly due to Von Winiwarter, and it affords me the greatest satisfaction to award him the honor of priority in the execution of cholecystenterostomy in 1881.

After a lapse of six years Monastyrski united the gall-bladder with the jejunum on the fourth of June, 1887. He incised the abdominal wall, punctured the gall-bladder, incised its walls and the jejunum, and sewed the edges with catgut. A fistulous communication was secured two metres below the duodenum, but death ensued from carcinoma of pancreas, as verified by autopsy.

The operation of Kappeler came next in the order of time, being done on the sixth of July, 1887, by uniting the gall-bladder with the ileum by Wölfler's suture. The patient progressed favorably for a time and returned to work, but eventually died on September 9, 1888, fifteen months after the operation. The autopsy showed that a biliary fistula was established about eight feet from the ileo-cæcal valve, and that its intestinal orifice was provided with a valve which allowed the contents of the gall-bladder to pass into the intestine, but prevented the passage of the intestinal contents into the gall-bladder. Doubtless, a similar provision exists in all such cases.

In the year following the operation of Kappeler, Fritzche accomplished a fistulous opening from the gall-bladder into the jejunum, three metres below the pylorus. At the post-mortem examination a carcinoma of the size of a walnut was found at the mouth of the common bile-duct.

Socin and Bardenheuer each attached the gall-bladder to a loop of the small intestine. The case of the latter died in the fourth week and no fistula was found. It is said to have been done with elastic ligature.

Robson operated, on March 2, 1889, upon a patient who had undergone a previous cholecystotomy, when the ducts were freed and the gall-bladder was sutured to the abdominal wall with firm adhesions. The common duct being subsequently occluded, an incision was made through the scar from the former operation, in the semilunar line, and it was found that the attachment of the gall-bladder could only be effected with the colon. Both were incised and united with chromicized catgut in two rows. The former external fistula was sewed up and a drainage-tube inserted in the wound. After one day bile came out of the drainage-tube, and also fecal matter came from the intestinal wound, mixed with bile, on March 5th. Afterward, up to the 18th, faces and bile continued to be discharged, and then bile alone, the wound granulating and ultimately completely closing on May 6th, when the motions were noticed to have regained their normal color. The patient reported herself in July as in perfect health.

Robson states that, "although Dr. Gaston proved the possibility of affixing the gall-bladder to the duodenum in dogs, and although this has been shown practicable in the human subject by Terrier's operation," he found that the difficulties are much greater than if a loop of the small intestine be selected.

On July 13, 1889, Terrier performed an operation for the relief of occlusion of the common duct. An incision was made in the median line, above the navel. The gall-bladder was punctured and the bile discharged. Upon incising its walls and exploring its cavity no stones were found, and the cystic duct was open. There was a gall-stone impacted in an oblong enlargement of the common duct which could not be removed. After attaching the gall-bladder to the duodenum by an oblong row of catgut sutures, and before tying the last stitches, the walls of both were incised and a rubber drainage-tube was introduced, so as to pass from the cavity of the gall-bladder into the duodenum. The fundus of the gall-bladder was sutured to the lower angle of the

external incision, which was then closed by a catgut suture. There was fever until August 1st, but the itching and jaundice gradually disappeared. The drainage-tube passed off with the evacuations nine days after the operation, and the stools gave evidence of the presence of bile. The external wound healed up by first intention. The patient was dismissed on August 10th, in ordinary health. The patient died in the spring of 1890, from influenza, and no gall-stone was found in the common duct.

Courvoisier, in like manner with Robson, performed the operation of natural cholecystotomy upon a patient without getting a satisfactory result. After the lapse of a year complications arose, which demanded cholecystenterostomy, and this was done March 28, 1890. An incision was made through the abdominal wall, below the ribs, along the border of the liver. The gall-bladder was detached from the abdominal wall, and after incising the sac a gall-stone was removed from the common duct and others were scraped from the hepatic ducts. An incision into the lower surface of the gall-bladder was united to the colon by an oval row of catgut sutures, and before putting in the last stitches the wall of the colon was incised. The fistulous parts of the gall-bladder were cut away and the edges stitched up. Two drainage-tubes were inserted and the external wound closed around them. There was no fever after April 2d. Bile was found on the dressings, but its source was not determined. There was bile in the stools on April 6th, and on the 8th the drainage-tubes were removed and the external wound was stitched up. On April 15th the patient was free from jaundice and got up feeling very well. The case was dismissed about the middle of May, and in July her condition was good.

A successful case of cholecystenterostomy has been reported, on February 25, 1892, as done by Helferich. The patient, a man, aged twenty-nine, had suffered periodically from pains in the stomach since 1885, and developed jaundice in April, 1891. During the following month he had attacks of biliary colic, recurring every fortnight, the jaundice being marked after each attack. It was thought that the common duct was obstructed by calculi, and an operation for their removal was undertaken in November. An incision was made midway between the lower border of the ribs and the border of the enlarged liver, extending vertically in the linea alba to the ensiform cartilage. After the liver had been retracted, the gall-bladder came into view; it contained no calculi, but an examination disclosed a number of calculi in the common bile-duct, which it was found impracticable to remove. An opening was therefore made in the gall-bladder and another in the first part of the jejunum, and a communication was established between these two structures by suturing the corresponding margins of the apertures. The fistula thus formed was of the calibre of a lead-pencil. The patient made a rapid recovery, with disappearance of the jaundice.

Körte reports a favorable result of the union of the gall-bladder with the wall of the duodenum, after the process of Terrier, thus affording two successful cases of duodeno-cholecystostomy.

He states that the patient, after having shown total acholia in the fæces for four weeks, was operated upon. He was, however, unable to lay bare the choledochus, and it remained uncertain as to whether the obstruction was caused by stones or cicatricial stenosis; the indications were, however, in favor of the latter diagnosis. Finding himself completely thwarted in his efforts to lay bare the gall-passages, he determined to establish an anastomosis between the gall-bladder and the duodenum. He sewed the gall-bladder to the bowel, opened both organs, and then stitched the edges of the cuts together. The act of applying a suture so deep in the abdominal cavity constituted not only a difficult, but most tedious, undertaking. For the sake of precaution he wound a strip of iodoform gauze around the suture and kept part of the abdominal wound open. The suture uniting the gall-bladder and intestine healed well and the bile began to flow into the intestine. No bile was ever discharged through the wound to mar the cure.

Richelet performed this operation in one case. The gall-bladder was secured to the duodenum. The results were not very satisfactory, biliary retention persisted, and a second laparotomy was performed, the gall-bladder was opened, and an effort was made to extract the calculus. This resulted in a hemorrhage so severe that death resulted in an hour. At the autopsy it was found that the forceps had seized a calculus, which was so firmly adherent that its displacement had caused tearing of the gall-bladder and had resulted in hemorrhage.

A case of temporary cure is reported by Czerny for occlusion of the choledochus by the operation of cholecystoduodenostomy. This makes four recorded operations by the process which I have designated as duodenocholecystostomy, with favorable results in three of the cases; and the miscarriage in the fourth case was due to an accidental lesion in the extraction of a gall-stone by forceps in the performance of a second laparotomy. It is evident in this case that Richelet had overlooked an essential condition for success in his first operation, by attaching the gall-bladder to the duodenum without taking the precaution to remove the calculus from the cystic duct.

Choleeystocolostomy was performed in one case by Czerny, in occlusion of the ductus choledochus by a calculus. The immediate result of the operation appeared satisfactory, but death occurred two weeks afterward from hemorrhage.

Another operation reported by Czerny presents features of interest, which warrant a record of some details of this case of cholecystenterostomy after temporary cholecystotomy.

A vertical incision was made through the right rectus muscle. The enlarged blackish-yellow liver presented itself in the opening, and on its side was the very tense gall-bladder of the size of a fist. Puncture of the latter yielded 300 c.c. of a clear, watery fluid. The sound could be entered a distance of 14 ctm. through this puncture without meeting with calculi, but its further progress was arrested by some obstruction. Neither concretions nor any tumors could be detected by palpation. An obstruction of the ductus choledochus was suspected, but no cause could be found for it, and a temporary biliary fistula, opening externally, was established in place of the cholecystenterostomy, in order to remove if necessary, later on, the obstruction in the duct, through the gall-bladder. The peritoneal covering of the gall-bladder was stitched to the parietal peritoneum. A part of the abdominal incision was closed, and the opening in the gall-bladder occluded by applying a Péan clamp forceps. Two days after the operation, when the dressing was changed for the first time, 500 c.c. of pure bile rushed forth as soon as the Péan forceps was removed. The unknown obstruction in the ductus cysticus was thus removed. Pure bile was now discharged regularly, but in spite of this, the existing icterus diminished but slowly, and never disappeared entirely; the urine contained, continually, more or less bile, and the fæces were entirely acholic. Therefore, the occlusion seemed not to have been perfectly removed, and cholecystoenterostomy was performed two months after the establishment of the fistula. The fistula was now temporarily closed by sutures, and the existing opening into the abdominal cavity was elongated above and below. The separation of the gall-bladder from the parietes could not be accomplished without injuring its walls, which had several rents. The injured part of the wall of this organ was extirpated, and the resulting circular opening was diminished by two rows of catgut sutures to the size of a bean. A loop of small intestine was then drawn out and united to the posterior wall of the gall-bladder by means of five sutures in the serosa. An incision 1½ ctm. long was then made in the small intestine, thirteen anterior and posterior sutures through the mucosa were inserted, and finally nine sutures through the serosa were applied. Drainage was effected by means of iodoform wick, and the abdominal wound was closed around it.

Temporary improvement followed. Soon afterward, however, the patient sank rapidly and death took place

from exhaustion, induced by cancer of the pancreas, gangrene of the lungs, and other complications. The fatal result occurred three months after the operation, and hence was not a direct consequence of the union of the gall-bladder and the intestine.

An interesting case, in which an anastomosis between the gall-bladder and colon was effected by a process differing materially from the previous operations has been reported by Chavasse.

A man, forty-eight years old, had undergone cholecystotomy for relief of jaundice dependent upon biliary obstruction by calculi, which was followed by the persistence of a biliary fistula. Other means failing, with the aid of Senn's bone-plates, a communication was established between the gall-bladder and the colon at its hepatic flexure. At first, bile and fecal matter were discharged through the abdominal wound, but ultimately this closed, the stools were passed naturally, and the general condition of the patient was much improved.

Further experience with this process may prove as satisfactory as its use in intestinal anastomosis. The increasing interest exhibited by surgeons in the serious consequences resulting from any obstruction to the discharge of bile is strikingly manifested by these aggressive measures, and a new era has dawned upon gall-bladder surgery.

A revolution has been brought about not only in the theoretic views of surgeons, but in the appliances resorted to in the surgery of the gall-bladder and ducts, which encourages the expectation of obtaining a satisfactory solution of the problem of relief for occlusion of the common bile-duct.

"A comparison," says Robson, "of the statistics of the different operations on the gall-bladder, as collected by Dr. Delaganière, would seem to show that although cholecystenterostomy is apparently the most complicated, it is the least dangerous operation."

The practicability of effecting an outlet from the gall-bladder into the duodenum or the intestinal canal, can no longer remain in doubt, and in the view of Courvoisier this operation stands more and more securely as the details from trustworthy sources become more widely disseminated.

Excluding from the reported cases those of a cancerous nature, all should be content with the results of the various procedures for uniting the gall-bladder and the common duct with the duodenum and intestinal canal.

The inferences to be drawn from a study of the results obtained in surgery of the gall-bladder and ducts are the following:

1. In all cases presenting a history of biliary obstruction with manifestation of enlarged gall-bladder, exploratory incision of the abdominal wall, and, conditionally, of the gall-bladder, is warranted.

2. When obstructions of the cystic and common ducts from gall-stones are found, they should be removed by needling, crushing, or incision of the duct and suturing the wound.

3. In case of the presence of a gall-stone in the cystic duct without impediment of the common duct, after removing the obstruction from the former, it would favor the restoration of normal conditions to close the incision in the walls of the gall-bladder without attachment to the parietes.

4. Should there be a degenerated or disorganized state of the coats of the gall-bladder, precluding the performance of its functions, the extirpation of the sac with ligation of the cystic duct will be proper.

5. Under circumstances of doubt as to the permeability of the cystic and common ducts, catheterization should be attempted with flexible bougies, guided by the fingers outside of the ducts.

6. In the event of an impermeable stricture or permanent obstruction of the common bile-duct, with a patulous cystic duct and good condition of the walls of the gall-bladder, the latter may be attached to the duodenum or adjacent portion of the small intestine, so as to effect a communication and thus admit of the passage of the bile.

7. Should the walls of the gall-bladder be likely to undergo disintegration and the walls of the common duct above the obstruction be in a favorable state, an incision in the duct may be united by suture with an incision in the duodenum or other part of the intestinal canal, to give exit to the bile.

8. While the results of a communication of the gall-bladder or common bile-duct with the duodenum or the upper part of the small intestine have proved more salutary than with the large intestine, there are cases in which the connection with the last named is alone practicable, and should be resorted to in preference to establishing an external fistulous opening.

9. Experiment has demonstrated the practicability of securing a union of the walls of the gall-bladder and duodenum with an opening by a single stitch of silk or elastic ligature, but the operations upon the human subject, attended with the best results, have been by incision and suture, with gauze tamponage.

10. The great importance of restoring the bile to the alimentary canal, in all cases of permanent occlusion of the common bile-duct, renders it desirable that an operation shall be undertaken at the earliest practicable period after obstruction to the flow of the bile into the duodenum is recognized as tending to cholæmia.

11. Cholecystotomy and cholecystostomy are not adequate to the relief of occlusion of the common bile-duct, and duodeno-cholecystostomy or cholecystenterostomy is indicated wherever it is evident that there is no outlet for the bile into the alimentary canal by the natural channel.

12. In the advanced stage of cholæmic intoxication from occlusion of the common bile-duct, there is such vital depression as to preclude any benefit from an operation, and it is only calculated to bring discredit upon the surgery of the gall-bladder and ducts to operate under such untoward conditions.

In 1889, Dastre communicated his experiments to the Physiological Congress at Basel, in which he united the gall-bladder with the intestinal canal with a view to study the effects on digestion. It was demonstrated that an animal can live without suffering from the loss of a portion of the bile from the upper part of the small intestines, and that a smaller quantity of bile than the natural secretion or excretion is sufficient for digestion. But the practical inference of most importance in connection with his experiments, is the feasibility of effecting a communication from the gall-bladder into the intestinal tract by incising and suturing their walls together in cases of total occlusion of the common bile-duct.

As in most cases requiring cholecystenterostomy it is requisite to make an incision of the wall of the gall-bladder for the removal of calculi from its cavity, or for proper exploration of the ducts, it is very desirable that some speedy process for suturing the edges of this incision to those of a like incision in the coat of the intestine shall be adopted. If mechanical devices can be dispensed with entirely in the junction of the gall-bladder and intestinal canal, and thus allow a free outlet for the bile, it is a consummation devoutly to be wished for in the performance of this important operation.

Lambotte reports a case, in the *Belgian Medical Press* of July 3, 1892, of external biliary fistula, resulting from cholecystostomy, for which he performed a unique operation. An incision was made in the abdominal wall in close proximity to the fistula, and a portion of the colon was drawn out through it. He then availed himself of the enterotrite of Dupuytren to effect a communication from the fistulous tract into the bowels, thereby conveying the bile off through the colon, instead of letting it flow out through the abdominal wall. The external fistulous opening was subsequently obliterated by a plastic operation.

The instrument presented by Grant at the late meeting of the Southern Surgical and Gynecological Association, at Louisville, Ky., for effecting intestinal anastomosis, meets the indications more satisfactorily than that of Dupuytren, for uniting the gall-bladder with the intestine. Although the author had not even suggested this application of his instrument, the writer submits

that a modification of the blades of this clamp, of such a nature that they can be carried through a small incision into the cavity of the gall-bladder and into the duodenum, or other portion of the intestine, would admit of the use of this instrument in effecting anastomosis of these viscera, and also in lateral intestinal anastomosis without resection.

A paper read before the Mississippi Valley Medical Association, October 15th, by Dr. J. B. Murphy, of Chicago, Ill., and published in the New York *Medical Record* of December 10, 1892, presents the details of a process styled "button anastomosis." It is the application of this procedure in cholecysto-intestinal operations which is of special interest for our investigation.

While this principle of anastomosis is not entirely new, having been adopted by another for uniting the viscera with an opening from one to the other, and by the writer in a case of gastrostomy reported at the Nashville meeting of the American Medical Association in 1890, yet the improvements in the mode of construction entitle Dr. Murphy to the claim of originality in the practical adaptation of the anastomosis button to this class of operations. I have the permission of the author to use his cuts for illustration.

He gives the following description of this device:

The buttons are made in three sizes. A button consists of two small circular bowls (Fig. 163); size No. 2 measures as follows: diameter, 23 mm.; depth, 8 mm. There is "sweated" into a circular opening, 12 mm. in diameter, at the bottom of one bowl, a cylinder 15 mm. in length, with female screw thread on its entire inner surface. The cylinder extends perpendicularly from bottom of bowl. There is an opening in the male bowl in which is "sweated" a similar and smaller cylinder of a size to easily slip into the female cylinder. There are two brass springs soldered on either side of the inner surface of the lower end of the male cylinder, which extend almost to the top, where small points of them protrude through openings in the cylinder. These points are designed to catch the screw-thread when the male cylinder is pressed into the female cylinder, and thus hold the bowls together at any point desired. To separate them again, they are simply unscrewed.

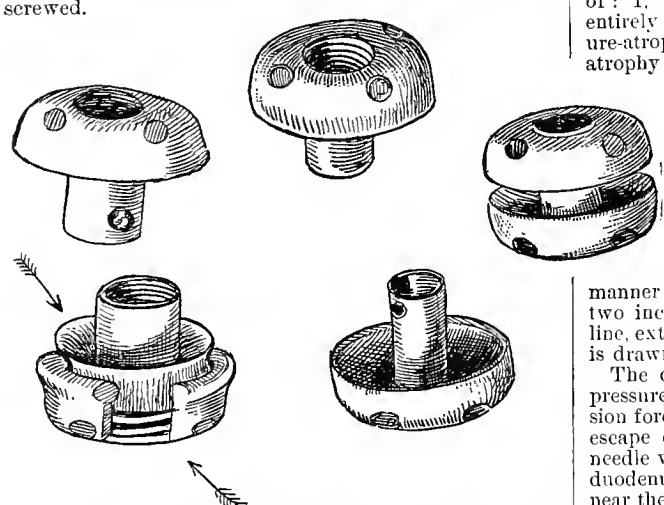
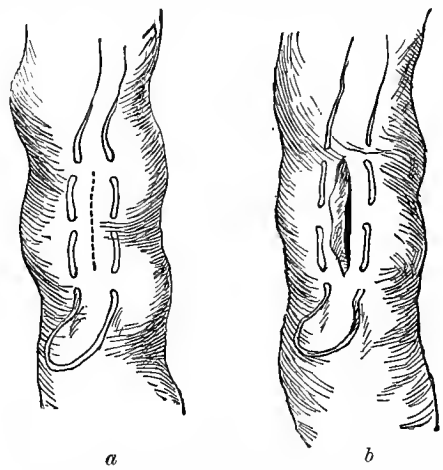


Fig. 163. Appearance of Button, with and without Spring-cup Attachment. (After Murphy.)

A small brass ring, with a thin though not cutting edge, to which is attached a wire spring, is placed in the male bowl and retained in position, projecting one-eighth of an inch above the edge of the bowl. This is held up by the wire spring, and is there for the purpose of keeping up continuous pressure until the entire tissue between the edges of the bowls is cut off. This spring attachment is absolutely necessary only when the stomach is operated on. There are four openings, 5 mm. in diameter, in the side of each bowl, for the purpose of drainage. By this, it will be seen, we have two hemispherical bodies held together by invaginating cylinders (Fig. 163). These hemispheres of the button are inserted in slits or ends of the viscera to be operated on. A running thread is placed around the slit in the viscus, so



a *b*

Fig. 164.—Showing Running Thread before (*a*) and after (*b*) Incision in Bowel. (After Murphy.)

that when it is tied it will draw the cut edges within the clasp of the bowl. A similar running thread is applied to the slit in the viscus into which the other half of the button is inserted, and the bowls are then pressed together. The pressure-atrophy at the edge of the bowl is produced by the brass ring supported by the wire spring. The opening left after the button has liberated itself is the size of the button.

Dr. Murphy claims that this differs from all other devices in the following particulars or combinations thereof: 1. It retains its position automatically; 2, it is entirely independent of sutures; 3, it produces a pressure-atrophy and adhesion of the surfaces at the line of atrophy; 4, it insures a perfect apposition of surfaces, without the danger of displacement; 5, it is applicable to the lateral, as well as to the end-to-end, approximation: 6, it produces a linear cicatrix, and thus insures a minimum of contraction; and 7, it has the merit of extreme simplicity of technique, which makes it a specially safe instrument in the hands of the every-day practitioner, as well as the more dexterous specialist. Dr. Murphy then describes the mode of application. The button is inserted in the following manner: An incision is made from the edge of the rib, two inches to the right of, and parallel to, the median line, extending downward three inches. The gall-bladder is drawn into the wound, and also the duodenum.

The duodenum is cleared of its contents by gentle pressure with the finger. His short intestinal compression forceps is placed upon the duodenum to prevent the escape of gas and fluids after the incision is made. A needle with fifteen inches of silk thread is inserted in the duodenum, directly opposite its mesentery and at a point near the head of the pancreas. A stitch is taken through the entire wall of bowel, one-third the length of the incision to be made. The needle is again inserted one-third the length of the incision from its outlet, in a line with the first, and brought out again, embracing the same amount of tissue as the first (Fig. 164). A loop three inches long is held here, and the needle is inserted in a similar manner, making two stitches parallel to the first in the reverse direction, and one-eighth of an inch from it, coming out at a point near the original insertion of the needle (Fig. 164). This forms a running thread which, when tightened, draws the incised edge of the

bowel within the cup of the button. In the gall-bladder a similar running thread is inserted. An incision is now made in the intestine, two-thirds the length of the diameter of the button used. The button is slipped in, in the manner hereafter to be shown, the running string tied, and the button held with the forceps.

The contents of the gall-bladder are withdrawn with an aspirator. An incision is then made in the gall-bladder of the same length, and between the rows of sutures, the button is inserted in a similar manner, and the running string tied. The serous surfaces to be approximated are scraped with the edge of a scalpel. The forceps is then removed and the two halves of the button are held between the fingers and pressed together (Fig. 165). A sufficient degree of pressure must be used to bring the serous surfaces of the gall-bladder and intestine firmly in contact and maintain pressure upon them. The elastic pressure of the spring-cup of the button produces a pressure-atrophy of the tissue embraced within the cup, and leaves an opening as large as the button, the latter dropping into the bowel and being passed through the intestines.

The time occupied in the case of the first woman on whom he operated was eleven minutes, from the entering of the peritoneal cavity until the closing of the same. On dogs he was from eleven to eighteen minutes in performing the operation. He states that the operation is more difficult to perform on the dog than on man, as it is more difficult to bring the gall-bladder into the wound.

Dr. Murphy draws attention to the number of cases of chronic jaundice from obstruction to the common gall-duct, requiring some operation for relief, and to the defects of the operations now in vogue, namely, the unpleasant and sometimes dangerous sequence of cholecystostomy —an external biliary fistula, which may of itself be a menace to life. He also adverts to the difficulties and dangers of cholecystectomy as a radical operation.

He says that the effect of a permanent fistula of the gall-bladder and the constant escape of bile secreted, as frequently follows cholecystostomy, is different, depending, first, on the quantity of bile that escapes from the opening, and second, upon what proportion is admitted into the intestinal tract. This accounts for the great differences of opinion as to the gravity of biliary fistula ; and if we let the entire quantity of bile escape through a fistula, the patient soon succumbs. Therefore, a safe way of allowing the bile to re-enter the intestine should be welcomed by the surgeon and the patient.

Dr. Murphy gives the result of five experiments upon dogs by uniting the gall-bladder and the duodenum with his anastomosis button, in three of which the animals were killed after the lapse of a month or more. It was found that the button had escaped, leaving an opening from the gall-bladder into the duodenum, with perfect union between their walls, and a valve was formed on the intestinal side of the opening by two folds of the mucous membrane closing over it, permitting the bile to flow out, but preventing the entrance of anything from the intestine. The writer would recall to the reader that this valvular provision was observed in the case operated upon by Kappeler, and reported in his description of the autopsy, the patient having died fourteen months after the cholecystenterostomy.

In one of the dogs, which was subjected to the same operation with the others, the additional experiment of tying the common duct was made and the result examined on the fourth day. A perfect adhesion of gall-bladder to bowel was found and the button was still in position. Hair and food were in the gall-bladder.

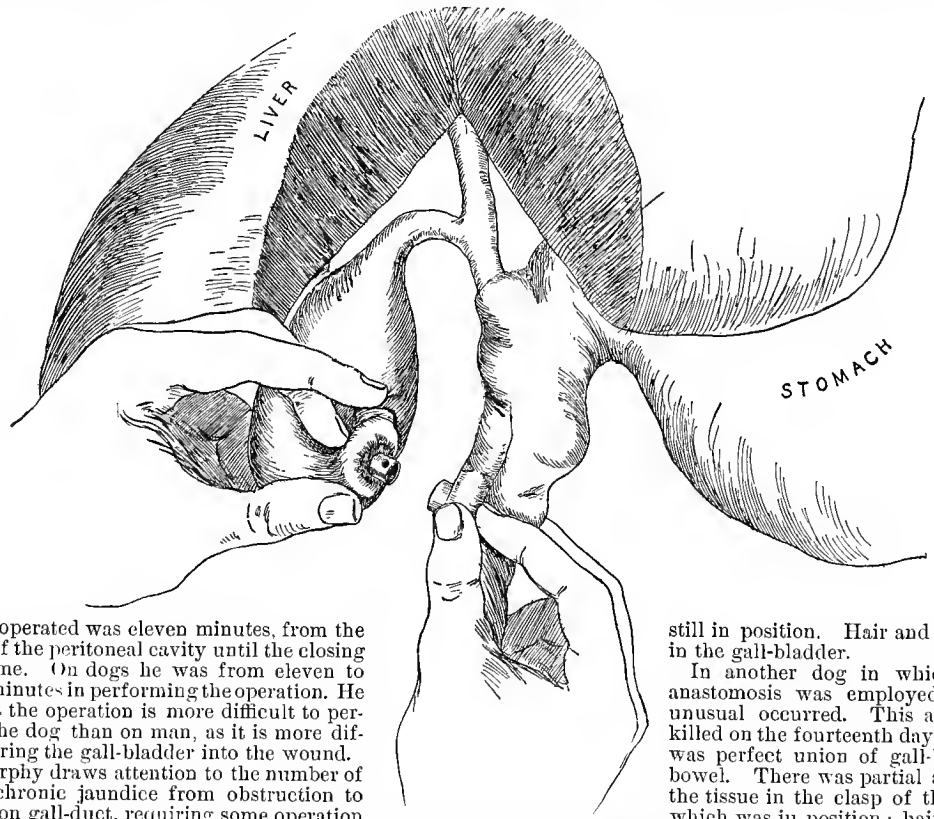


Fig. 165.—Button as Held when its Two Halves are Pressed together in the Performance of Cholecystenterostomy.

In another dog in which button anastomosis was employed, nothing unusual occurred. This animal was killed on the fourteenth day, and there was perfect union of gall-bladder to bowel. There was partial atrophy of the tissue in the clasp of the button, which was in position ; hair and food were in the gall-bladder, and the latter was of about the normal size.

An experiment was made upon one dog, with this modification : the stomach was used in place of the intestine for the anastomosis with the gall-bladder. A little difficulty was experienced in approximating the ends of the button, on account of the thickness of the wall of the stomach. The dog was sick on the following day ; would not eat or play. But on the third day all symptoms had disappeared. The dog was killed fifty-five days after the operation, and the gall-bladder was found to be firmly united to the stomach ; the little finger could be passed into the stomach from the gall-bladder, and there was neither hair nor food in the latter, which was somewhat contracted. The dog did not seem to suffer

any inconvenience from the bile passing into the stomach.

Three operations with the anastomosis button for effecting communication from the gall-bladder into the duodenum in the living human subject, have proved successful in the hands of Dr. Murphy. They were performed on June 11, October 19, and November 23, 1892, upon females aged thirty-five, thirty-eight, and thirty-six years. As the description of the second case embodies most of the points of interest in the operation, it will be given in the words of the author.

"October 19th, I made an incision, three inches long, from the edge of the tenth rib directly downward toward the border of the ilium. The tumor was exposed and found to be a very much enlarged gall-bladder, with large calculi within. The viscus was very œdematous, red, and thickened. It was decided to make a cholecystenterostomy with my anastomosis button (No. 2). The gall-bladder was aspirated and the running thread inserted. The running thread was then inserted into the duodenum and the intestine incised, and the male half of the button inserted; the female half was then inserted in the gall-bladder through a slit made between the running thread, and the button closed. There was no difficulty in inserting the button. The gall-stones were allowed to remain, as I do not consider it necessary to remove them unless they are larger than the button. They will pass out after the button escapes.

"October 20th.—Temperature, 101° F.; pulse, 96. Vomited considerably during the night and complained of headache, which seemed to be effects of the anæsthetic. There was no pain or abdominal tenderness.

"October 21st.—At 5 P.M. yesterday the vomiting ceased, and the patient is feeling very well this morning.

"October 27th.—The patient has had no unpleasant symptoms since October 20th. This morning, in the stool, were found two large gall-stones. The larger one weighed 117 grains (7.8 gm.); its longest diameter 1 inch, its shortest ½ inch. The second stone, 102 grains (6.8 gm.); shortest diameter ⅝ inch and its longest ⅞ inch. It will be noticed that the shortest diameter of the larger stone measures exactly the same as the diameter of button used.

"The patient is feeling very well and sitting up in bed. Complete primary union. Button passed eighteen days after operation."

Nothing is said by Dr. Murphy in regard to the further progress of this case, though his report of a patient subsequently operated on is brought down to November 28, 1892.

There seems to be some discrepancy in the dates of this paper, which was presented to the Association October 15th, containing reports of operations done on October 19 and November 23, 1892; but this may, perhaps, be explained upon the supposition that they were inserted afterward when the paper was published in the *Record*.

If the results of the experiments on dogs and the operations upon human subjects, reported by Dr. Murphy, are to be accepted by the profession as facts without criticism, we certainly have the most convincing proof of the superiority of the anastomosis button in this class of operations. There is an old adage that exceptions prove the rule, but there seems to be no discount to the uniform success of this new process of anastomosis for all the different tissues to which its author has applied it. He states that he performed the operation of gastro-enterostomy three times with the button on the human subject, and that Dr. Wiener did it once. "In all of the cases," he says, "we got a primary adhesion," and he adds that he will give a detailed report of these cases in a subsequent clinical paper on the subject.

Nothing is communicated as to the final outcome of the patients operated on excepting the first, but we are left to infer that all went well with them, as in a great variety of other successful operations with the anastomosis button referred to in this paper.

The writer has received specimens of three different sizes of these buttons from the manufacturer, and is convinced that a smaller button than either would be better suited to effect an opening from the gall-bladder into the duodenum. It is not desirable to have so large an outlet from the gall-bladder for the biliary discharges.

The two larger sizes of the button are of such bulk and weight that their passage through the small intestine may cause trouble, and more especially at the ileo-cæcal connection. It is a known fact that gall-stones, not exceeding greatly the diameter of the largest button, have been arrested in the small intestine, necessitating an operation for removal on account of the obstruction in the canal; and after examination of these buttons there seems to be cause for objecting to the employment of the larger sizes in attaching the gall-bladder to the duodenum. It will be observed that size No. 2 was used in the case recorded in this paper, and that the "button passed eighteen days after the operation." But nothing is reported as to the passage of the button in the other two cases. He states, however, that the patient operated upon on June 11, 1892, was examined by Dr. H. R. Wittmer on October 28th, and that she was in excellent health.

The weight of the buttons might be lessened materially by using aluminium in their construction, thus setting aside an objectionable feature, as the largest size at present weighs 340 grains.

Further experience in the use of the anastomosis button is desirable, before it is finally adopted in the surgery of the gall-bladder. *J. McFadden Gaston.*

GANGRENE. The subject of gangrene in its various forms was fully considered by the writer, in a previous article in the HANDBOOK, to which the reader is referred for a more extended discussion of the subject. It remains, however, to consider it from the stand-point of recent surgical pathology, more especially surgical bacteriology.

That form of gangrene which is due to lack of nutrition of the part, such as that caused by arteritis obliterans and by thrombosis, remains unaffected by recent experimental discoveries. We may therefore divide gangrene into two general classes—the first class being from lack of nutrition, and the second class being a gangrene of microbic origin. The first class, as has been known for a long period, includes alterations of the arteries and veins, and of the nerves of the arteries; these alterations consisting of atheroma, thrombosis, emboli, changes in the blood, and alterations in the structure of the nerves.

Reclus has given the term "direct gangrene" to the first class, including those produced by violent traumatism, by extreme cold, burns, and caustics; "indirect gangrene" to that series in which the lack of nutrition is due to arterial, venous, capillary, or cardiac derangements, and to the different alterations of the blood. The latter term is also applicable as well to the trophic or nervous gangrenes. Clinically, Reclus divides the gangrenes into four types: gangrene by cadaverization, white gangrene, dry gangrene, and moist gangrene.

Gangrene by cadaverization is an exceptional form, in which the skin is cold, dull, rigid, and discolored as after death, the epidermis is easily detached, and on puncturing the integument with a needle or by light strokes of the bistoury, small drops of blood appear. Sometimes the entire member is cold, but without being fatally lost, as in the case stated by Lemont, where after discoloration, coldness, and cornification, in about ten days there appeared, little by little, heat and sensation, and soon all traces of gangrene had disappeared. Ordinarily, however, says Reclus, the gangrene of cadaverization is succeeded by dry gangrene.

White gangrene, as described by Ousnay, appears in the same form and has been confounded with the gangrene of cadaverization. It appears as a hemorrhagic spot on the skin, a sort of limited ecchymosis, which may have its seat anywhere on the body; it is always superficial.

Dry gangrene, or mummification, is invariably produced by blocking of the blood-vessels or by trophic changes.

Moist gangrene applies to the septic variety, and is extremely rapid in its progress. Moist gangrene is distinctively septic, as has been proved by its reproduction by

inoculation, to such a degree that some pathologists have detached gangrenous septicæmia from the traumatic gangrenes.

As a means of determining the exact location of the thrombosis or obstruction, in the case of arteritis obliterans, Dr. W. S. Lyon, of Edinburgh, gives the following method of procedure: Gently raise the limb, keep it raised for two or three minutes to empty it in some degree of its blood, then apply the tourniquet or piece of elastic webbing on the proximal side of the injury or supposed site of the obstruction, and keep it applied for about a minute; then lower the limb and remove the tourniquet. If sufficient circulation remains in the part below the injury it will blush a rosy red and show in an unmistakable manner the condition of the blood-vessels. It must be evident that, as in the case of surface constriction when applied to a given surface, if the arteries are sound underneath, it will speedily cause tension below the ligature by reason of the accumulation of blood, and so, by readjusting the ligature from time to time, it is possible to approximately arrive at the site of obstruction.

Moist gangrene, or emphysematous gangrene, produced by the development of gases in the decomposed part, or putrefactive changes, is now supposed to be due to a bacillus morphologically like that of the malignant œdema, as described by Koch and Gaffney. It is known by the experiments of Rosenbach and others that in these cases of emphysematous gangrene there are present one or more varieties of the proteus micrococcus, with other forms of bacteria, and that the ptomaïnes of these bacteria themselves in some cases may cause tissue death; and that certain bacteria have the power of generating gases, this being true, in particular, of a variety which is called by the French "vibrion septique," which is anaërobic, and which resembles the bacillus anthracis. In this connection it is to be remembered that the treatment of moist gangrene has undergone a radical change; deep and thorough incisions, the injection of anti-bacillary agents, copious and repeated irrigation, are measures which are now practised, and amputation is reserved for cases in which the bones are so enfeebled as to be no longer capable of supporting the member.

It is evident from the mutiplicity of experiments and observations that no one microbe can be the sole cause of gangrene. Godlin[1] reported a case of gangrene resulting in emphysema, which started from an inflamed corn, rapidly extended, and in a week required thigh amputation. The man continued to show sapræmic symptoms after the amputation, and culture experiments with the pus showed the presence of streptococcus pyogenes and staphylococcus pyogenes albus. Lemont and Koch have described another bacillus which they found in a case of emphysematous gangrene, and which resembled the bacillus of glanders. Staphylococcus pyogenes aureus and staphylococcus cereus albus were found in metastatic gangrene of the skin, by Ciarrochi. He also isolated a short bacillus which, when injected under the skin of animals, produced gangrenous pus.

In conclusion it must be stated that the traumatic gangrene, where the parts are pulpified or bruised, and blood is extravasated into the tissues, affords favorable conditions for the growth and propagation of putrefactive bacteria. Senn has well summarized the etiology of septic gangrene as follows:

First Condition, the microbes are so numerous in the capillary vessels that their presence interferes mechanically with the blood-supply, and death of the part ensues in consequence of greatly diminished or suspended nutrition. *Second*, the microbes in the tissues produce ptomaïnes which destroy the tissue by their direct destructive chemical action on the protoplasm of the cells. *Third*, the specific inflammation caused by the microbic infection is so intense that the inflammatory product in the perivascular tissues accumulates so rapidly and in such abundance that nutrition is suspended by impairment or suspension of the arterial blood-supply, or mechanical interference of return of blood from the part, or both of these conditions combined.

Coagulative necrosis, a condition confounded by some with gangrene, was given its name by Cohnheim, and is a condition which takes place in the coagulation of the blood, whereby the colorless corpuscles die and undergo a fermentative change. This is the same as the "fibrine ferment" of the last decade. *John B. Hamilton.*

[1] British Medical Journal, July 27, 1887.

GAS ANALYSIS. I. General Properties of Gases.—(*a*) A gas is characterized by the property of filling uniformly any given space. If the pressure upon a gas be increased, its volume will diminish, and, providing the temperature remain constant, the volume of a gas will be inversely proportional to the pressure. Denoting the volumes by V and v, and the corresponding pressures by P and p, then,

$$V : v = p : P; \text{ or,}$$
$$(1)\quad VP = vp.$$

In other words, at a constant temperature the product of the volume and the pressure is always the same. This law of Boyle holds true only for relatively slight variations of pressure and volume. If it were correct for gases subjected to very great pressure, then the gas which would be first liquefied by the pressure would finally attain a density greater than solid substances, a phenomenon manifestly impossible, because liquid bodies are but slightly compressible. The variations from the law within the limits met with in ordinary analytical operations are, however, so slight, that for the present purposes it may be regarded as correct.

All gases expand in the same proportion when subjected to the same rise in temperature. If one volume of a gas be heated from 0° C. to 100° C., its volume then will be 1.367. The increase in volume for each degree would accordingly be .00367. If v is the volume at any temperature t, and V the volume at 0°, the above may be expressed.

$$(2)\quad v = V(1 + .00367\ t).$$

If a gas which has been thoroughly dried be collected over mercury in a tube closed at the top, and if then a small amount of water, sufficient to saturate the gas with water vapor, be introduced into the tube, it will be seen that the volume is thereby increased. In analytical operations it is quite difficult to dry each portion of gas before measuring, and in calculating the absolute volume of the gas, allowance is made for the increase in volume caused by the water vapor present. The pressure exerted by the water vapor has been determined experimentally for all temperatures, and the volume which a gas saturated with aqueous vapor would occupy if dry can be determined by ascertaining the volume which would correspond to the prevailing pressure, P, less the pressure exerted by the water vapor at the temperature observed. To illustrate, a gas volume saturated with water vapor, and measuring 63.2 cubic centimetres under a barometric pressure of 744.6 millimetres, and temperature of 18.4° C., would, in the dry state, and at the same pressure and temperature, equal $63.2\ \frac{744.6-15.72}{744.6}$ = 61.8 c.c., 15.72 being the tension of water vapor at 18.4° C.

It is evident that for scientific purposes, observed gas volumes should be reduced to the volumes which would be occupied under certain standard conditions. By common consent the pressure of a column of mercury 760 mm. high is termed the normal or standard pressure, and 0° C. the normal temperature. All observed gas volumes, then, are reduced to the volumes which the gases would occupy in a dry state at 760 mm. pressure and 0° C. The necessary data for the calculation have been given above.

In equation (1), if P be taken as the normal pressure of 760 mm., the equation becomes $V = \frac{vP}{760}$. Equation (2) would give for V, $V = \frac{v}{1 + .00367\ t}$. Combining

these two, and subtracting from the observed barometric pressure, P, the tension of the water vapor, m, at the observed temperature, t, we have

$$V = v \frac{P - m}{760\,(1 + .00367\,t)}.$$

To illustrate, 82.3 c.c. of a gas, measured in a moist condition under a barometric pressure of 748.2 mm., and a temperature of 18.6° C., would, under normal conditions, equal

$$82.3 \frac{748.2 - 15.91}{760\,(1 + .00367 \times 18.6)} = 74.1 \text{ c.c.}$$

(*b*) *Partial Pressure.*—Gases mix in all proportions. The pressure of the mixture is the sum of the pressures of the various gases in the mixture. The pressure exerted by each of the gases is the same as the gas would exert if present alone in unchanged amount in the same space. This pressure exerted by each gas of a mixture is known as its *partial pressure*. One hundred volumes of the atmosphere contain 20.9 volumes of oxygen and 79.1 volumes of nitrogen. If air were confined in a vessel under a pressure of 760 mm. and the oxygen were then removed, the remaining nitrogen would then fill the whole space and would exert a pressure of $760 \times 0.791 = 601.16$ mm. Had the nitrogen been removed, the oxygen would have exerted a pressure of $760 \times 0.209 = 158.84$ mm. These, then, are the partial pressures of the two chief constituents of the atmosphere.

The well-known researches of Paul Bert have shown that this partial pressure of atmospheric oxygen plays an important rôle in the process of breathing. We have seen above that the oxygen of the atmosphere exerts a pressure of about one-fifth of the total pressure of the air. Bert has shown that animals and men can live in pure oxygen if the pressure of the gas be reduced to one-fifth of an atmosphere, or, in other words, to the pressure which it exerts in the atmosphere. If, on the other hand, animals be confined in air whose pressure has been reduced to one-fifth of an atmosphere, death soon results, because here the partial pressure of the oxygen is only one-twenty-fifth of an atmosphere.

(*c*) *Diffusion of Gases.*—Molecules of gases move constantly in all directions, and if a layer of a light gas be carefully introduced over a layer of a heavier one, it will be found that, after some time, the lighter gas above has passed downward and mixed with the heavy gas below, and *vice versâ*. This property, known as diffusion, is possessed by all gases. Whenever different gases are in contact, the molecules of adjacent layers tend to intermingle and form homogeneous mixtures.

(*d*) *Solution of Gases in Liquids.*—All gases are more or less soluble in liquids, the amount dissolved depending upon the nature of the gas and solvent, and also upon the temperature and pressure. Gases which can be easily liquefied are more soluble than those which are liquefied only with difficulty, and, on the other hand, warming diminishes the solubility of the gas, perhaps because the rise of temperature removes the gas further from the liquefiable state. Henry, in 1830, found that at constant temperature the amount of gas dissolved is proportional to the pressure. That is, if a liquid absorbs a certain amount of gas at a pressure of one atmosphere, it will absorb twice as much of the gas under a pressure of two atmospheres, and at half an atmosphere half as much. This law of Henry is not absolutely correct, but it approaches the truth very closely for those gases which are but slightly soluble.

The amount of a gas taken up by an absorbent, as water, is determined by experiment with an "absorptiometer," such as that used by Bunsen,[2] or by L. W. Winkler,[9] and from the data thus obtained a table of the solubility of the gas at different temperatures can be made out. Bunsen denotes the solubility by the term "absorption-coefficient," by which he means the volume of gas reduced to 0° and 760 mm. pressure, which is absorbed by 1 c.c. of liquid at the same pressure.

It is important to remember in this connection that the solubility of a gas in a mixture of gases is not influenced by the presence of the other gases, and is not proportional to the total pressure of the mixture, but only to the pressure exerted by the gas in question, *i.e.*, its partial pressure. Thus water exposed to the air does not dissolve equal amounts of oxygen and nitrogen, nor amounts proportional to the solubility of the two gases, but rather the volumes of the two gases which the water will absorb depend upon both the solubility and the partial pressure of the two gases. To illustrate, the pressure exerted by nitrogen when the total atmospheric pressure is 760 mm. is about seventy-nine per cent. of 760, or 600.4 mm. At 760 mm. pressure and 20° C., 1 c.c. of water absorbs 0.014 c.c. of nitrogen; hence at 600.4 mm. pressure it would absorb $0.014 \times \frac{600.4}{760} = 0.0109$ c.c. Under the same conditions 1 c.c. of water dissolves $0.028 \frac{159.6}{760} = 0.0058$ c.c. of oxygen. Hence, when air is dissolved by water under the above conditions 65.2 per cent. of the dissolved gas would be nitrogen and 34.8 per cent. would be oxygen, or, in other words, the oxygen would amount to more than one-third of the total volume of dissolved gas, although in the air it amounts to one-fifth.

The law of partial pressure thus explains why the various components of a mixture of gases are taken up by a solvent in amounts depending upon the pressure of each gas and independent of the other gases present.

When the molecules of a gas come in contact with the surface of a solvent such as water, they are held fast or are absorbed, and this absorption continues until the water has taken up a certain number of the molecules. Some of the gas-molecules will meanwhile escape from the water and pass back into the gas, and when the number of molecules which enter the water in a given time is equalled by the number which escape, the water is said to be saturated with the gas. If the pressure of the gas be increased the number of molecules absorbed by the water will also be increased, and with diminished pressure the opposite will be true.

In the absorption of the gases in a mixture the amount of each gas absorbed will, as we have seen, depend upon the partial pressure of that gas, and the escape of the same gas from the water will be influenced by its own partial pressure in the mixture, but not by the pressure exerted by any other constituent. In other words, the atmosphere of another gas prevents the escape of a dissolved gas no more than would a vacuum. There are no molecules of the dissolved gas present to enter the water, and the gas, by reason of its elasticity, passes out. That many gases can be driven out of water by boiling, even although the gases are somewhat soluble in boiling water, may be explained by the fact that the surface of the water becomes covered with a layer of aqueous vapor, the partial pressure of the gas upon the surface of the water is thus made very slight, and, as a consequence, the dissolved gas escapes.

II. The Analysis of Gases.—(*a*) *The Collecting and Keeping of Gas Samples.*—In gas analysis, as in all other analytical work, the proper taking of the sample is one of the most important operations. Notwithstanding the rapid movement of gas molecules, currents of gases are often of varying composition, especially when chemical processes are simultaneously going on. On this account the place at which the samples of gas are taken is of the greatest significance. In pipes or other channels the point of smallest cross-section is the most suitable. In the examination of furnace gases it is best to take the sample at the point where the visible flame ends, because farther away, on account of the porosity of the wall, considerable quantities of air are always mixed with the gases from the fire. To take the sample an iron tube is introduced into the furnace at a suitable point. A small lead pipe, such as is used for pneumatic bells, is attached to the outer end of the iron tube by means of a piece of rubber tubing. At temperatures under 300° the lead pipe itself may be inserted into the furnace. The great

advantage possessed by such lead pipe is that it is very small internally and can be manipulated as easily as rubber tubing. For very high temperatures either porcelain tubes or cooled iron tubes may be used. With acid gases glass tubes should be employed if possible.

Long rubber tubes must be avoided, but short pieces may safely be used for connections. Rubber receivers also are to be rejected. Vulcanized rubber acts toward gases as does a liquid, absorbing the gases, and later, according to the prevailing pressure, giving them up again. For example, a piece of rubber tubing, 3 ctm. long and from 4 to 5 mm. external diameter, absorbed 0.2 c.c. of carbon dioxide and 0.9 c.c. of nitrous oxide, and on lying in the air it gradually gave up these gases.

If the place where the gases are to be collected is directly accessible, as, for example, in the examination of mine-gases, the small "medicine bottles" * proposed by Bunsen may be used, the neck of the bottle being drawn out in the flame of the blast-lamp as in Fig. 166. Bunsen states that the bottle should first be carefully heated between the shoulder and the neck, and the neck then drawn out by

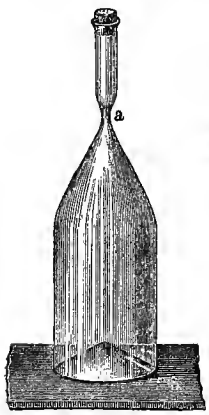


Fig. 166.

Fig. 167.

Fig. 168.

means of suitable tongs (Fig. 167). To fill the bottle with gas, the air in the bottle is sucked out through a small glass tube reaching to the bottom, this operation being repeated until the air originally in the bottle is completely replaced by gas from outside. Five or six full breaths are sufficient. It is self-evident that at each exhalation of the air sucked from the bottle one must step aside from the spot where the gas sample is being taken. The tightly stoppered bottle is then slightly warmed over a spirit-lamp, and equilibrium between the expanded air inside the bottle and the outside atmosphere is re-established by lifting the cork for a moment. After cooling, the diminished pressure inside the bottle prevents the blowing-out of the glass when the narrow neck is fused together. The fusion may conveniently be performed with the blow-pipe shown in Fig. 168. The small lamp (*a*) holds 3 grammes of oil and is connected with the blow-pipe by means of a flexible wire that carries a collar (*b*) through which the tip of the blow-pipe is inserted.

The cork *c* serves as a mouth-piece, by means of which the whole apparatus can be held and guided by the teeth alone. Thus both hands are left free, and the flame can still be moved in all directions, since the relative positions of the blow-pipe tip and the lamp remain the same, however the instrument be held.

The arrangement used by Hempel in his parallel researches "upon the composition of the atmosphere at different parts of the earth" is also a very convenient one. The air was collected in glass tubes of the form shown in Fig. 169. *d* is about 4 mm. thick; *a*, *b*, and *c*, only 1 mm. These tubes were heated in an air-bath in the laboratory to 200°, and were then exhausted with the mercury air-pump and fused together at *c*. By simply breaking the tube at *b*, it is filled instantly and with the greatest certainty by the gas in question. The tubes are then closed for a few moments with a rubber cap, and are melted together at *a* over a candle. The exhausting with the air-pump has the advantage of rendering one less dependent upon the care of the person who fills the tubes. If, however, it is desired to avoid this exhausting, the tubes are given the following form (Fig. 170). To fill such a tube, the gas to be examined is drawn through it and the tube is then fused together at *a* and *b* in a candle flame (Fig. 171).

Fig. 169.

Fig. 170.

Such tubes can be most safely shipped by packing them

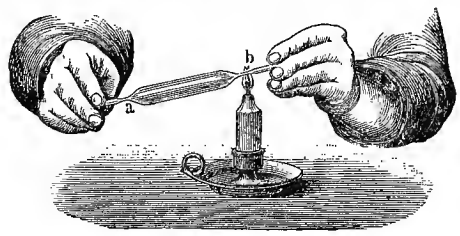


Fig. 171.

in sawdust in boxes which have a separate compartment for each tube. The boxes themselves are placed in a larger box filled with hay.

The tube last described is filled by the displacement of the air already contained therein. Naturally it is here presupposed that large amounts of gas are at one's disposal. If only a small quantity of gas is obtainable, the receiver must be filled with water or mercury, which is then displaced by the gas. Water can be used only when it is first saturated with the gases in question, as, for example, is always the case with the water of bubbling springs.

To collect gas from such springs as are directly accessible, the small apparatus proposed by Bunsen is used (Fig. 172).

This consists of a test-tube, *c*, of from 40 to 60 c.c. capacity, drawn out at *a* before the blast-lamp to the size of a fine straw, and connected air-tight with the funnel *b* by means of a well-fitting cork or a piece of vulcanized rubber tubing. Instead of the test-tube a small long-necked medicine bottle may be used, this being drawn out in the middle of the neck to a similar straw-like contraction. The apparatus is then filled with the water of the spring. This cannot be done without access of air, which would change the composition of the gases diffused through the spring water in the tube. Hence the inverted apparatus, with the mouth of the funnel upward, is lowered below the level of the spring, and, with a narrow tube reaching to the bottom of the test-tube, the water which in the first filling had come in contact with the air is sucked out until one is satisfied that it has been entirely replaced by other water from the spring. If now the gas of the spring is allowed to rise through the funnel into the test-tube thus filled, the purity of the sample is assured. If the rising bubbles stop in the neck

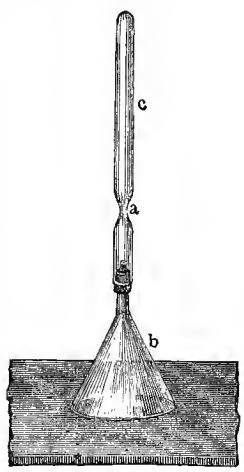


Fig. 172.

* These so-called medicine bottles are common glass bottles about 12 ctm. high. They were recommended by Bunsen because they can be found almost everywhere, even small village drug-stores having a supply of them.

of the funnel or at the contraction *a*, they can easily be made to ascend by tapping the edge of the funnel upon some hard substance. The apparatus is then placed in a small dish and removed from the spring, and the tube is melted together at *a*. This can easily be done with the blow-pipe, the moisture at the point *a* having first been driven away by warming.

For the determination of the volume and composition of the absorbed gases in liquids, the Tiemann and Preusse

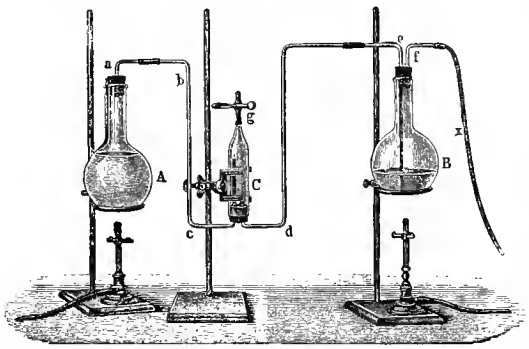


Fig. 173.

modification of Reichardt's apparatus[3] can be recommended (Fig. 173).

This consists of two flasks, *A* and *B*, each of about one litre capacity, and connected by tubes with the gas-collector *C*. The flask *A* is fitted with a perforated rubber stopper, in which is inserted the glass tube *a*, bent at a right angle and ending flush with the lower surface of the stopper. *a* is joined by a piece of rubber tubing to the tube *bc*, which in turn connects with the gas-collector *C*. *C* is held by a clamp, has a diameter of 35 mm., is about 300 mm. long, and at the upper end is drawn out to a short, narrow, and slightly bent tube which can be closed with the rubber tube and pinchcock *g*. In the lower end of *C* is a rubber stopper with two holes, through one of which the tube *bc*, projecting about 80 mm. into *C*, is inserted. Through the other opening passes the tube *d*, which extends only slightly beyond the stopper and connects *C* with the flask *B*. *B* has a double-bore rubber stopper carrying the tubes *e* and *f*. *e* ends about 10 mm. above the bottom of the flask, and above the stopper it is bent at a right angle and is connected with *d*. The tube *f*, which need not project below the stopper, carries a thin rubber tube (*x*), about one metre in length and provided with a mouth-piece. A pinchcock for closing the rubber tube between *a* and *b* is also needed.

The apparatus thus arranged is made ready for a determination by filling the flask *B* somewhat more than half full of boiled water, and removing the flask *A* by slipping the tube *a* out of the rubber connection; then, by blowing into the rubber tube *x*, water is driven over from the flask *B* into the gas-collector *C* and the adjoining tubes until the air is wholly displaced. The rubber tubes at *b* and *g* are now closed with pinchcocks. The flask *A* is then filled to the brim with distilled water, the stopper is inserted, water being thereby driven into the tube *a*, and the flask is again connected with *b*, the pinchcock being opened.

The water in *B* is now heated to gentle boiling, and that in *A* is allowed to boil somewhat more rapidly. The absorbed air is thus driven out, and the gases dissolved in the water which is in *A* and *C* collect in the upper part of *C*, from which they are removed by occasionally opening the pinchcock at *g* and blowing into the rubber tube *x*.

When, upon cooling the apparatus, the gases which have collected disappear, the heating of the flask *A* is discontinued, the pinchcock between *a* and *b* is closed, and *A* is disconnected and emptied. The water in *C* and *B* is now entirely free from absorbed gases, and air cannot enter from without because the liquid in *B* is kept continually boiling. The apparatus is now ready for a determination, which is made as follows:

The cooled flask *A*, whose capacity has been previously determined, is filled with the water to be examined, and the stopper is pressed in so far that the air in the tube *a* is completely driven out. *a* is then connected with *b*, care being taken that in so doing no air-bubbles are enclosed. The pinchcock between *a* and *b* is opened, and the water in *A* is heated to gentle boiling. The dissolved gases are hereby driven over into the gas-collector *C*. Steam is formed at the same time. The heating of the flask *A* must now be so regulated that the gas and steam evolved never drive out more than half the liquid in *C*; otherwise there is danger of gas-bubbles entering the tubes *d* and *e* and thus escaping.

After heating for about twenty minutes the flame under *A* is removed. In a few minutes the steam in *A* and *C* condenses, and water passes from *B* toward *C* and *A*. If a gas-bubble is observed in *A*, the flask *A* must again be heated and cooled in the manner just described. The operation is ended when the hot liquid flows back and completely fills *A*. The rubber tube *g* is then connected with a small tube which is filled with water or mercury, and the gas standing over the hot liquid in *C* is driven over into a eudiometer, gas burette, or gasometer by blowing into the tube *x* and opening the pinchcock *a*.

As it is difficult, and sometimes impossible, to completely remove the dissolved gases from water by boiling alone, it has been found advantageous to combine with the boiling of the water the use of the mercury air-pump. One of the best forms of apparatus thus far devised for the purpose has been recently described by Hoppe-Seyler[4] (Fig. 174).

A is first filled with mercury by raising *C*, the clamp *b* is closed, and the air in *B* is removed by opening *c* and lowering *E*, thus drawing most of the air in *B* over into the upper part of *D*. *c* is then closed and by raising *E* the air is driven out through *e*. Upon opening *c* some mercury will enter *B*, and the above procedure is repeated until all air has been removed from *B* and *D* and the tubes are filled with mercury. The water whose dissolved gases are to be examined, can then be drawn into *B* and *A* without coming into contact with the air. The water in *A* is then heated to boiling, the evolved gas collects in *B*, and, *b* having been closed, the gas can be

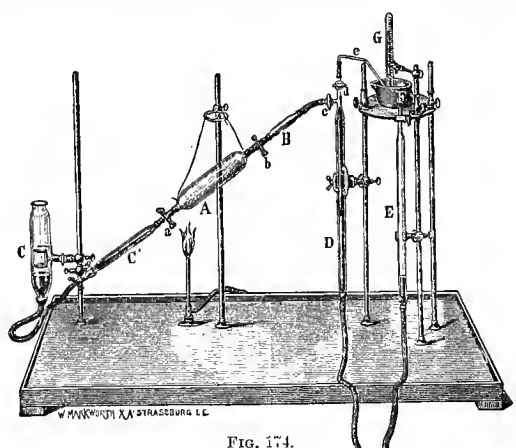


Fig. 174.

drawn over into *D* and transferred to the measuring tube *G* or any other desired apparatus.

The researches of Jacobsen and Pettersson have shown that it is impossible to remove the dissolved carbon dioxide from the water by boiling, and Hoppe-Seyler, in his description of the apparatus figured above, says that after forty boilings of a water containing carbon dioxide some of the gas still remained in the liquid. For these reasons it is best not to attempt to remove the gas

from the water, but to determine it while still in solution. One of the best methods for accomplishing this is one devised by Pettenkofer, which consists of precipitating the carbon dioxide dissolved in the water by adding a solution of calcium hydroxide of known strength, allowing the precipitate to settle, and then determining the excess of the calcium hydroxide in an aliquot portion of the clear supernatant liquid by titration with dilute oxalic acid. Litmus solution is used as the indicator. Sutton describes the method as follows :

"The following is the best method to be pursued for ordinary drinking-water not containing large quantities of carbon dioxide: 100 c.c. of the water is put into a flask with 3 c.c. of a strong solution of calcium chloride, and 2 c.c. of a saturated solution of ammonium chloride ; 45 c.c. of lime-water, the strength of which has been previously ascertained by means of decinormal acid, is then added, the flask well corked and put aside to settle. When the solution has fully subsided, take out 50 c.c. of the clear liquid with a pipette, and titrate this with

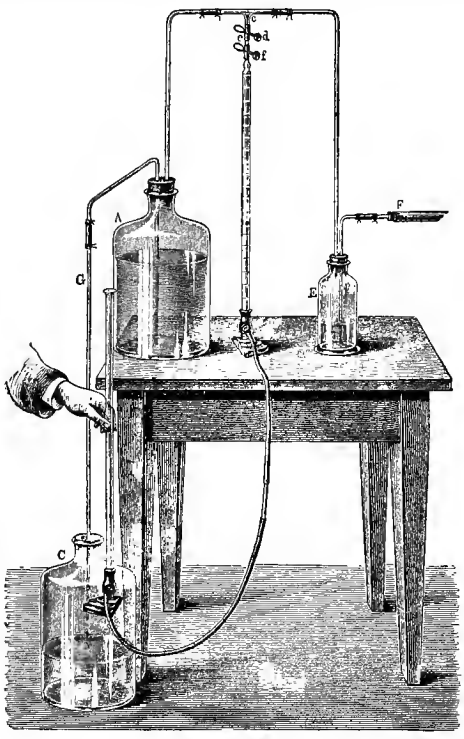


Fig. 175.

decinormal acid. The quantity required must be multiplied by three for the total lime solution, there being only 50 c.c. of the solution taken ; the number of cubic centimetres so found must be deducted from the original quantity required for the calcium hydroxide solution added ; the remainder multiplied by 0.0022 (the acid being decinormal) will give the weight of the carbonic acid existing free and as bicarbonate in the 100 c.c. of water.

"The addition of the calcium chloride and the ammonium chloride is made to prevent any irregularity which might arise from the presence of alkaline carbonates or sulphates; or of magnesia. If it be desired to ascertain the volume of the carbon dioxide from the weight, 1,000 c.c. of the gas at 0° C., and 760 mm. pressure, weigh, 1.96503 gramme."

If the gases to be collected have a pressure less than the prevailing atmospheric pressure, an aspirator must be used. The simplest form consists of two interchangeable bottles of equal size and the same width of neck.

Fig. 175 shows an arrangement which may be used when one wishes to take samples at the same time in a Hempel gas burette (see later). The water passes from the bottle *A* through the siphon *G* into *C*, and thereby draws the gas from the tube *F*. When *A* is empty, *C*, which is now full, is put in its place, the aspirating of the gas continuing as long as the samples are being taken. While the gas is being thus drawn from *F* into *A*, a sample for analysis may be at any time drawn off into the gas burette by lowering the level-tube, as shown in the figure, and opening the pinchcocks *d* and *f*.

When running water is at hand, the aspirating may be done by means of the ordinary glass or brass suction-pump attached to the faucet.

A gas can be best kept in the fused glass tubes already

Fig. 176.

described, but glass bulbs supplied with two glass stopcocks are also quite satisfactory (Fig. 176).

Metallic receivers should be used for analytical purposes only when the gas is to remain in them but a short time. They are, however, not easily broken, and are especially well adapted to the transport of large quantities of gas.

Rubber sacks should never be employed, since gas mixtures confined in them rapidly change in composition.

If large amounts of gas are to be collected and kept for analysis for a considerable length of time, the portions of gas taken for analysis must be displaced with mercury. It is utterly impracticable to use water for this purpose, for continual changes would take place, since the absorption varies with the pressure and temperature. A gasometer

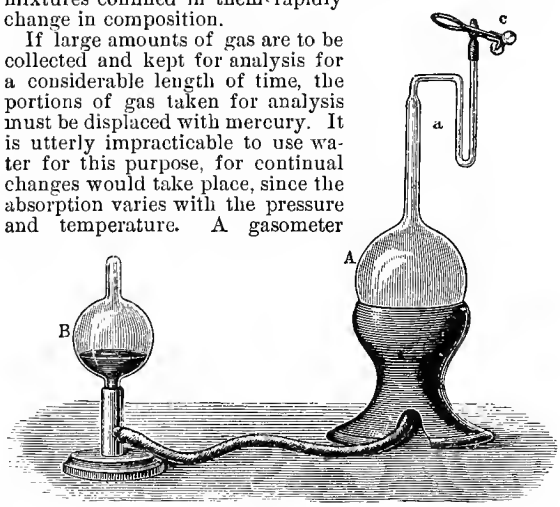


Fig. 177.

well adapted to keeping comparatively small volumes of gas is shown in Fig. 177.

The large glass bulb *A* serves to hold the gas. At the top it carries the bent capillary tube *a*, and at the bottom it is joined to the level-bulb *B* by a rubber tube. The capillary is closed by a rubber tube and pinchcock. The apparatus is first filled with mercury. By lowering or raising the level-bulb, gas can be drawn in or driven out as desired. If gases are to be kept for some time, the capillary tube *a* is filled with mercury by means of a little pipette inserted at *c*. This closes the bulb perfectly. In such an apparatus gases may be kept unchanged for an unlimited time.

Small glass bulbs (Fig. 178) are also very convenient. They are filled with gas in a mercury trough, and are then placed mouth downward in small porcelain crucibles containing mercury. The gas is taken out with the gas pipette to be described later.

Fig. 178.

(*b*) *The Apparatus.*—The amount of a gas may be determined by : 1, The direct measuring of its volume ; 2,

absorbing the gas with a solution of known strength, and then ascertaining by titration the amount of the solution which has been acted upon ; 3, absorbing the gas with a weighed amount of an absorbent, and then ascertaining the increase of weight ; 4, burning the gas, and determining the products by either volumetric or gravimetric methods.

Although isolated analyses of gases had been made before his time, Robert Bunsen[2] was the first to develop gas analysis as a distinct branch of analytical chemistry, and to devise methods by which gas mixtures could be examined with accuracy. The forms of apparatus and the methods which he introduced, and which have since been improved by Geppert,[7] have made possible, in the analysis of gases, an exactness that has perhaps never

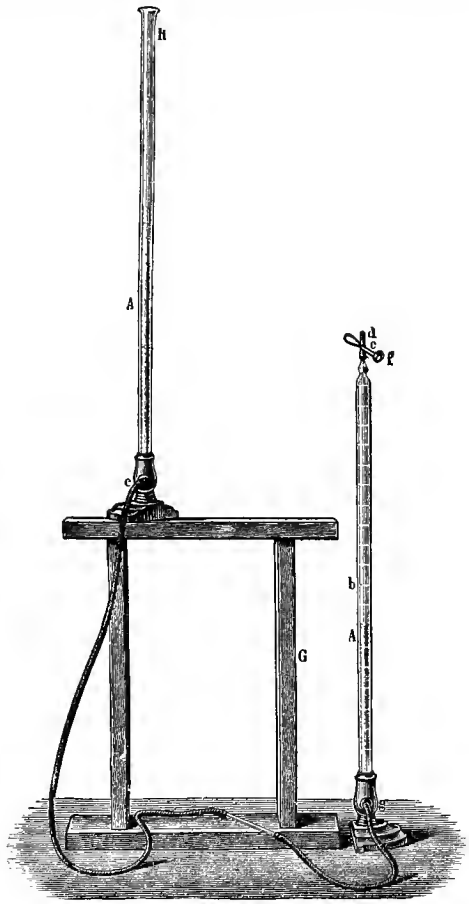


Fig. 179.

been exceeded by other procedures. But the apparatus used by both Bunsen and Geppert is cumbersome, and the analysis of a gas mixture of any complexity is a long and tedious operation, so that while Bunsen's methods have met with early and lasting approval, they have not found wide use among chemists.

With the growth of the great industrial processes in Europe, and especially in Germany, there arose a demand for analytic methods which, if not so exact as those of Bunsen, should be fairly accurate, simple, and rapid. This demand was met, with remarkable success, by Clemens Winkler, whose classical work upon qualitative and quantitative gas analysis[6] made the field of technical gas analysis as easily accessible as the other branches of analytical work developed by Rose, Mohr, Fresenius, and Plattner. In 1880 Walter Hempel published his "Neue Methode zur Analyse der Gase," and there described apparatus and methods remarkable for their exactness and ease of manipulation. The many improvements which Hempel has made in his methods since that time he has embodied in a second work, "Gasanalytische Methoden" (1890), from the English translation[1] of which many of the following descriptions are taken.

Hempel's Apparatus for Technical Gas Analysis. —*Gas Burettes.*—These are carefully graduated tubes in which the gases are measured.

A. The Simple Gas Burette (Fig. 179). This consists of two glass tubes, *A* and *A*, which are set in iron feet and are connected by a thin rubber tube about 120 ctm. long. To facilitate the cleaning of the burette the rubber tube is divided in the middle and the two ends joined by a piece of glass tubing.

Inside the feet the tubes are bent at right angles and conically drawn out. The end projecting from the iron is of about 4 mm. external diameter and is somewhat cor-

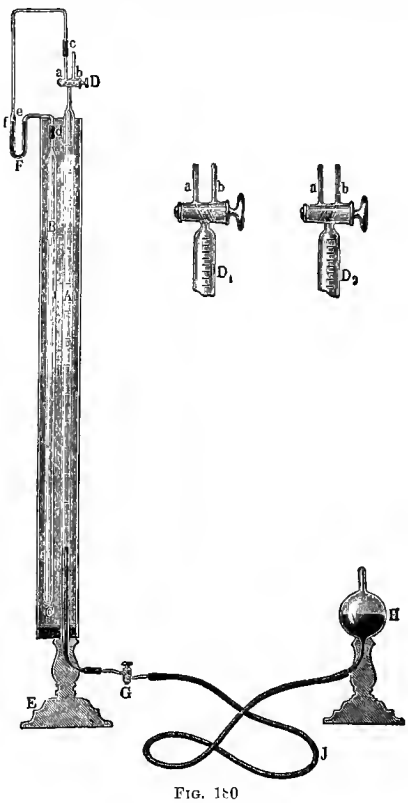


Fig. 180

rugated, so that a rubber tube may be tightly fastened to it by wire ligatures.

The measuring tube *b* ends at the top in a thick-walled tube, *c*, of from ½ to 1 mm. internal diameter and about 3 ctm. long. Over this a short piece of new black rubber tubing is wired on. The rubber tube is closed by a Mohr pinchcock, which is put on close to the end of the capillary. Notwithstanding the fact that readings cannot be made under the rubber tube, and that the pinchcock cannot always be put on above the tube in exactly the same position, no error results therefrom, since the glass tube *c* is very small.

The graduated measuring tube *b* contains 100 c.c., the lowest mark being slightly above the iron foot. The cubic centimetres are divided into fifths, and the numbers run both up and down. The other tube, which we will call the level-tube, is somewhat widened at the upper end, *h*, to facilitate the pouring in of liquids.

B. The Hempel-Pettersson Gas Burette, Independent of Changes in Temperature and Atmospheric Pressure (Fig.

180). The graduated measuring tube *A* contains 100 c.c. and is fastened into the heavy cast-iron foot *E*. The burette is closed at the top by an obliquely bored stopcock, which opens into the two capillary tubes *a* and *b*. The burette is connected by two short pieces of rubber tubing with the manometer *F* and the Pettersson correction tube *B*. This correction tube is a plain glass tube closed at the bottom and joined at *d* to the manometer *F* by a piece of rubber tubing. Both the burette and correction tube stand in a wide glass tube, *C*, filled with water. *C* is open at the top, and is closed at the bottom by a single-bore rubber stopper. The **U**-shaped part of the manometer tube *F* is about 6 mm. wide; from *e* to *e* it is capillary when mercury is used as the confiuing liquid, but when water is used this part is 3 mm. wide. The burette is connected by rubber tubing with the stopcock *G* and the level-bulb *H*.

Mercury, or water saturated with the gas to be analyzed, is used as confining liquid. If the gases are to be measured in a moist condition, as is generally advisable, a drop of water is introduced into the correction tube *B*.

Before using the apparatus for an analysis, the size of the space between *f* and *e* in the manometer tube must be determined once for all. This is done by drawing some air into the burette, and then bringing the three-way cock into the position D_1, so that the burette communicates with the manometer. By raising or lowering the level-bulb the enclosed gas can easily be brought to the pressure of the gas in the correction tube *B*. This is accomplished when the liquid stands at the same height in both sides of the **U**-tube of the manometer. The cock *G* is now closed, and the size of the gas volume is read off on the scale.

Upon again opening *G* and lowering the level-bulb, the liquid in the manometer tube may easily be drawn over as far as *e*; *D* is then closed again and another reading of the volume is taken, the gas being first brought to the pressure of the atmosphere by raising the level-bulb. The difference of the two readings gives the capacity of the tube between *f* and *e*. It is here presupposed that the air enclosed in *B* has the same pressure as the outside atmosphere. This can easily be brought about, for equilibrium is established by simply drawing the manometer tube at *d* out of the rubber connection.

Other slight changes of pressure need not be considered in making this measuremeut, since the volume of gas is itself very small.

This constant having been determined, the measurement of gases is made as follows:

Fill the burette completely with the confining liquid by raising the level-bulb, connect *b* by a capillary tube with the vessel containing the gas to be examined, and draw the gas into the burette. The stopcock must of course be in the position of D_2. To measure the gas, turn the cock into the position D_1, and by then raising or lowering the level-bulb bring the liquid in both sides of the manometer to the same level. The stopcock *G* is now closed and the reading is taken. The true volume is equal to that read off plus the correction-constant. After measuring, draw the gas out of the manometer-tube back into the burette.

The absorptions are made in gas pipettes described below, which are connected by means of capillary tubes with the tube *b*.

Absorption Pipettes.—A. The Simple Absorption Pipette for Liquid Reagents (Fig. 181). It consists of two large bulbs, *a* and *b*, joined by the tube *d*, and of a thick-walled glass tube, *e*, of ½ to 1 mm. internal diameter, and bent as shown in the figure.

This tube is called the *capillary tube*. The bulb *a* holds about 100 c.c., and *b* about 150 c.c., so that when 100 c.c. of gas is brought into *b* sufficient space for the absorbing liquid will remain. To protect the pipette from being broken and to facilitate its manipulation, it is screwed to a wooden or preferably an iron standard. On account of the different behavior of wood and glass or iron toward changes of temperature and atmospheric moisture, it is advisable to fasten the glass at only three places by means of metal bands and sealing-wax, the capillary tube being allowed to project from 2 to 3 ctm. above the frame.

A short piece of rubber tubing is wired on to the free end of the capillary. The distance *h* must be greater

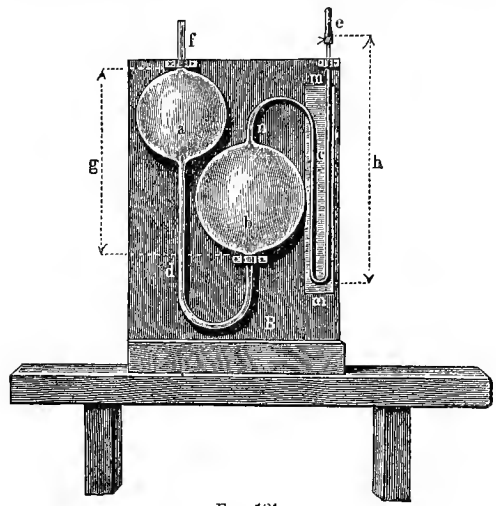


Fig. 181.

than *g*, so that it may be possible to enclose a gas between two columns of liquid in the pipette. If a wooden stand is used, a white porcelain plate is set in at *m* to render the liquid in the capillary tube more distinctly visible, but if the stand be of iron, as shown in Fig. 182, no plate is necessary.

B. The Simple Absorption Pipette for Solid and Liquid Reagents. The only difference between this and the simple pipette is that in place of the bulb *b* there is inserted a cylindrical bulb provided with a neck through which solid reagents can be introduced (Fig. 182). The neck can be closed by a cork or rubber stopper, held in place by a wire. Or a glass tube closed at the top, and over which a rubber ring, cut from a rubber tube is drawn, may be used (see cut).

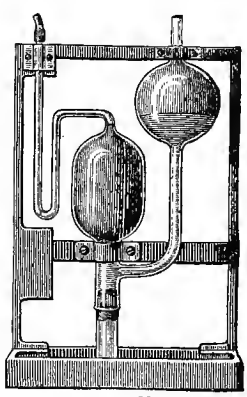


Fig. 182.

Double Absorption Pipettes. Reagents which are acted upon by oxygen, *i.e.*, potassium pyrogallate, cuprous chloride, ferrous salts, etc., cannot, of course, be kept in the above form of pipette, since the reagent in *a* would become inactive in a short time through contact with the air. To avoid this difficulty, Hempel devised

C. The Double Absorption Pipette (Fig. 183). The reagent is contained in the bulbs *a* and *b*. The bulbs *c* and *d* contain water and prevent all access of air to the reagent. *a* is of about 150 c.c. capacity, and *b*, *c*, and *d* contain each about 100 c.c. The bulbs are connected by the bent tubes *e*, *f*, and *g*, and end in the bent capillary tube *k*.

To permit of the use of solid reagents in this double pipette, it may be modified as was the simple pipette.

D. The Double Absorption Pipette for Solid and Liquid Reagents (Fig. 183). The solid reagent is introduced into the cylindrical bulb *a* through the neck, a hole being bored through the wooden base opposite the neck to permit of this.

The double pipettes are prepared for use as follows: If a solid substance is to be used, the last-named pipette (Fig. 183) is employed and the solid is introduced into *a* through the neck. The cork is then inserted and wired in. The

method of filling is now the same for either of the double pipettes. Pour some water through *m* into the bulb *d* until *g* is full. Insert into the rubber tube *l* a funnel, and fill the funnel with the liquid reagent to be employed. Attach to *m* a piece of rubber gas-tubing about a foot and a half long, and suck with the mouth. The rubber tube may, of course, be connected with the aspirator, but in that case care must be taken that the suction

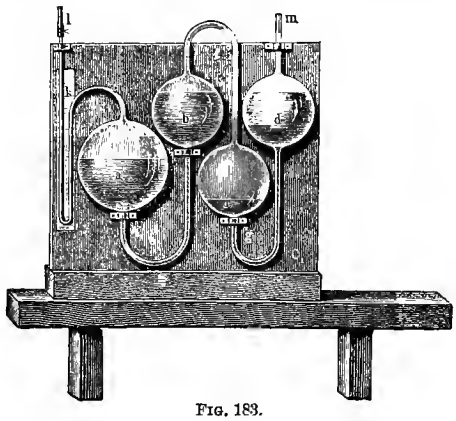


Fig. 183.

does not become strong enough to crush the bulbs. After there has been drawn into *a* and *b* sufficient reagent to fill *a*, the bulb *d* is nearly filled with water, and the gas remaining in *a* is driven out through the capillary by blowing into *m*. The pipette is now closed at *l*, and shaken for some time to remove from the bulb *b* the gases absorbable by the reagent. After any gas-bubbles which may now be in *a* have been driven out, suction is applied at *m*, and so much gas is sucked out of the bulb *b* that the liquid in *d* will enter and completely fill *c*. If the water first poured in is not sufficient, more must be added from time to time.

In pipettes thus prepared the tubes *k* and *e* and the bulb *a* are filled with the absorbent, the space from *b* to *f* with a gas free from oxygen, *c* and *g* with water, and *d* with air (Fig. 184). While the reagent in the simple

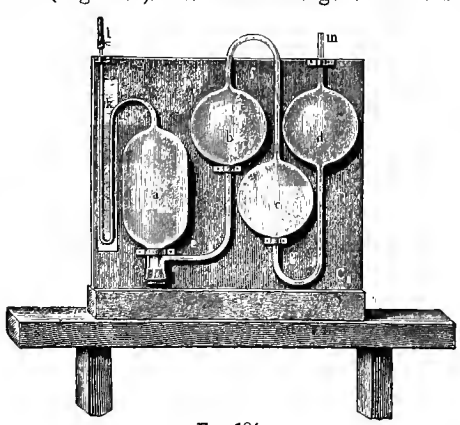


Fig. 184.

pipette may be considered to be saturated with gas only when it is kept in continual use, that in the double pipette, on the contrary, remains saturated for an exceptionally long time, since the diffusion must take place through the confining 100 c.c. of water and through the narrow tube *g*. The error caused by this theoretical possibility may be wholly disregarded in using the pipette. When a new filling of the pipette is necessary, the reagent may easily be driven out by inverting the pipette and blowing into *l*.

Manipulation of the Hempel Burette and Pipettes.— To analyze a gas with the apparatus described, the burette is filled with distilled water which has been previously saturated, by shaking, with the gas in question. The saturating of liquids is best done in a flask half filled with the same, a rapid stream of gas being led through the liquid, and the flask vigorously shaken. If simple pipettes are used, these are so filled with the absorbent that the bulb *a* remains empty. The absorbent also must be saturated, by shaking, with the gases which are but slightly soluble in it.

In technical work, where the same analyses are repeatedly made, the absorbent is kept saturated through continual use.

Before beginning the analysis pour into the level-tube of the gas burette (Fig. 185) enough water to fill the measuring tube *b* and the connecting rubber tube, taking care to drive all air out of the latter by suitably raising and lowering the tubes. Then join the burette to the vessel containing the gas by means of a glass or rubber

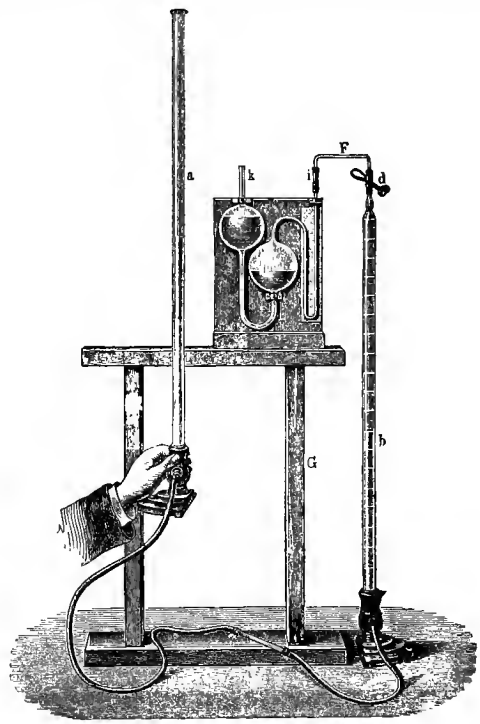


Fig. 185.

tube filled with water. (This connecting tube can be easily filled with water by raising the level-tube).

To fill the burette with the gas to be examined, place the level-tube on the floor and open the pinchcock *f*. The water will now flow into the level-tube and the gas will be drawn into the burette. When *b* is filled with the gas, close the pinchcock *f*, disconnect *b* from the gas-holder, and after the liquid has run down from the walls of the burette, take up the tubes by the iron feet and by raising or lowering bring the water in the tube to the same level. The gas is now under atmospheric pressure and its volume is read off. To measure off exactly 100 c.c., bring somewhat more than 100 c.c. of the gas into the burette, close the latter with the pinchcock, and let the water run down. Now compress the gas to less than 100 c.c. by raising the level-tube, close the rubber tube at *g* with the thumb and first finger of the left hand, set the level-tube on the table, and raising the burette in the right hand to the level of the eyes, carefully open the rubber tube and let the water run back until the meniscus stands at the 100 c.c. mark. Keeping the rubber tube still compressed, open the pinchcock for a moment; the excess of

gas will escape, and there remains in the burette exactly 100 c.c. of gas under atmospheric pressure.

If the pipettes have the temperature of the room, as can easily be ascertained by introducing a thermometer at *k* (Fig. 185), the apparatus is now arranged as there shown.

The pipette is placed on the wooden stand *G* and is connected with the burette by the capillary tube *F*, which is a piece of thermometer tubing of about 0.5 mm. internal diameter.

To avoid the enclosing of air-bubbles *F* is first inserted in *d*, the level-tube *a* is raised, and the pinchcock opened for a moment. *F* is, in this way, filled completely with water. Then the rubber tube *i* of the pipette is squeezed between the thumb and the first finger of the right hand, and while thus compressed and free from air the capillary connecting tube is inserted.

Upon raising the level-tube *a* and opening the pinchcock the gas passes through the connecting tube into the absorption pipette. Any small air-bubbles which may have been enclosed when *F* was inserted into *i* are, at the beginning, separated from the gas by the water in *F*. If these bubbles do not take up more than 5 to 10 mm. space in the capillary of the pipette, they may be disregarded, since the error arising therefrom is about 0.03 c.c. If the bubbles are larger, although with a little cleverness this may always be avoided, the gas is brought back into the burette by lowering the level-tube, and the operation is repeated.

When the gas has passed over into the pipette, about ½ c.c. of water is allowed to follow, this water serving to rinse the capillary and to free it sufficiently from the absorbing liquid which it previously contained. The gas is now enclosed between two columns of liquid, the absorbent on the one side, and the water in the capillary on the other.

The pinchcocks at *d* and *i* (the latter is not shown in the figure), are closed, the pipette is disconnected by drawing *F* out of *i*, and by shaking the pipette horizontally the absorption of the gas is effected.

The burette and pipette are then reconnected, the level-tube is placed on the floor, and the gas is brought back into the burette, care being taken that the absorbing liquid does not pass farther than the bend in *F* above *d*. The pinchcock *d* is closed, the pipette removed, and the reading of the remaining volume is made as before described.

The manipulation of the pipettes filled with solid absorbents is still simpler, for in this case no shaking is necessary, because of the large surface between the solid and the gas. On this account, also, the apparatus need not be disconnected.

A separate pipette is used for each absorbent, and aside from the economy of reagents the frequent cleaning of the apparatus is thus avoided. An especial advantage is, further, the complete assurance that no loss can take place through ill-fitting glass or rubber stopcocks while the gas is in the pipette or when the pipette is vigorously shaken, and that without fear of error due to the taking up of gases not chemically absorbable, large amounts of reagent may be used, and the work be thereby greatly shortened. After using, the pipettes are closed at *i* with a piece of glass rod, and at *k* with a small cork. It is advisable to record the number of cubic centimetres of gas which the reagent has absorbed. When the wooden support for the pipette is used, this record is kept upon a piece of paper fastened to the back. If the iron support shown in Fig. 182 is in use, a ground glass plate fastened between the sides of the base may be conveniently employed for the purpose. If the absorbing power of the reagent be known, waste may be avoided, and with one filling of the pipette several hundred analyses (the number depending upon the nature of the gases examined) may be made, with certainty throughout as to the efficiency of the absorbent.

If the work has not been carelessly done, the gas burette stands ready for the next analysis. If, on the other hand, reagents have been allowed to enter the burette, it must be cleansed, its simple construction rendering this quite easy.

With the Hempel apparatus just described, analysis of gas mixtures may be made with great rapidity and considerable accuracy, the exactness being increased by the use of the Hempel-Pettersson burette. But as the unavoidable error in measuring the gas volume in the burette amounts to about 0.1 c.c., *i.e.*, to 0.1 per cent., it is clear that if greater accuracy is desired certain modifications in the method become necessary. Hempel has devised an apparatus with which results agreeing as closely as those of Bunsen and Geppert may easily be obtained, and as his method is more rapid and the apparatus simple in form and easy to handle, a brief description of it is here given.

Hempel's Apparatus for Very Exact Gas Analysis.—Usually in analytical work the gases are measured under constant (atmospheric) pressure, the observed

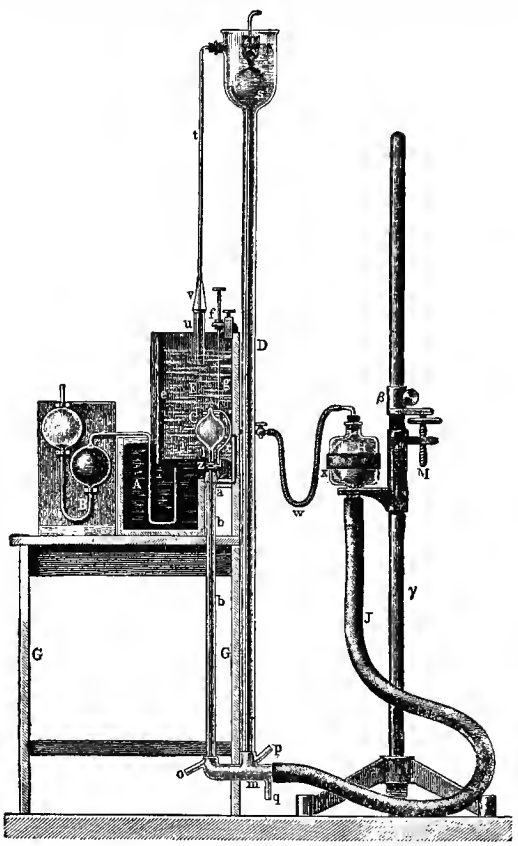


Fig. 186.

changes in the volume, as each constituent is absorbed, giving the percentage composition of the gas. In the method about to be described the measurements are, however, made under constant volume and varying pressure. That is, after the absorption of each constituent the gas is expanded to exactly the volume which it occupied in the beginning, and the change in the pressure which it exerts is read off on a graduated barometer tube.

Following Boyle's law, the values so found bear the same proportion to one another as do gas volumes under the same pressure, and hence give the percentage results directly. If the gases are saturated with moisture when measured, corrections for the tension of aqueous vapor and for barometic pressure are unnecessary.

The gases are expanded to a certain volume in small glass bulbs, which can easily be brought into communication with a barometer. The expanding is done by lowering a movable vessel filled with mercury. The pressure exerted by the gas is then read off on the barom-

eter scale. The temperature is kept constant throughout by surrounding all parts of the apparatus with running water. The absorptions are made in the gas pipettes to be described later.

Description of the Apparatus.—Fig. 186 gives a sectional view of the apparatus. The iron mercury-trough *A* is fastened to the wooden stand *G*, and is connected with the graduated barometer tube *D* by the iron tube *b*. The barometer tube is connected at *m*, by means of a rubber tube, *J*, with the level-bulb *H*. The upper part of the mercury-trough consists of the reservoir *E*, whose overflow-tube (this is not given in the drawing) can be connected with a barrel by means of glass or rubber tubes.

The sides of the water reservoir *E* are glass panes, one of which, *c*, extends only so deep into the mercury as to leave it easily possible to bring under it the end of the capillary tube of the pipette *B*. The measuring bulb *C* serves to hold the gas. The tubes *b* and *D* are surrounded with larger glass tubes, and the rubber tube *J* is double, so that *b*, *D*, and *J* may be cooled with water. By means of a glass tube with three arms (this tube does not appear in the figure) water is admitted simultaneously through the tubes *o*, *p*, and *q* when the apparatus is in use. *o*, *p*, and *q* are joined to the three-arm tube by rubber tubes supplied with glass stopcocks. A part of the water enters at *o*, surrounds *b*, and enters the water reservoir *E* through a small canal, *r*. The water entering at *p* surrounds the barometer tube *D* and its bulb *s*, and runs through a side opening and the tube *t* into *E*. To prevent the spattering caused by the air-bubbles drawn along with the water, a wider tube, *u*, is hung upon *t* by means of the thread *v*. A third stream of water entering at *q* passes through the outer rubber tube of *J*, and through the double-walled level-bulb and the rubber tube *w* into *E*.

The outer wall of the level-bulb is simply made by joining together the ends of two broken bottles by the rubber band *x*. The rubber tube *w* is joined to the bulb by means of a cork and a bent-glass tube.

By this arrangement it is possible to keep all parts of the apparatus at the same temperature.

The Gas Pipettes for the Exact Apparatus.—They consist of two bulbs, *a* and *b* (Fig. 187) of the same size, joined together by the tube *c* and ending in the bent capillary tube *d*. A very small-bore thermometer tube is used as the capillary, thus making it easy to avoid the introduction of absorbent into the measuring bulb or the remaining of any considerable quantity of gas in the pipette.

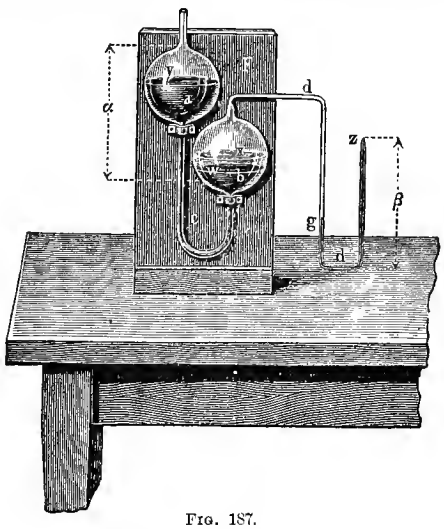


Fig. 187.

Gases move rapidly in capillary tubes, but liquids, especially concentrated solutions of salts, move very slowly; hence it is easily possible to bring the gas residue in the pipette to less than $\frac{1}{1000}$ of a cubic centimetre without danger of the absorbent entering the measuring bulb.

The pipettes must be so made that the distance *a* (Fig. 187) is only as large as or smaller than β: the capillary must be bent close to the bulb *b*. The pipettes are fastened to the wooden standard in such a manner that the capillary *d* comes to within a few millimetres of the bottom of the mercury-trough when the pipette is placed in the position shown in Fig. 186.

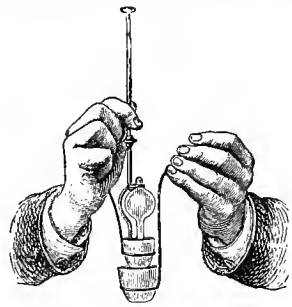


Fig. 188.

Fig. 189.

The bulbs of the pipettes must be considerably larger than the volume of the gas to be brought into them. The inconvenience of carefully cleaning the pipette after the absorption is avoided by using a special pipette for each reagent. Pipettes of very different sizes are employed, the sizes depending naturally upon the dimension of the measuring bulbs.

Manipulation.—One of the pipettes is filled with mercury, and the gas to be analyzed is passed into the pipette through the capillary. A little mercury is allowed to follow the gas and fill the capillary from *g* to *z* (Fig. 187). The gas is thus confined between two surfaces of mercury, *g* and *w*.

If the samples of gas have been collected in the glass tubes shown in Figs. 169 or 170, the tubes are opened in a small mercury-trough by breaking off the immersed end of the tube with pliers. A small crucible is then slipped under the tube, and the tube is lifted out and placed in a cylinder containing mercury. The capillary of a gas pipette filled with mercury is then lowered beneath the surface of the mercury and introduced into the tube containing the gas, and the gas is drawn over into the pipette by sucking with the mouth upon a rubber tube attached to the open end tube of the bulb *a*. One of the measuring bulbs (*C*, Fig. 186) with its iron holder is then cleaned and dried, and is brought into the mercury-trough of the apparatus by placing it in two porcelain crucibles, one within the other (see Fig. 188), and filling these with mercury. If these are then lowered through the cooling water of the trough into the mercury, and the longer crucible removed by lowering it still further, the measuring bulb may now be lifted out of the small crucible under the surface of the mercury without a trace of water entering it. If only one crucible is used, water may easily get into the bulb, the probable cause being surface adhesion. The instrument shown in Fig. 189 is then lowered into the mercury-trough *A* (Fig. 186), the end of its tube is introduced into the measuring bulb, and the air in the latter is sucked out completely.

The pipette containing the gas is now placed as shown in Fig. 186, the measuring bulb, which now is full of mercury, is lowered over the end of the capillary of the pipette, and, by blowing into the open end of the pipette, some of the gas is driven over into the measuring bulb. The pipette is removed and the measuring bulb is placed over the end of the tube *b* (see Fig. 186), and, by means of the screw at *f*, is pressed down tightly upon the rubber stopper surrounding the end of *b*. The level-bulb is lowered until the meniscus of the mercury column at *l* exactly coincides with the cross-hair of a magnifying-

glass fastened to the mercury trough. (This magnifier does not appear in the figure.) The reading of the barometer tube, which is best done by means of a telescope, gives then directly the pressure of the gas ; this pressure is obviously independent of barometric changes, since the barometer vacuum is closed with mercury. If the gas being measured is saturated with moisture, the correction for the tension of aqueous vapor is unnecessary,

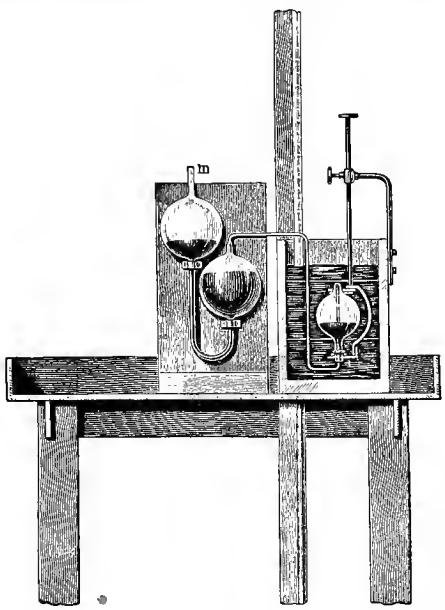


Fig. 190.

because there is in the bulb of the barometer aqueous vapor which at the same temperature exercises the same pressure in an opposite direction.

The exact adjustment is made with the micrometer screw of the level-bulb, and the reading on the scale is then immediately made with the telescope. It is advisable to repeat both the adjustment and the reading.

Into one of the pipettes filled with mercury there is now introduced, through the capillary, a suitable amount (about two cubic centimetres) of the desired reagent. The measuring bulb is removed from the end of the barometer tube, and the bulb and pipette are brought into the position shown in Fig. 190.

The gas is drawn into the pipette by sucking with the mouth on a rubber tube attached to *m*. The suction is discontinued at the moment when the mercury begins to flow from the capillary into the bulb of the pipette.

The pipette then contains (see Fig. 187) mercury from *v* to *w*, absorbent from *w* to *x*, gas from *x* to *g*, and mercury from *g* to *z*, so that the pipette, after it is taken out of the mercury trough, may be vigorously shaken and a rapid absorption effected.

To drive the gas from the pipette back again into the measuring bulb, the apparatus is brought into the position shown in Fig. 191.

One must at first blow into the pipette at *m* to set the gas in motion; when it has once started, the mercury in the measuring bulb acts with an aspirating effect, so that the gas passes over of itself. At the moment when the absorbent has risen to about one centimetre from the end of the capillary in the measuring bulb, the capillary is lowered under the mercury and mercury is drawn into the capillary by sucking on the rubber tube attached to *m*. In this manner the entering of the reagent into the measuring bulb may be avoided with certainty.

If a gas thread about 1 ctm. long remains in the capillary, this corresponds to approximately 0.001 c.c. of gas, since the total 35 ctm. length of the capillary has a volume, determined by weighing the mercury which it holds, of 0.038 c.c. Hence from this source no appreciable error arises.

The measuring bulb is again brought into the position shown in Fig. 186, the mercury in the bulb adjusted exactly at *e* by raising or lowering the level-bulb, and the variation in pressure is read off on the graduated barometer tube *D*. As the original pressure is to the change in pressure as the original volume is to the volume absorbed, the per cent. of the absorbed constituent is easily calculated.

The other necessary measurements, absorptions, and explosions now follow, their order being determined by the nature of the gas.

The Quantitative Analysis of a Gas Mixture.— Before proceeding with the quantitative determination of the various gases in any gas mixture, it is, of course, necessary to know what gases are present. If this is not known, a qualitative analysis of the sample must first be made. As a description of the methods of qualitative gas analysis would take too much space, and as the constituents of mixtures with which we purpose here to deal are usually known, the reader is referred for information upon qualitative gas analysis to the exhaustive treatise of Clemens Winkler.[6]

Assuming that it is known what gases are present, the remainder of the article will be devoted to descriptions of the various methods by which the amounts of these gases may be ascertained.

In the analysis of a mixture of gases the usual procedure is to measure off a definite volume of the gas, and then, with the apparatus already described, to absorb

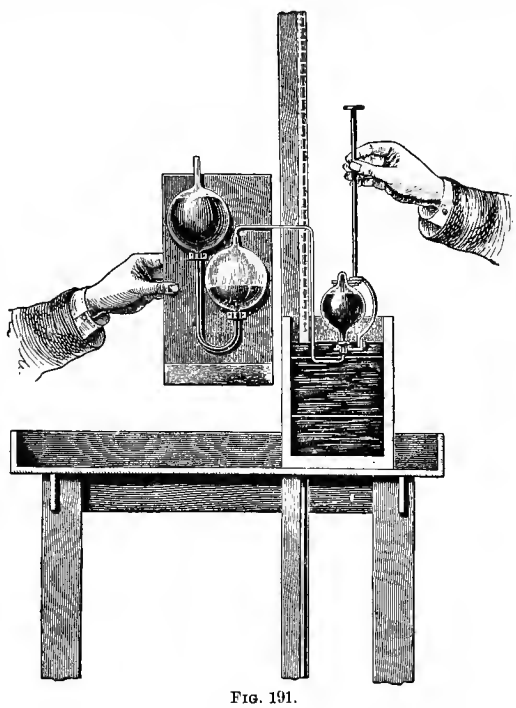


Fig. 191.

one after another of the gases present, the diminution in the volume of the gas after each absorption showing the amount of the absorbed constituent which was present in the original mixture. Those gases which cannot be absorbed, such as certain hydrocarbons and nitrogen, will still remain after the absorption of the others. The hydrocarbons are usually determined by burning them with oxygen or air, and the gas now remaining is nitrogen.

The absorbable gases whose determination is most frequently called for are:

Gases.	Absorbable by
Carbon dioxide (CO_2).	Potassium hydroxide or barium hydroxide.
Oxygen (O).	Alkaline pyrogallol or phosphorus.
The "heavy hydrocarbons," as ethylene, propylene, etc.	Fuming sulphuric acid.
Carbon monoxide (CO).	Cuprous chloride.
Hydrogen (H).	Palladium sponge.

The solutions just mentioned may be prepared as follows:

Potassium Hydroxide Solution.—One part of commercial caustic potash is dissolved in two parts of water.

This solution is put into the simple pipette for solid and liquid reagents (Fig. 182), the cylindrical part *b*, being first closely filled with very short rolls of iron-wire gauze. The gauze has a mesh of 1 to 2 mm., and the rolls are from 1 to 2 ctm. long and about 5 mm. thick.

When the per cent. of carbon dioxide is not too high it can be completely absorbed by simply passing the gas once into the pipette. The complete manipulation does not take one minute.

Small quantities of carbon dioxide are best determined by absorption in a solution of barium hydroxide and titration with oxalic acid (see Analysis of Air).

Alkaline Pyrogallol (Potassium Pyrogallate).—Dissolve 150 grammes of potassium hydroxide in 100 c.c. of water and allow it to stand until the insoluble residue has settled. Five grammes of pyrogallol (pyrogallic acid) dissolved in 15 c.c. of water is then mixed with four-fifths of the caustic potash solution, only the clear portion of the latter being used for this purpose. In the Hempel apparatus for technical analysis this solution is used in the pipette shown in Fig. 183. The 15 c.c. of the alkaline pyrogallol should first be run into the bulb *a* through the capillary, and then the caustic potash solution be run in after it. If there is not enough solution to fill the bulb *a*, more of the two solutions, in their proper proportions, should be added. The solution must not be diluted with water.

The absorptions should not be carried on at a temperature under 15° C., for it has been observed that the potassium pyrogallate used for absorption is very much less active at a temperature under 7° C. At a temperature of 15° C. or higher the last trace of oxygen can be removed with certainty in the space of three minutes by shaking with the solution of potassium pyrogallate, while at lower temperatures the absorption is not complete after six minutes; moreover, the liquid begins to foam, and this, in exact determinations, is very troublesome.

A solution prepared as above gives off no carbon monoxide during the absorption, or at the most only such slight traces that the error thus caused comes within the limit of error of the readings.

Fuming Sulphuric Acid.—The sulphuric acid used should be so concentrated that when the temperature is slightly lowered, crystals of pyro-sulphuric acid will separate. The acid is used in a Hempel pipette which has above the large bulb *b*, Fig. 181, a small bulb filled with glass beads which serve to give to the sulphuric acid the largest possible surface. With this arrangement the complete absorption of the heavy hydrocarbons, and of ethylene in particular, is effected by passing the gas into the pipette but once.

In this reaction some sulphur dioxide is usually formed, and, moreover, the vapor of fuming sulphuric acid has a very high tension, so that the gas residue, before being measured, must be freed from the acid vapors in the caustic potash pipette, a single passage of the gas into the pipette being also here sufficient.

To avoid having the rubber connections between the pipette and burette attacked by the fuming sulphuric acid, the apparatus is so put together that the sulphuric acid does not quite fill the capillary of the pipette, and the connecting capillary is allowed to remain empty; the short rubber tube of the burette is also freed from liquid by means of a narrow-tipped suction pipette, any reagent remaining in the rubber tube being first washed out by water with the same pipette. If care be taken that the sulphuric acid is stopped, after the absorption, at the same point in the capillary at which it stood when the burette and pipette were first put together, then the small volume of air contained in the empty capillary tubes in the beginning causes, of course, no error in the determination of the heavy hydrocarbons or other gases, with the exception of nitrogen. In the nitrogen determination allowance may be made for this air volume, but as each centimetre of the empty capillary corresponds to only 0.008 c.c., this value falls below the limit of the usual unavoidable experimental errors.

After the absorption the rubber tube is taken off from the pipette, and the capillary and the larger tube are closed air-tight by little glass caps, which are pushed over narrow rubber rings placed upon the tubes.

Cuprous Chloride.—This solution may be conveniently prepared as follows: Twenty-five parts of crystallized copper sulphate, and 12 parts of sodium chloride are put into 50 parts of water, which is then heated until all dissolves. Some sodium sulphate may separate as a white powder. Filter it off and add 100 parts of concentrated hydrochloric acid and 13 parts of copper turnings (also a few pieces of platinum foil to hasten the solution of the copper) and boil until decolorized. Pour the solution into a glass-stoppered bottle and keep tightly stoppered until needed.

Palladium Sponge.—Finely divided metallic palladium is heated, in portions of about one gramme at a time, nearly to redness upon the cover of a platinum crucible. The platinum cover is slowly lifted out of the flame, the palladium, as it cools, becoming covered with a coating of palladious oxide. About four grammes of the sponge thus prepared is placed in the **U**-tube shown in Fig. 193.

To illustrate the procedure in an analysis of a gas mixture with the Hempel apparatus the analysis of a sample of illuminating gas is given.

First of all, the water with which the burette is to be filled must be saturated with the gas, as described above. The carbon dioxide is first absorbed with caustic potash, then the heavy hydrocarbons with fuming sulphuric acid, then oxygen with alkaline pyrogallol, and lastly carbon monoxide with the cuprous chloride solution. The residue, which consists of methane, hydrogen, and nitrogen, is measured, and is then led back into the cuprous chloride pipette, and a portion is taken for the explosion analysis.

With ordinary illuminating gas about 12 c.c. of the residue suffice for the explosion.

These 12 c.c. are measured off exactly in the gas burette, and enough air is drawn in to bring the mixture to about 100 c.c. In all these measurements the running down of the liquid must be most carefully waited for, because the amount of gas taken is so small that any errors that may be made are greatly multiplied. Three minutes is a sufficient time to wait for the water to run down the sides of the burette, but whatever brief interval is taken it should be the same for each measurement. To insure uniformity in this respect, a three-minute sand-glass may be used with advantage.

The gas mixture is now burned in the explosion pipette (Fig. 192).

This consists of the thick-walled explosion-bulb *a*, and the level-bulb *b*, which are joined together by a wrapped piece of rubber tubing. At *e* two fine platinum wires are fused into the explosion pipette, the ends of the wires being about 2 mm. apart. At *d* is a glass stopcock, and the pipette terminates in the capillary *e*, whose end is closed by a short piece of rubber tubing and a pinch-cock. In general the pipettes and burettes for technical gas analysis are filled with aqueous solutions, but the explosion pipette is filled with mercury. By using mercury as confining liquid during the explosion it is possible to afterward determine the carbon dioxide formed by the combustion. If the explosion is made over water, a subsequent measuring of the carbon dioxide formed is inadmissible, because the pressure in the pipette is so high during the explosion that considerable quantities of carbon dioxide are absorbed by the water. By explod-

ing over mercury very satisfactory results are obtained, even if the carbon dioxide is afterward measured in a burette which is filled with water.

After the gas is burned in the explosion pipette it is transferred to the burette and the total contraction is measured. Then the carbon dioxide is absorbed with potassium hydroxide, and finally the oxygen in excess is absorbed with phosphorus. The last determination is made merely to be sure that a sufficient excess of oxygen was present in the combustion.

The manipulation and the results obtained in an analysis of a sample of illuminating gas with the Hempel apparatus were as follows:

Exactly 100 c.c. of the gas was measured off in the burette.

Passed into caustic potash pipette and drawn directly back into the burette; measured after three minutes. Measurement gave 4.1 c.c.; hence there was present 4.1 c.c. or per cent. carbon dioxide.

Burette now connected by means of a dry piece of rubber tube and a dry capillary with the pipette containing fuming sulphuric acid. Gas driven over and drawn back at once into the burette. Gas now passed again into caustic potash pipette, and after being drawn back into the burette and allowed to stand three minutes, again measured. The measurement gave 8.4 c.c.; hence there

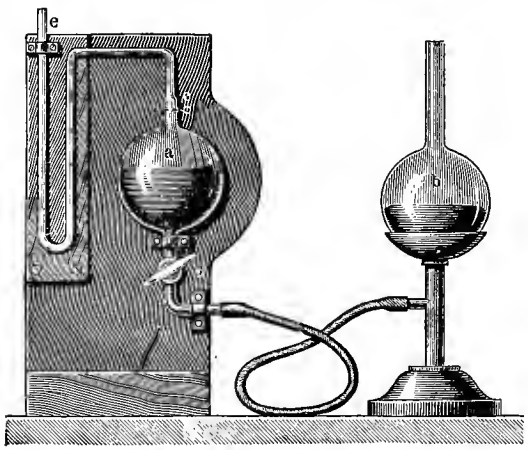


FIG. 192.

were $8.4 - 4.1 = 4.3$ c.c. or 4.3 per cent. of heavy hydrocarbons present.

The gas now passed into the double pipette containing alkaline pyrogallol, the burette and pipette closed with pinchcocks, the pipette disconnected and shaken for three minutes. Then connected with the burette again, drawn over and measured at the end of three minutes. Reading gave 8.4 c.c.; hence no oxygen was present.

The gas was then passed into the pipette containing cuprous chloride, and was shaken for three minutes. Drawn back into the burette and measured after three minutes; the reading was 18 c.c.; hence there was 18 c.c. $- 8.4 = 9.6$ c.c. or per cent. carbon monoxide present.

The remaining 82 c.c. of gas was then passed back into the cuprous chloride pipette, and the pipette was closed with an ordinary pinchcock.

The water in the burette is poured out, the burette washed with hydrochloric acid and then with distilled water, and then filled with water which is saturated, not with illuminating gas, but with air.

Twelve to fifteen c.c. of the gas residue is now measured off into the burette. In this case 13.2 c.c. was taken.

So much air is then drawn in that the total volume of the gas residue taken and the air amounts to about 100 c.c. In this case it was 99.6 c.c.

This mixture is now brought into the explosion pipette filled with mercury, care being taken that the capillary remains full of water. The rubber connecting-piece is closed by a strong pinchcock, and a piece of glass rod is slipped into the end of the rubber tube. The pipette is then vigorously shaken, the glass stopcock is closed, the pipette is connected with the poles of an induction coil, and by turning on the current from a fairly strong battery the mixture is exploded.

The glass stopcock is at once opened and the remaining gas is transferred without delay to the burette, and, after three minutes, measured. The result here was 78 c.c.

The total contraction was therefore $99.6 - 78 = 21.6$ c.c.

The gas remaining from the combustion is now passed into the caustic potash pipette, drawn directly back into the burette, and, after three minutes, measured. The reading was 73.2 c.c. Hence by the combustion $78 - 72.2 = 4.8$ c.c. of carbon dioxide was formed.

Although this gave all the data necessary for the calculation of the analysis, the remaining gas was nevertheless passed into the alkaline pyrogallol pipette in order to be sure that an excess of oxygen was present in the combustion, or, in other words, that the gas was completely burned. The measurement gave 70.2 c.c.

Hence there was $73.2 - 70.2 = 3$ c.c. of oxygen in excess.

In the combustion of the marsh-gas its own volume of carbon dioxide is formed, as may be seen from the equation representing the reaction:

$$\underset{1\text{ vol.}}{CH_4} + \underset{2\text{ vol.}}{2O_2} = \underset{1\text{ vol.}}{CO_2} + 2H_2O.$$

Hence in the 13.2 c.c. of the gas residue taken for the explosion there were 4.8 c.c. of marsh-gas.

The marsh-gas in the total gas residue of 82 c.c. is found by the proportion:

$$13.2 : 82 = 4.8 : x,$$
$$x = 29.8 \text{ per cent. marsh-gas.}$$

Since marsh-gas in burning unites with twice its volume of oxygen, the contraction which has resulted from the combustion of the hydrogen is found by subtracting twice the volume of the carbon dioxide found from the total contraction. $21.6 - (2 \times 4.8) = 12$ c.c. contraction due to the burning of hydrogen.

One volume of hydrogen unites, in burning, with one-half its volume of oxygen; hence the volume of the hydrogen is found by multiplying 12 by $\frac{2}{3}$. Thus the 13.2 c.c. of the gas residue taken for the explosion contained 8 c.c. of hydrogen. The total amount of hydrogen is given by the proportion:

$$13.2 : 82 = 8 : x,$$
$$x = 49.6 \text{ per cent. hydrogen.}$$

The nitrogen is found by subtracting the sum of all the other constituents from 100. This gives 2.6 per cent.

Hence the illuminating gas contained:

4.1	per cent.	carbon dioxide.
4.3	"	heavy hydrocarbons.
0.0	"	oxygen.
9.6	"	carbon monoxide.
29.8	"	methane.
49.6	"	hydrogen.
2.6	"	nitrogen.
100.0		

Instead of determining the hydrogen indirectly, as just described, it may be absorbed by means of palladium

sponge. The arrangement of the apparatus for carrying out the reaction is shown in Fig. 193.

The gas burette *A* and the gas pipette *B* are joined together by means of the capillary tubes *E* and the tube *H*. This tube *H* is of about 4 mm. internal diameter and 20 ctm. total length, and it contains 4 grammes of palladium sponge.

The gas pipette upon the stand *G* is filled with water, and its only use is to render it possible to repeatedly pass the gas through the palladium tube.

To determine the amount of hydrogen present in a mixture of hydrogen, nitrogen, and marsh-gas, from which, so far as possible, the absorbable constituents have already been removed, measure the gas in the burette, join it in the manner described to the pipette *B*, which is filled with water nearly to *i*, place the tube *H* in a large beaker containing warm water of from 90° to 100° C., and, after opening the pinchcock *d*, drive the gas three times back and forth through the palladium by raising and lowering the tube *a*. Then replace the hot water with water of the temperature of the room, and lead the gas residue twice back and forth through the tube in order to completely cool the gas. It is in this manner possible to absorb with certainty every particle of hydrogen. Upon drawing the gas so far back into the measuring tube that the water in the pipette again stands near *i*, the difference between the two measurements made before and after the absorption corresponds to the hydrogen plus the amount of oxygen in the air enclosed in the U-tube when the apparatus was put together. This air volume, and therewith its oxygen contents, may be determined with sufficient exactness once for all by closing, with a piece of rubber tubing and a glass rod, one side of the tube filled with palladium, cooling the tube to about 9° C. by placing it in cool water, and then, after connecting it by a capillary with a gas burette completely filled with water, warming it to 100° C. by placing it in boiling water. The expansion of the enclosed air volume corresponds to a difference of temperature of 91° C., *i.e.*, to a third of the enclosed volume of gas.

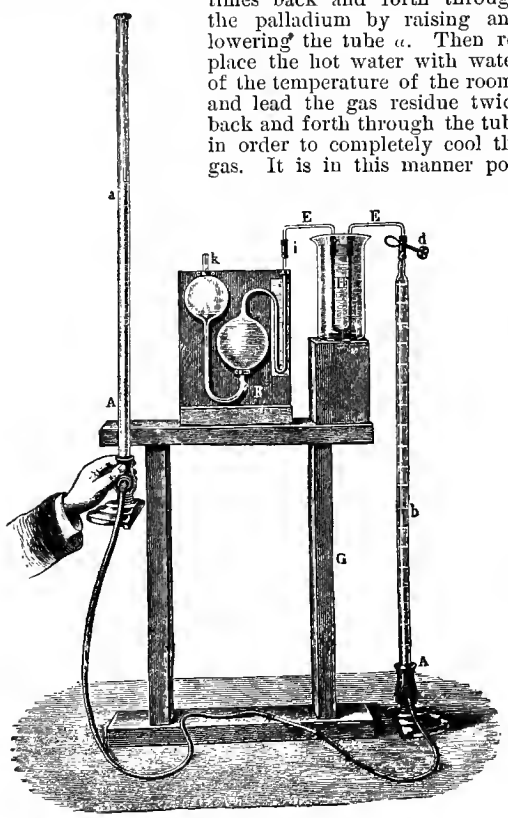


Fig. 193.

The palladium is regenerated after the reaction by first leading air over it, whereby it becomes quite hot; removing any drops of moisture which may collect, so that the palladium may easily be shaken out of the tube in the form of a dry powder; and then superficially oxidizing the metal by heating it on the lid of a platinum crucible.

The residue of nitrogen and marsh-gas which remains after the absorption of the hydrogen is burnt by explosion in the manner described.

The Analysis of Air.—The atmosphere of the earth consists chiefly of nitrogen, oxygen, a small amount of carbon dioxide, and varying quantities of water vapor. In addition to these constant constituents we may expect to find, at times, the various gaseous products of the many chemical processes on the earth, such as ammonia, hydrocarbons, sulphur dioxide and sulphur trioxide. The presence of solid substances, floating in the air in finely divided form, has also been detected. A small amount of the oxygen exists in the form of ozone, the quantity of this gas varying with the weather, time of year, and locality. In an analysis of air, aqueous vapor, carbon dioxide, and oxygen are usually determined. No direct method for determining nitrogen being known, its percentage amount is ascertained by subtracting the sum of the other constituents from 100. In addition to the quantitative determination of the foregoing, qualitative tests to show the presence or absence of carbon monoxide and ozone are often desired. For sanitary purposes the determination of carbon dioxide and water are those most frequently called for.

The Determination of Aqueous Vapor in the Atmosphere.—The water can be determined with great exactness by leading a measured or weighed volume of air through tubes filled with calcium chloride or phosphorus pentoxide, and ascertaining their increase in weight. It hardly need be mentioned that the calcium chloride must first be treated with carbon dioxide, so that it may contain no basic salt which, by taking up carbon dioxide, could change in weight. The common phosphorus pentoxide is never pure, but always contains traces of phosphorus and phosphorous acid. For this reason a current of dry air should be led for some time through the absorption apparatus before it is used.

For most purposes the hair hygrometer and the psychrometer give sufficiently accurate results.

A very fine form of the hair hygrometer, devised by Saussure, is made by Hermann Pfister, in Berne.

The construction of the instrument is based upon the property possessed by hair from which the oil has been removed, of lengthening or shortening according to the amount of moisture in the air. By alternately moistening and drying the hair thoroughly for a number of times, it is given, according to Pfister, the property of quite regular expansion.

Figure 194 shows the arrangement. A hair, prepared as above mentioned, is fastened to a suitable frame. The hair passes aronnd a little wheel below, and the changes in length cause the pointer to move and give the relative moisture directly on the scale.

August's psychrometer is based on the fact that water exposed to the air evaporates the more rapidly, and thereby extracts more heat from its surroundings, the farther the air is removed from the condition of saturation. From the lowering of the temperature $(t - t^1)$ of a thermometer which has been moistened in a suitable manner, the tension e of the water vapor in the air is calculated from the formula—

$$e = e^1 - k\,(t - t^1)\,b,$$

in which e^1 is the tension corresponding to the temperature t^1, b the barometric pressure in millimetres, and k an empirical factor which has, according to the researches of Regnault, the following values:

In small closed rooms	0.00128
" large closed rooms	0.00100
" halls with open windows	0.00077
" courts	0.00074
" open air (no wind)	0.00090

The Determination of Carbon Dioxide in the Atmosphere.—The most varied experience has shown that through the process of breathing the air acquires properties which cause it to act deleteriously upon health when the products of breathing exceed a certain limit. Brown-Séquard and d'Arsonval[8] have shown that air expired by animals has a poisonous action upon other animals, and that this poisonous property is not due to the carbon dioxide present. In fact, they themselves breathed air containing twenty per cent. of carbon dioxide, but otherwise pure, without experiencing any serious inconvenience or lasting effect. Rabbits breathing air which had already been breathed by other rabbits died in from two to six days. The expired air from the first rabbits was

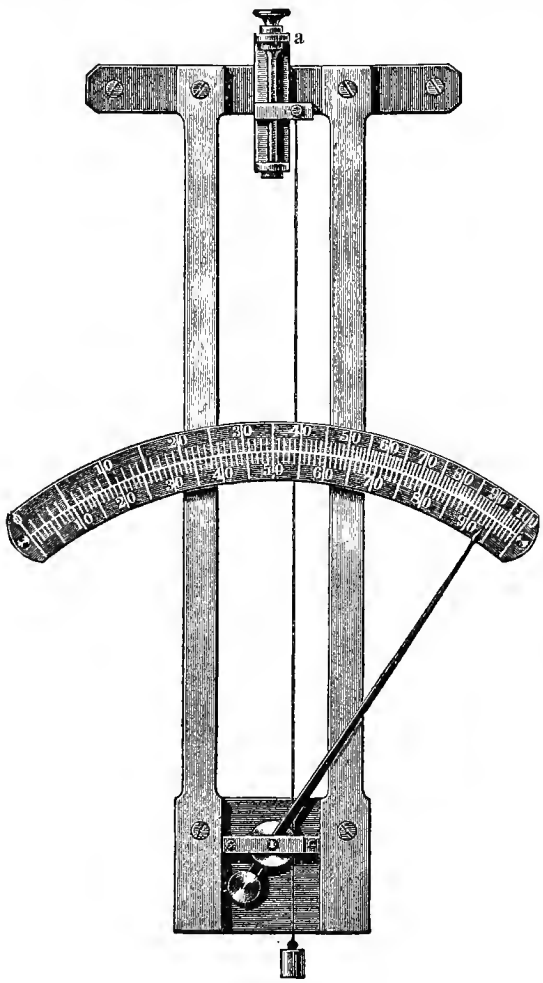


FIG. 194.

then passed through concentrated sulphuric acid, before being breathed by the other rabbits. This sulphuric acid destroyed the poisonous matter coming from the lungs, but allowed the carbon dioxide to pass. The air thus deprived of the pulmonary poison, but charged with the carbon dioxide as before, had no poisonous action upon the animals breathing it.

In examining the air of rooms, halls, or theatres, it is of the utmost importance that we be able to ascertain to what extent the air has been vitiated by the exhalations of the people present. Unfortunately we are not able by ordinary means to determine the amount present of the organic impurities given off by the lungs, but inasmuch as these injurious substances are exhaled simultaneously with carbon dioxide their amount can be indirectly ascertained by determining the amount of carbon dioxide in the room, and for this reason we make use of Pettenkofer's suggestion and judge of the purity of the air by the per cent. of carbon dioxide present.

In the open air the per cent. of carbon dioxide is quite constant, the average amount being 0.04 per cent. by volume, or four parts in ten thousand. In rooms where the air impresses the new-comer as being "good," the carbon dioxide usually varies from 0.055 per cent. to 0.087 per cent. Pettenkofer states that as soon as the carbon dioxide reaches 0.1 per cent., an odor becomes noticeable, and he places this amount as the limit of admissible carbon dioxide resulting from breathing. Yet the air in crowded school-rooms and in well-filled halls and theatres will be found in most cases to contain carbon dioxide far in excess of 0.1 per cent., the amount often rising to from 0.25 to 0.4 per cent. To ascertain the rate of increase of carbon dioxide in smaller rooms, the writer recently analyzed the air of a room about 40 × 20 ft. and 11 ft. high, occupied by thirty-eight adults. At the beginning of the session the air contained 0.058 per cent. of carbon dioxide, and

at the end of		28	minutes,	0.070	per cent.	CO_2,
"	"	39	"	0.101	"	"
"	"	58	"	0.128	"	"
"	"	83	"	0.148	"	"
"	"	103	"	0.240	"	"

One of the best methods for quantitatively determining the carbon dioxide in the atmosphere is that first used by Saussure,[18] and modified by Pettenkofer.[19] It consists in absorbing the carbon dioxide of a measured volume of air with a barium hydroxide solution of known strength, and then determining, by titration with oxalic acid, the amount of barium hydroxide still unacted upon. This method has been used by many investigators, and has been modified in minor details. A very practical form is that devised by W. Hesse, which is as follows:[6]

The necessary apparatus may be divided into a stationary and a portable portion.

A. The reserve apparatus in the laboratory comprises the following:

1. A glass balloon, or large bottle, holding several litres, and filled with a concentrated solution of barium hydroxide. One kg. of barium hydroxide and 50 grammes of barium chloride are put into from 4 to 5 kg. of distilled water. As the solution is used it is replaced by water as long as there is material in excess to saturate the water.

2. A bottle containing dilute baryta water. The bottle is provided with a small absorption flask containing pumice-stone saturated with caustic potash, for freeing the entering air from carbon dioxide (Fig. 195). This dilute baryta water is made by adding about 30 c.c. of concentrated barium hydroxide solution to 1 litre of water, or directly by dissolving 1.7 gramme of a mixture of barium hydroxide and barium chloride (20 : 1) in 1 litre of distilled water.

3. A solution of oxalic acid containing 5.6325 grammes of crystallized oxalic acid in 1 litre of water. 1 c.c. = 1 c.c. CO_2.

4. A solution of phenol-phthaleïn, 1 part in 250 parts of alcohol.

B. The portable apparatus comprises—

1. Five thick-walled conical Erlenmayer flasks of $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{12}$, and $\frac{1}{16}$ litre capacity, and supplied with well-fitting double-bore rubber stoppers. The point to which the rubber stopper reaches is marked on the first four flasks, and their capacity up to this mark is written on the outside of each flask with a diamond. The openings of the stoppers of these four flasks are closed with pieces of glass rod from 3 to 5 ctm. long. These rods are well rounded at the lower ends, the upper ends being widened like a button.

2. A thick-walled 10 c.c. pipette.

3. A glass stopcock burette holding from 10 to 15 c.c., graduated in tenths, and having a tip 7 to 10 ctm. long.

4. A 300 c.c. flask provided with a small guard bottle, as in *A*, 2, and filled with dilute baryta water. This is

filled in the laboratory by connecting it with the large reserve bottle containing dilute baryta water, and driving the solution over through the siphon. Before beginning the experiment a few drops of a solution of rosolic acid are added to the barium hydroxide solution. The fainter the color the sharper is the reaction, but the color must not be so faint as to be indistinct. The proper coloration will last for about three days ; it is then so indistinct that a few drops of rosolic acid must again be added.

5. A 250 c.c. bottle filled with dilute oxalic acid. This is prepared by bringing 25 c.c. of the standardized oxalic acid into the 250 c.c. flask, and then filling the flask to the mark with water.

6. A thermometer.

7. A barometer (a small aneroid).

The amounts of solutions here given for the portable apparatus are sufficient for thirty separate determinations ; in other words, at least ten analyses, including a control determination each time and the standardizing of the solution, can be made with the above quantities.

Each determination of carbon dioxide by Hesse's method is a double one, the two determinations being made with volumes of air of different size. Accordingly, flasks of $\frac{1}{2}$ and $\frac{1}{4}$, or $\frac{1}{2}$ and $\frac{1}{8}$, or $\frac{1}{2}$ and $\frac{1}{16}$ litre capacity are used for taking the samples of air, the sizes of the flasks chosen depending upon whether a smaller or a larger amount of carbon dioxide in the air is to be expected. The samples are taken by completely filling the flasks at the place where the air is to be examined with water which has the temperature of the place, and then emptying the flasks and rinsing them

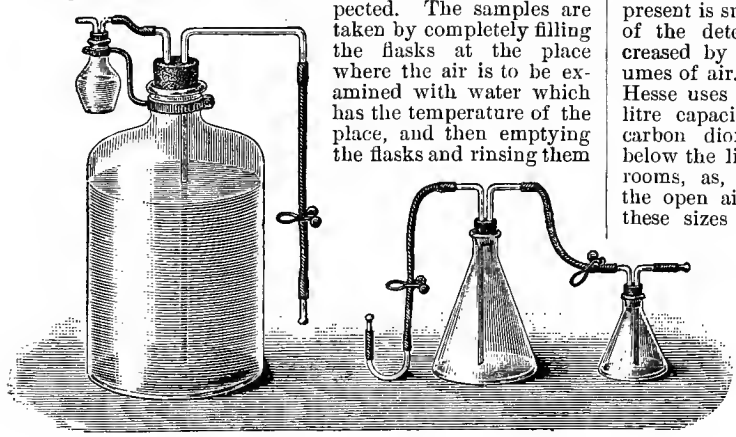


Fig. 195.

with distilled water. In this operation care must be taken that the flask is not warmed by the hand, and that no air exhaled by the operator enters the flask.

To absorb the carbon dioxide, the 10 c.c. pipette is put through one of the openings of a stopper fitting the flask, its end is inserted in the rubber tube of the supply flask, and the pipette is rinsed with a little barium hydroxide solution drawn up into it. The pipette is now filled to the zero mark by suction, and the stopper through which it passes is inserted in the neck of the flask containing the sample of air. The barium hydroxide is now run into the flask, the second opening of the stopper being obstructed with the finger or a glass rod to such an extent that the displaced air can just escape. The glass rod is then pushed into place, and the pipette is freed from the few drops of solution adhering to it by closing it at the top and warming it with the hand. The pipette is then drawn out of the stopper, and the second opening is closed with a glass rod. The same proceeding is repeated with a second flask of different capacity. The two flasks are allowed to stand for some time with occasional shaking, and in the meantime the strength of the baryta water is determined.

The strength of the baryta water is determined by putting into the small flask of $\frac{1}{16}$ litre capacity nearly as much standardized oxalic acid solution as will be required in the titration, and then running in 10 c.c. of the solution of barium hydroxide. The solution is then neutralized by slowly running in more oxalic acid, and the total oxalic acid necessary is thus determined. By proceeding in this manner a very exact standardizing of the solution is possible, even in an atmosphere containing much carbon dioxide, because the solution is never strongly alkaline enough to absorb appreciable amounts of carbon dioxide from the air.

The baryta water which has been shaken with the air is titrated without previously removing the barium carbonate. The titration is made as follows :

Remove the glass rod from one of the openings in the stopper, and immediately insert the tip of the burette which has already been filled with oxalic acid solution. The tip of the burette should reach as far as possible into the flask (Fig. 196). Open the stopcock of the burette and allow the oxalic acid to enter rapidly at first, but at the last only drop by drop. If the increased pressure resulting inside the flask checks the flow of liquid from the burette, this pressure is removed by lifting the glass stopper for a moment. When the solution is neutral, *i.e.*, when it is completely decolored, the height of the solution in the burette is noted, and the contents of the second flask is titrated in the same manner.

It is clear that when the amount of carbon dioxide present is small, the accuracy of the determination is increased by using larger volumes of air. For this reason Hesse uses a flask of $\frac{1}{2}$ or 1 litre capacity whenever the carbon dioxide is probably below the limit for dwelling-rooms, as, for example, in the open air. He also uses these sizes when great accuracy is desired. Of course sufficient barium hydroxide solution must be taken to insure its being present in excess up to the end of the operation. The small amount of carbon dioxide which the baryta water takes up from the air that it displaces when running into the flask may be disregarded.

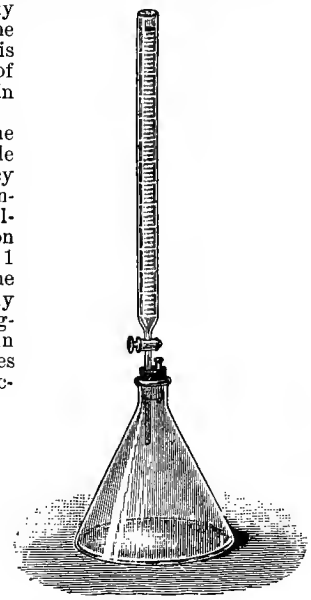


Fig. 196.

In using this method for determining the carbon dioxide present in the soil or in walls Hesse employs the apparatus shown in Fig. 197. The air in the soil is drawn through the flask by means of a rubber pump ; the glass tubes are then removed, and the openings in the stopper are closed with glass rods. The titration is made as before described, but more concentrated reagents are required. In examining the air of graves, Hesse used a solution of barium hydroxide ten times as strong as that previously given (10 c.c. = about 10 c.c. oxalic acid solution A3 = 10 c.c. CO_2).

In calculating the analysis the volume of air taken is reduced to normal pressure and temperature, so that correct comparisons may be made. This calculation takes considerable time, and to Hesse belongs the merit of having compiled a table [21] giving the figures by which the amounts of carbon dioxide found in the uncorrected gas volume are to be multiplied. The table contains for each degree of temperature the multiplier for any barometric pressure.

Example—

$$V = 223 \text{ c.c.}, t = 19^{\circ}, b = 739 \text{ mm.} ;$$

the titration of the baryta water gave 10 c.c. baryta water = 11.5 c.c. oxalic acid, and in the experiment 6.2 c.c. oxalic acid was used. Hence the amount of carbon dioxide which had already united with the barium hydroxide was equivalent to 11.5 − 6.2 = 5.3 c.c. oxalic

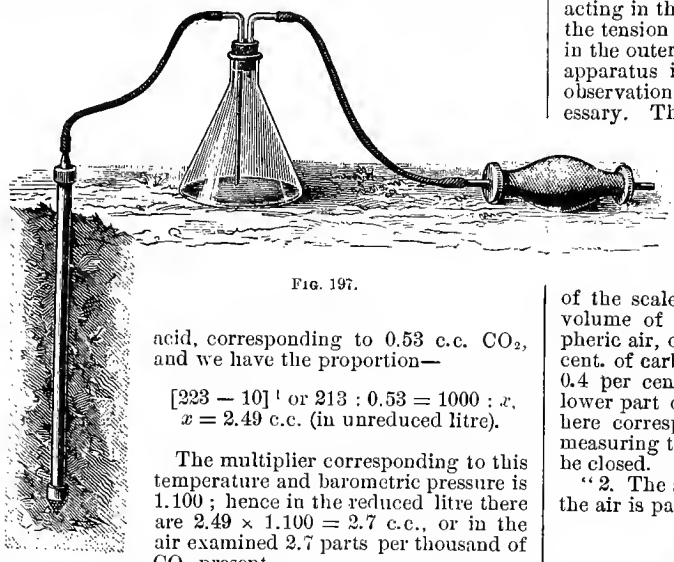


Fig. 197.

acid, corresponding to 0.53 c.c. CO_2, and we have the proportion—

$$[223 - 10]^{1} \text{ or } 213 : 0.53 = 1000 : x,$$
$$x = 2.49 \text{ c.c. (in unreduced litre).}$$

The multiplier corresponding to this temperature and barometric pressure is 1.100; hence in the reduced litre there are 2.49 × 1.100 = 2.7 c.c., or in the air examined 2.7 parts per thousand of CO_2 present.

The whole operation, including the control determination and the calculation, may be completed in from a quarter to half an hour.

Pettersson and Palmqvist have described [10] an apparatus for determining carbon dioxide in air, with which very accurate results can be obtained in a few minutes. Their description of the apparatus is, in part, as follows:

"Fig. 198 shows the apparatus which we used, and which is easily portable. The apparatus can be covered by a wooden box which fits over it, and to which a metal handle is strongly fastened (this cover is not shown in the figure). When the apparatus has been brought to the place where the air is to be examined, the glass jacket is filled with water, the outside air is drawn in through the tube *e*, and by a few simple manipulations, which take only a few minutes, the carbon dioxide is determined with an accuracy of about 0.01 per cent. The dimensions of the apparatus are as small as possible. For example, the pipette *A* into which the air to be analyzed is drawn holds only about 18 c.c. With larger volumes of air it would be easy to attain greater accuracy.

"The carbon dioxide is absorbed in the Orsat potash-tube *B*, and the air is measured, before and after the absorption, in the pipette *A* and its graduated tube. The measuring pipette can be filled with mercury or air, or emptied of the same, by raising or lowering the mercury reservoir *E*, which is joined to the lower end of the graduated tube of *A* by means of a rubber tube wrapped with copper wire. There must always be a drop of water on the surface of the mercury; the air standing over the mercury is thus kept saturated with moisture. In reading the volumes the meniscus of the mercury is each time so adjusted that the pressure in *A* is exactly the same as the pressure of the air in the compensation cylinder *C*.

"A differential manometer containing a drop of a colored liquid (petroleum, in which azo-benzol is dissolved), and connected by capillary glass tubes on the one side with *A* and on the other with *C*, serves as the indicator in these operations. By moving the reservoir *E* and then—having closed the stopcock *d*—suitably turning the screw *e*, the level of the mercury in *A* is so adjusted that the drop of liquid in the manometer stands at zero. It is obvious that in this manner it is always possible to bring back the air in *A* to the same pressure as that prevailing in the compensator *C*. Since the air in both the compensator and pipette is, from the beginning of the experiment, separated from the external atmosphere by closing the stopcocks *f*, *g*, and *c*, any variations in the external atmosphere have no effect. This is also true of changes in temperature; these eliminate themselves by acting in the same manner and to the same extent upon the tension of the air in *A* and *C*, provided that the water in the outer vessel which surrounds the main parts of the apparatus is sufficiently stirred. For these reasons no observation of temperature or barometric pressure is necessary. The changes in volume read off on the scale give directly the amount of carbon dioxide in hundredths of per cent. by volume.

"Each analysis consists of three operations.

"1. The air is drawn in from the outside and is measured, the level of the mercury in the graduated tube being brought to the zero mark. The upper and narrower part of the scale, where each division denotes $\frac{1}{10000}$ of the volume of the pipette, is used in analyses of atmospheric air, or the ordinary air of rooms, where the per cent. of carbon dioxide is at the most not higher than 0.4 per cent. In the analysis of very impure air the lower part of the graduated tube is used, each division here corresponding to $\frac{1}{1000}$ of the whole volume. In measuring the volume the stopcocks *f*, *g*, *b*, *c*, and *d* must be closed.

"2. The stopcocks *d* and *b* are opened, *a* is closed, and the air is passed from *A* to *B*. After one or two minutes

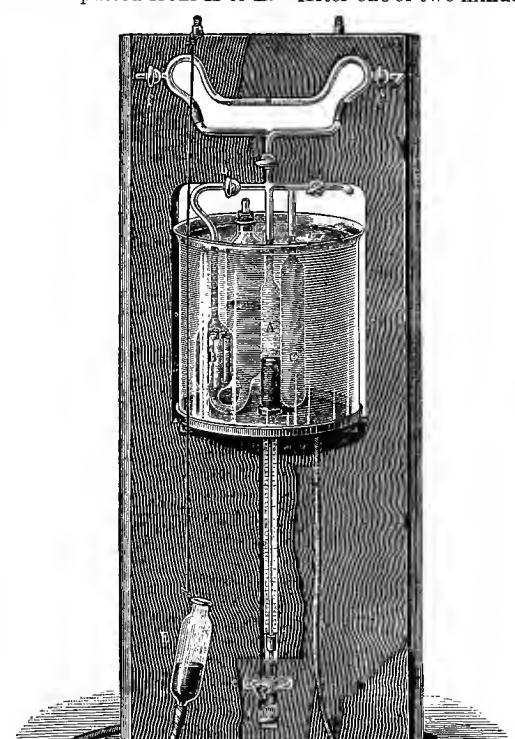


Fig. 198.

the carbon dioxide is absorbed and the air may be brought back into *A*, *b* is then closed, and *a* is opened.

"3. The mercury level in *A* is so adjusted that the index again takes its normal position. The decrease in volume is then read off on the scale."

The Determination of Oxygen in the Atmosphere.—The

great significance which the oxygen in the atmosphere has for all living beings has made this gas the subject of frequent investigations. The amount in a sample of air can be determined with considerable accuracy with the Hempel technical apparatus already described, the oxygen being absorbed in the Hempel pipette filled with alkaline pyrogallol. If, however, great accuracy is desired, methods which admit of more delicate measurement of the gas volumes before and after absorption must be used. The best agreeing results upon the amount of oxygen in the atmosphere seem to have been obtained by Hempel with his apparatus for exact gas analysis (Fig. 186). He collected the samples of air in glass tubes which had previously been exhausted of air, as already described. The oxygen was absorbed with alkaline pyrogallol. Four analyses of the same sample, by one of Hempel's assistants, gave 20.936, 20.938, 20.938, and 20.938 per cent. oxygen.

The Detection of Carbon Monoxide in the Air of Rooms.—The extremely poisonous character of this gas and the ever-present possibility of its production by defective heating apparatus make its sure and easy detection a matter of great importance. If the poisonous effects of carbon monoxide showed themselves only when comparatively large amounts of the gas were present, its detection and the determination of its amount could easily be effected in the customary absorption analysis. Inasmuch, however, as decided symptoms of poisoning are observed when less than $\frac{1}{10}$ of one per cent. of carbon monoxide is present, and as death would probably result from breathing air containing only one per cent. of the gas (a mouse breathing air containing 2.9 per cent. carbon monoxide died with convulsions in from one to two minutes) it is clear that quite delicate tests for the presence of the gas are necessary. The change produced in the absorption spectrum of blood, upon its taking up carbon monoxide, was first utilized by H. W. Vogel,[11] for the detection of small amounts of the gas in the air of a room.

Blood which has been highly diluted with water shows in a layer two centimetres thick (a large test-tube) the absorption spectrum plotted in 1, Fig. 199, and sketched in 2. If this blood be then shaken with carbon monoxide, the bands of the oxyhæmoglobin are replaced by those of carbon monoxide hæmoglobin, 3, the latter lying slightly nearer the violet end of the spectrum. This displacement of the bands, though but slight, is yet sufficient to admit of its being sharply measured, and, in the hands of a practised spectroscopist, is sufficient evidence of the presence of carbon monoxide in the blood. The test is, however, rendered much more delicate by taking advantage of the fact that certain reducing agents, when added to the blood, change the spectrum of oxyhæmoglobin to a broad and weakly defined band, 4, but produce no variation in the spectrum of the carbon monoxide hæmoglobin. In applying these

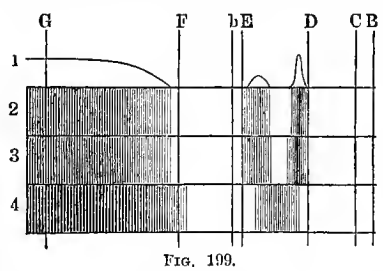


Fig. 199.

characteristics of the blood spectrum to the detection of carbon monoxide in the air of rooms, Vogel filled a 100 c.c. bottle with water, emptied the bottle in the room containing the gas, and then poured into the bottle two or three centimetres of blood highly diluted with water and showing only a faint red color, yet still giving the oxyhæmoglobin bands in a column as thick as a test-tube. The blood is then shaken in the bottle for some minutes. Upon pouring the blood into a test-tube and observing its spectrum through the spectroscope two absorption bands are of course visible, either those of the oxyhæmoglobin or of the carbon monoxide hæmoglobin, or all together. Upon now adding a few drops of strong and freshly prepared ammonium sulphide to the blood, the spectrum, if no CO was present in the air of the room, will change in a few moments to that shown in 4. But

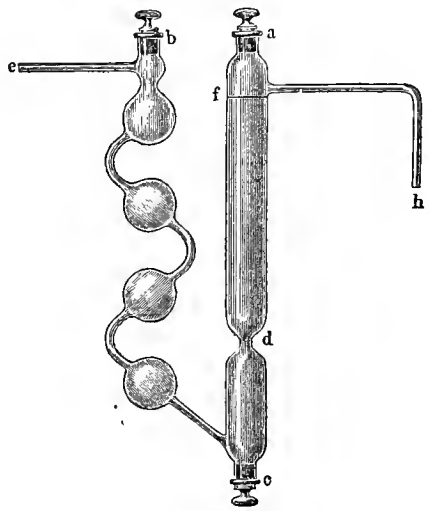


Fig. 200.

if the two absorption bands shown in 3 are still seen, the presence of carbon monoxide in the air under investigation is definitely proved.

Vogel states that amounts down to 0.25 per cent., or 2.5 parts in 1,000, can be clearly detected, but that the delicacy is not increased by using great volumes of air.

Later, Hempel [12] increased the delicacy of the test by using live mice instead of the dilute blood solution. A mouse was made to breathe for some time the air in question, and was then killed and its blood examined spectroscopically, as above. By this means Hempel was able to detect as small an amount as 0.03 per cent. of carbon monoxide.

In 1880 C. H. Wolff described [13] a very effective absorption apparatus adapted to the use of small amounts of blood. As his method is quite as delicate as Hempel's, and does not call for the presence of the difficultly obtained and elusive monse, a description of it is here given.

The apparatus used by Wolff for absorbing the carbon monoxide is shown in Fig. 200.

The tubes are closed at *a*, *b*, and *c* with carefully ground stoppers. In filling the apparatus a little wad of glass-wool is inserted into *d* from above, and gently pressed into place, and the remainder of the tube as far as *f* is then filled with moderately fine powdered glass. This powdered glass is about as fine as ordinary gunpowder. It is freed from any fine powder and dust by sifting, and is then digested with hydrochloric acid, and carefully washed and dried.

The glass powder is moistened with water from above; strong suction is then applied at *e* by attaching an aspirator thereto, and the excess of water which is thus drawn off from the powdered glass is removed at *c*. Two cubic centimetres of dilute blood (1 to 40) is then allowed to drop from above, from a pipette, upon the moistened glass, *a* is closed, and by gently blowing into *h* with the mouth a uniform distribution of the blood solution throughout the column of powdered glass down to the glass-wool is effected. The apparatus is ready for the absorption, and it is now connected either at *e* with the aspirator or at *h* with the bottle, depending upon whether the 10 litres of air are to be drawn through or driven through. An or-

dinary bottle containing somewhat more than 10 litres is very well suited to the taking of the sample of the air to be examined. This bottle is supplied with a double-bore rubber stopper, through the openings of which pass two glass tubes bent at right angles above the stopper.

One of these tubes ends just below the stopper, and the other reaches to the bottom of the bottle. Pieces of rubber tubing of sufficient length, and closed by Bunsen screw-pinchcocks, are slipped over the free ends of both tubes. Since the bottle holds more than 10 litres, it is provided near the bottom with a mark, from which point up to the stopper the capacity is exactly 10 litres. To fill the bottle with the air to be examined, it is filled completely with water, and this is then run out through the rubber tube which is connected to the longer glass tube, and which acts as a siphon. When the water has fallen to the 10-litre mark both pinchcocks are closed. To pass the air through the absorption apparatus, the same rubber tube which has acted as a siphon is attached to a bottle filled with water, and standing higher than the first bottle, and the other rubber tube is connected with the absorption apparatus. The current of air, which may be very exactly regulated by means of the screw-pinchcock, must pass through the absorption apparatus very slowly—on an average 1,000 c.c. in twenty to twenty-five minutes. To be able to observe and regulate the passage of the air through the apparatus, 2 to 3 c.c. of water are run in at *b*, after the powdered glass has been moistened with the blood solution. When the experiment is ended this water is let out at *c*. Any burette-holder is suited to holding the absorption apparatus; a Vogel "universal stand" is also well adapted to the purpose. If it be desired to draw the air of the room in question directly through the apparatus—a proceeding which is, however, not to be recommended, because of the possible change in the composition of the air during the long duration of the experiment—the end *h* is joined by a cork to a so-called calcium chloride cylinder containing pieces of pumice-stone moistened with water. The air enters the cylinder from below, becomes saturated with moisture, and then passes into the absorption apparatus. When 10 litres of air have been led through, in one manner or the other, the stopper at *c* is removed to let out the water. A small test-tube, upon which is a mark for 3 cubic centimetres, is then placed under *c*, the stopper at *a* is removed, and pure water is slowly dropped from a pipette upon the powdered glass. The blood solution is thus gradually displaced, and the washing is continued in this manner until the liquid in the test-tube amounts to 3 c.c. The tube is then taken away, several cubic centimetres of water are allowed to flow through the powdered glass, all the stoppers are inserted, *e* is connected with the aspirator, and when the excess of water has thus been removed the apparatus is ready for another experiment.

The same powdered glass may be used for from fifty to sixty determinations without renewal.

The absorption apparatus contained originally 2 c.c. of dilute blood, 1 to 40; hence the 3 c.c. now in the test-tube have a concentration of 1 to 60.

Small rectangular bottles with flat sides, which are 0.5 ctm. and 1 ctm. wide, are very well suited to holding the blood solution for the observations with the spectroscope: these little bottles hold about 1.5 c.c. of solution, and are closed with carefully ground stoppers. One of these bottles is filled with the blood solution used in the experiment, and a second bottle is filled with the original blood solution, also diluted to 1 to 60. One drop of ammonium sulphide is added to the contents of each bottle; the bottles are shaken, and after half an hour the spectra of the two solutions are examined, preferably by lamp-light, with a delicate pocket spectroscope.

Wolff states that when there is 0.03 per cent. carbon monoxide in atmospheric air, both absorption bands are distinctly recognizable. When the air contains less carbon monoxide, about 0.02 per cent., the presence of the gas is shown merely by a somewhat stronger absorption in the absorption spectrum, which now appears at *D* as a broad band, the maximum absorption of the reduced blood solution lying toward *E*.

It is very desirable to possess for these experiments a solution of blood which is clear and which will keep for a long time. Wolff recommends Jäderholm's method of mixing together equal volumes of blood freed from fibrine, and of cold saturated borax solution, and he says that the solution remains clear for months and does not need to be filtered before being used for the spectroscopic examination.

To determine quantitatively the amount of carbon monoxide in the blood, Fodor suggests placing the blood in a small flask provided with a perforated stopper carrying two glass tubes. One of the tubes reaches to the bottom of the flask, and through it is led in a current of air which has been previously freed from carbon monoxide by passing it through a solution of palladious chloride. The air, after leaving the flask through the shorter tube, is passed through a wash-bottle containing a solution of lead acetate, then through a second bottle containing dilute sulphuric acid, and finally through two **U**-tubes containing a palladious chloride solution as free as possible from acid. The flask is now warmed upon the water-bath to 90° C. for from one-fourth to one-half an hour, the current of air being passed through slowly and the flask being frequently shaken. The carbon monoxide is thus driven out of the blood, and passing through the two wash-bottles it enters the palladium solution, from which it precipitates metallic palladium. The precipitated palladium is collected, dissolved in aqua regia, and the amount of palladium determined by titration with a standard solution of potassium iodide. If a solution containing 1.486 gramme of potassium iodide to the litre is employed, then each cubic centimetre corresponds to 0.1 c.c. CO.

The Detection of Ozone in the Atmosphere.—A large number of reagents may be used for the detection of ozone. For the detection of such small amounts of ozone as are present in the atmosphere, so-called ozone papers are employed.

Houzeau [14] has suggested that this be prepared by dipping strips of Swedish filter-paper into a wine-red litmus solution which contains in a cubic centimetre about 0.013 gramme of the extracted constituents dried at 100° C.: the paper is dried and then impregnated to a fourth of its length with a one per cent. solution of neutral and pure potassium iodide free from iodate. The dried paper must be protected from the air, and is on this account kept in tightly closed bottles.

This paper is colored slightly blue by from 0.0002 to 0.0003 mm. of ozone. In air containing $\frac{1}{261000}$ of its weight of ozone the paper turns blue at once. The part of the paper which is colored with the litmus solution, and is not impregnated with the potassium iodide, serves to show the presence in the air of acid or alkaline substances which might influence the reaction. By the action of ozone the potassium iodide is decomposed and potassium hydroxide is formed, which turns the litmus paper blue. Chlorine, nitric acid, and other acid substances do not, of course, turn the paper blue; in this respect it is superior to those which follow.

According to Schönbein,[15] strips of paper are saturated with a dilute starch and potassium iodide solution (1 KI + 10 starch + 200 water), and these strips are exposed to the air. A distinction of ten shades from white to dark blue is made.

Wurster [16] uses tetra-methyl-para-phenylene-diamene, which, upon taking up one atom of oxygen, is quantitatively oxidized to a blue coloring matter, and by further union with six oxygen atoms changes to a colorless substance.

To detect ozone, the paper prepared by one of the foregoing methods is fastened over the end of a glass tube by means of a rubber band, and a measured quantity of gas is drawn through the tube by an aspirator.

Houzeau found that the ozone in the atmosphere reached its maximum in May and June, and was least in the winter months. Böckel [17] states also that there are daily variations, the air usually containing more ozone

in the evening of days from July to September than in the morning, while the reverse is true for the remaining months of the year.

THE GASES OF THE BLOOD.—Various forms of apparatus have been devised[20] for the extraction of the gases from blood. Probably as satisfactory as any is the Pflüger Mercurial Pump, shown on page 201, Vol. VI., of this HANDBOOK. For facilitating the measurement of the blood before pumping out the gases, Geppert[7] has proposed (page 63) a form of apparatus which with some slight modifications might be of considerable value.

As the blood-gases are chiefly oxygen, nitrogen, and carbon dioxide, the analysis of the mixture is easily performed, the method employed depending upon the amount of gas at the operator's disposal, and upon the degree of accuracy desired. *L. M. Dennis.*

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[15] Schönbein: Poggendorff's Annalen, 93, p. 627; 94, p. 335.
[16] Wurster: Berichte der deutsch. chem. Gesellschaft, 1888, p. 921.
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[19] Pettenkofer: Jahresbericht der Chemie, 1857, p. 132. Also, Quarterly Journal of the London Chemical Society, 10, 292.
[20] Zuntz: Handbuch der Physiologie, vol. iv., Part II., pages 24–32.
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GENITO-URINARY SURGERY. Since the publication of the first edition of the REFERENCE HANDBOOK OF THE MEDICAL SCIENCES the advances which have been made in the department of genito-urinary surgery have been mainly in the direction of therapeutics and pathology. But little has been added to our knowledge of the anatomy and physiology of these organs.

Space will not admit of an exhaustive consideration of all the literature which has appeared, the views which have been advanced, or the many new or revived methods of treatment which have been suggested.

It will, however, be the aim of the writer to take up the subjects, as far as practicable, in the order in which they originally appeared, and to give, as briefly as possible, the practical results of our accumulated experience.

BLADDER.

Exstrophy.—In cases of exstrophy of the bladder, Trendelenburg, with a view to narrowing the anterior gap between the pubic bones, has suggested and successfully practised double posterior symphysiotomy.

Inflammation (Cystitis).—Etiology.—Th. Rossing has contributed the results of some elaborate experiments regarding the etiology of cystitis, and concludes that the urine usually contains one of several varieties of pathogenic organisms. These organisms may be pyogenic or non-pyogenic. Of the organisms which he isolated, all, with the exception of the tubercle bacillus were found to be capable of causing a decomposition of the urea. This decomposition would give rise to vesical irritation, and if the organism was of the pyogenic variety a suppurative cystitis would result.

In twenty-three out of thirty healthy individuals examined by this author bacteria were found in the urethra which were capable of producing this decomposition of urea. In this manner he explains the frequently observed fact of the occurrence of cystitis after the most careful employment of surgically clean urethral instruments.

It was also found that the injection of pure cultures of these organisms into the bladder frequently gave rise to no symptoms of irritation when the urine was allowed to pass at regular intervals. If, however, an artificial retention was produced in the animal by ligature of the penis for from six to twelve hours, a decomposition would be occasioned which would give rise to an inflammatory reaction.

Similar results have been obtained by Guyon, Albarran, and others, and these facts seem to explain the remarkable tendency to infection observed in patients suffering from retention due to stricture or obstructive disease of the prostate.

In a paper published by P. Bazy, the statement is made that in nearly every case of cystitis, where there is a genuine purulent inflammation, the origin may be traced to gonorrhœa, tuberculosis, or infection by means of instruments.

Mechanical irritation alone, such as that produced by a foreign body, new growth, or obstructive urethral or prostatic disease, cannot give rise to a suppurative inflammation. There are, however, certain rare cases, where a cystitis appears spontaneously, without the possibility of gonorrhœa, tuberculosis, or direct septic infection being present. These are usually loosely spoken of as due to "cold" or the somewhat mysterious action of rheumatism or gout.

This author made several such cases the object of careful investigation. In one of these he discovered that an alveolar abscess preceded the symptoms of cystitis by several days; in another, a purulent balano-posthitis, and in still another, a suppurative tonsillitis had been present a short time before the occurrence of the hitherto unexplained vesical inflammation.

The author stated, as his belief, that the disease in each of these instances had been produced by direct infection of the bladder by pathogenic organisms passing from the blood through the renal filter into the urine, the origin of which could be traced to the antecedent septic disease.

Diagnosis.—The possibility of confounding the symptoms of cystitis with those of a posterior urethritis was pointed out in the former edition of this work. Since that time much has been written on the subject, and it is now a generally accepted fact that the occurrence of frequent micturition, vesical tenesmus, and pyuria do not necessarily indicate the presence of intra-vesical inflammation. In fact, in the majority of cases, these symptoms simply indicate the presence of a posterior urethritis, for experiments have abundantly demonstrated the fact that the desire to urinate is due, in a great measure, to an irritation of the peripheral nerves located in the prostatic urethra, caused generally by the relaxation of the internal sphincter, and the consequent introduction of the urine into this portion of the canal. The presence, moreover, of any slight irritation, such as the introduction of a foreign body, or the occurrence of an inflammation of the mucous membrane in this region, will give rise to the desire for frequent micturition, and, if more severe, to marked vesical tenesmus. It has also been conclusively shown that pus generated in that portion of the urethra posterior to the compressor urethræ muscle, when present in any considerable amount, invariably flows backward into the bladder.

If, therefore, in a condition of acute posterior urethritis, the urine be passed in two glasses, both specimens will be found to contain free pus, which continually flows backward from the seat of the inflammatory process into the bladder. The first specimen, in addition, will contain the washings of the canal, which will appear as minute, thread-like bodies, to which the name of *Tripperfaden* has been given by the German surgeons, who first discovered them and demonstrated their importance.

The presence of an anterior urethritis, which might

account for these bodies, may be excluded by a previous irrigation of the anterior portion of the canal.

In cystitis (excepting in those rare instances where the infection is purely a tubercular one) the decomposition of urea gives rise to the presence of a free alkali. This, if allowed to remain in the bladder for a moderate length of time, by its action on the pus, forms a thick, tenacious substance resembling mucin, which collects at the bottom of the bladder, is expelled with the last portion of urine passed, and is pathognomonic of intra-vesical inflammation.

Finger describes three conditions usually spoken of as cystitis: First, posterior urethritis; second, posterior urethritis, with a moderate amount of cystitis in the immediate vicinity of the internal urethral orifice, and third, cystitis without posterior urethritis.

As an easy method of determining which of these conditions are present in a given case, if the patient urinates in three glasses, the following facts will be observed:

Condition.	First specimen.	Second specimen.	Third specimen.
Posterior urethritis.	Reaction generally acid. Large amount of free pus and urethral shreds.	Moderate amount of free pus.	Moderate amount of free pus.
Posterior urethritis, with cystitis about internal urethral orifice.	Reaction faintly acid or neutral. Large amount of free pus; urethral shreds.	Moderate amount of free pus.	Larger amount of pus, and moderate amount of mucoid material.
Cystitis without posterior urethritis.	Reaction alkaline. Moderate amount of free pus.	Moderate amount of free pus.	Large amount of pus and mucoid material, with crystals of triple phosphate.

Treatment.—A few suggestions only can be added to those already mentioned in the first edition of this work.

Internal Treatment.—Many drugs have been employed with a view to rendering the urine antiseptic, and thus preventing or inhibiting the further development of pathogenic organisms in the bladder. Of these, boric acid and salol have been found most useful. To be of value, however, they must be given in large doses, from twenty to thirty grains of the former and from forty to sixty grains of the latter during the twenty-four hours.

Local Treatment.—It is desirable in cases of bladder inflammation, especially if acute, to avoid the use of instruments beyond the compressor urethræ muscle. The old method of bladder irrigation by means of the catheter had the disadvantage of producing often mechanical irritation and septic infection.

Lavaux, of Paris, has shown that the bladder can be successfully irrigated without the use of a catheter by means of hydrostatic pressure furnished by the fountain syringe.

To inject the bladder by this method the patient should be made to recline on his back with the thighs raised to relax the abdominal muscles. The nozzle of the syringe should be placed just within the meatus, the lips being firmly compressed upon it, and the reservoir raised to a height of three or four feet above the patient's body. If the patient will then take three or four deep inspirations, the fluid will usually pass rapidly beyond the compressor urethræ muscle into the bladder. As soon as the bladder becomes distended, a strong desire to urinate will be experienced, and the solution can be expelled in the usual manner. This method has the additional advantage of insuring thorough irrigation of the whole urethral canal, the deeper portion of which is usually involved in cases of cystitis. In the milder cases a saturated solution of boric acid will be found most useful as a bladder-wash. Permanganate of potash, 1 to 10,000; nitrate of silver, 1 to 5,000, and bichloride of mercury, 1 to 30,000 will often be found useful in the more chronic and obstinate conditions.

Injuries of the Bladder.—The tendency among surgeons during the past few years has been toward more radical procedures in cases of ruptured bladder. When the rent in the bladder-wall is known to be extra-peritoneal, measures should be at once taken to insure free drainage, and the wound left to heal by granulation. With this end in view, Cabot, of Boston, advises an immediate laparatomy, with a view to accurately determining the region of greatest infiltration which should guide the surgeon in the selection of his point of incision for drainage.

Since the report by Hofmokl and MacCormac of successful laparotomies and vesical suture in cases of intra-peritoneal rupture of the bladder, there no longer remains any question as to the indications for treatment in this condition. A number of other successful cases have since been reported by European and American surgeons, so that now it is generally conceded that, in the presence of symptoms indicating an intra-peritoneal rupture of the bladder, an exploratory laparotomy should be performed at once, and the wound promptly united. A subsequent perineal section should then be made, to insure adequate bladder drainage.

A number of cases of rupture of the bladder have been collected and reported by Ullmann, the result of injections made preparatory to the operation of supra-pubic cystotomy.

New Growths.—Under this head may be mentioned the *nodular or follicular cystitis*, described by Dr. Samuel Alexander, in a paper read before the American Association of Genito-urinary Surgeons, at Richfield, in June, 1892. This paper was a preliminary report based upon a number of cases of intense cystitis, associated with hæmaturia, upon which the author had operated, in most cases by the supra-pubic method.

In all of these cases similar lesions were found in the bladder. The mucous membrane was intensely congested, and was studded, especially in the region of the trigone, with nodules varying in size from one-eighth to one inch in diameter, usually oval, soft, and limited to the mucous membrane proper. These tumors consisted of lymph nodules and more diffuse collections of lymphatic cells, the former resembling the nodules found in the intestine in certain cases of enteric inflammation. These vesical nodules were surrounded by an exceedingly rich net-work of newly formed capillaries with exceedingly thin walls. The nodules were covered by the upper epithelial layer of the mucous membrane.

This condition has been mentioned by Chiari, Weichelbaum, Hamburger, Toldt, Ziegler, and others, and the post-mortem appearances have been described by Paderowski, who regarded them as tubercular growths. Alexander differs from this view and believes that lymph-nodules exist in the normal urinary tract, and that they may enlarge as the result of intense inflammation, and be often mistaken for tubercles in the bladder. He described the clinical history of these cases and advises supra-pubic cystotomy and thorough drainage.

An extended report and description of this most interesting, and hitherto imperfectly understood, condition is soon to be published.

Stone (*Lithotomy, Litholapaxy, Supra-pubic Cystotomy*).—The statistics published by Sir Henry Thompson, Dittel, and a large number of other operators, embracing thousands of cases of calculus disease, operated upon by all methods, conclusively show the great advantage and low mortality of litholapaxy over all other procedures. Although several modifications have been made in the tubes and evacuating apparatus, practically nothing can be added to the description of the operation of litholapaxy which appeared in the first edition of this work.

The advantages which the supra-pubic method of opening the bladder offers over the perineal incision, for exploration and the removal of foreign bodies and new growths, are now generally recognized by surgeons. Trendelenburg advises for this operation a specially constructed operating-table, which insures an elevation of the patient's pelvis eighteen or twenty inches above the head and shoulders. He also advocates the transverse section of the recti muscles.

Regarding the question of primary vesical suture, Watson, of Boston, reaches the following conclusions from the analysis of one hundred cases: 1. Suture should be employed where the pathological changes in the bladder are slight. 2. Suture should be avoided when the bladder-walls are much thickened, when there is much liability to hemorrhage within the bladder, or when there is a foul cystitis. 3. Short needles and catgut should be used with that form of suture which is most easily introduced.

Tuberculosis.—The treatment of tubercular cystitis by supra-pubic opening, curetting and cauterizing the ulcers, and the subsequent employment of iodoform, has been sufficiently successful in the hands of Guyon, Reverdin, and others to justify the hope that in early cases marked relief may often follow and recovery occasionally result.

Cystoscope.

An instrument designed for the purpose of affording the possibility of an ocular inspection of the interior of the human bladder. This idea was most successfully carried out by Josef Leiter, of Vienna.

The following diagram and description of this instrument appeared in the *Medical Record* for May 5, 1888:

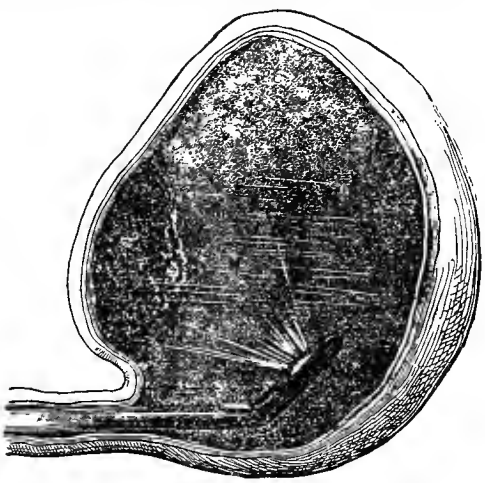

Fig. 201.—The Leiter Cystoscope in Position in the Bladder.

"The Leiter cystoscope (Fig. 202) consists of a metal tube about seven inches in length, of a calibre of 22 F., having at the proximal end a funnel-shaped ocular opening, at the distal end a short beak, similar to that of the catheter coude. A window of rock crystal is set in the end of this beak, behind which a small electric lamp controlled by a switch at the ocular end is placed. A rectangular prism, the hypothenuse plane of which is silvered, is placed in the end of the straight portion of the tube, its superior face being seen just anterior to the angle formed by the beak. The distended bladder is illuminated by the electric lamp, the rays reflected from its walls falling on the prism experience total reflection, an inverted image being formed within the tube. The size of the image thus obtained is greatly increased by means of a telescope introduced into the tube. The image seen through the cystoscope is inverted, but right and left are not transposed."

To properly examine a bladder by means of this instrument, the patient should be placed in the horizontal position on the table or operating-chair. The bladder should be emptied of urine and afterward slightly distended with a solution of boric acid. The cystoscope is then introduced and the current turned on. If the eye of the operator is placed at the eye-piece of the small telescope introduced within the tube of the cystoscope, a limited area of the bladder-wall can be made out. If the fluid remains clear and the light is of sufficient strength, the mucous membrane may be minutely studied, its vessels, folds, and color easily appreciated, and any pathological lesion detected. By changing the position of the instrument, the whole interior of this viscus may be examined.

This instrument has been modified in many ways. When the illuminating and reception windows are placed on the posterior portion of the beak, a better view can often be had of the *basfond* in contracted bladders which do not admit of sufficient distention to permit of free rotation of the beak downward. Care should be taken not to allow, for any length of time, the contact of the illuminated beak with the bladder, as the heat generated by the lamp might cause a superficial destruction of the mucous membrane.

There can be no question of the great diagnostic value and importance of this discovery. By the aid of this instrument, accurate knowledge regarding the presence or absence of tumors, ulcerations, wounds, foreign bodies, and diverticula may be obtained without the necessity of an exploratory operation.

Another and most important use of the cystoscope is to determine from which kidney the blood or pus proceeds in cases of grave pyelitis or renal hemorrhage. By watching the openings of the ureters, the periodic discharge of urine from the kidneys can be observed, and the presence of abnormal substances in the secretion detected.

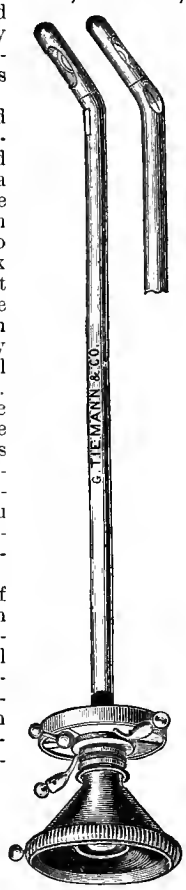

Fig. 202.

Endoscope.

An instrument for the visual inspection of the urethral mucous membrane.

As it would be a useless expenditure of time to describe the old and cumbersome instruments of Desormeaux and Cruise, mention will be made only of the modern instruments of Leiter, Brown, and Otis.

The following description of the Leiter endoscope is quoted from a recent article by W. K. Otis: "Roughly described, this instrument consists of a sheet metal trough, two inches and three-quarters in length by an inch and a half wide, at the proximal end of which a concave mirror, about an inch and a half in diameter, is placed. At the distal end of the trough is the funnel-shaped opening of the urethroscopic tube, the upper edge of which is about half an inch above the upper edge of the mirror. About an inch and a half from the mirror, coming through the bottom of the trough, a small electric lamp is placed, the electrical

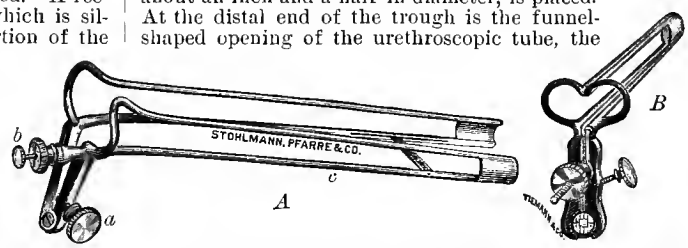

Fig. 203.—*A*, Brown's Wire Urethral Speculum. Open. *c*, The lever for spreading the vesical end, which is governed by the right-angled rod attached to the travelling screw button *b*; *a*, the screw which spreads the base or meatus part of the speculum. *B*, Brown's Wire Urethral Speculum, Closed. Shows the small square aperture in the binding screw for the attachment of the illuminator.

connections to which run through a round handle four inches long by half an inch in diameter, with a somewhat complicated arrangement for controlling the lamp, fitted with binding-posts at its lower end, to which the cords from the battery are fastened. The urethroscopic tubes are attached to the funnel by means of a sliding joint. The rays of the lamp falling upon the mirror are rendered parallel, and enough light thrown down the tube to give very excellent illumination at its distal end, the eye looking directly over the upper edge of the mirror."

The urethral speculum, devised by Dr. F. Tilden Brown, of New York, and seen in the accompanying illustration

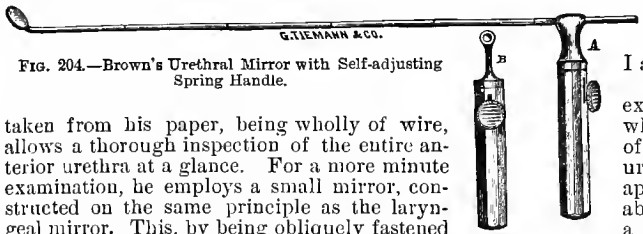

FIG. 204.—Brown's Urethral Mirror with Self-adjusting Spring Handle.

taken from his paper, being wholly of wire, allows a thorough inspection of the entire anterior urethra at a glance. For a more minute examination, he employs a small mirror, constructed on the same principle as the laryngeal mirror. This, by being obliquely fastened to the handle, when passed within the canal, reflects the image of any inequality or pathological condition of the mucous membrane. By means of the urethral digit (Fig. 205), the presence of any submucous deposit or band of stricture can be readily appreciated. The light which Dr. Brown employs is from a strong electric lamp, with lens condenser reflected by means of a head-mirror.

FIG. 205.—Brown's Straight Six-inch Urethral Digit. *C*, The movable probe-tip controlled by U-spring and thumb-screw at handle. Inch marks are indicated along the upper rod.

The Otis perfected urethroscope (Fig. 206) is perhaps the most perfect appliance for urethral illumination. From his article in the *New York Medical Journal* the following description is taken:

"This instrument consists of a metal tube or cylinder, an inch and a quarter in length by half an inch in diameter, closed at one end. A quarter of an inch from the open end of this tube is a plano-convex lens, so arranged that it may be easily removed for cleaning. On the inferior surface, near the closed end of the tube, an elbow is let in, a quarter of an inch in length and half an inch in diameter, through

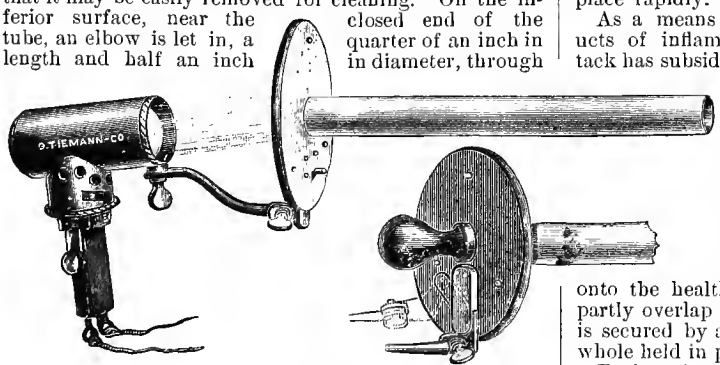

FIG. 206.

which the source of illumination (a small incandescent electric lamp) is introduced, a row of holes being bored at its base to allow of ventilation. The handle of the instrument consists of a piece of hard rubber an inch long by half an inch wide, the electrical connections running through it to the lamp which is placed on top. This handle fits into the elbow by means of a bayonet-joint, bringing the lamp immediately behind the plane side of the lens. A thumb-screw 'switch' in the handle places the lamp under control, so that it may be turned on or off at pleasure.

"The instrument is attached to the urethroscopic tube by means of a stout wire an inch and a half in length, with hinged joints at each end, which swing in opposite directions and are furnished with set-screws, thus allowing the instrument to be put in any position, though when once adjusted it will rarely be necessary to move it. If the ordinary form of tube is used the distal end is provided with a simple ring sliding-joint; but, as I have already said, I greatly favor the use of the tube of Dr. Klotz. I have arranged the instrument for this form of tube.

"When the instrument is in position and the lamp illuminated, a strong beam of light is thrown down the urethroscopic tube and the urethral mucous membrane more easily and clearly observed than with any other form of urethroscope with which I am familiar.

"The advantages of this instrument are: 1. The exclusion of all extraneous light, the presence of which is a most annoying fault in the urethroscope of Leiter. 2. A very much more ready access to the urethral field, both to the eye and for instrumental applications. 3. Increased illumination. 4. By abandoning the funnel and sliding-joint an inch and a half in distance is gained from the source of illumination to the distal end of the urethroscopic tube, increasing the illumination and allowing the eye to be placed just so much nearer the mucous membrane to be examined. 5. Its extreme compactness and lightness, weighing *less than one ounce*, even when constructed of brass. 6. Its great simplicity, which should insure a moderate cost."

EPIDIDYMITIS.

In the *Journal of Cutaneous and Genito-Urinary Diseases*, May, 1888, the writer published the results of some experiments in the treatment of acute epididymitis by means of the Paquelin cautery. The method employed was that first suggested by Halsted, which consists in lightly touching the surface of the skin overlying the affected organ with a white-hot cautery point. This, if successfully performed, requires but a few seconds, and is but moderately painful. A dressing of iodoform or boric acid ointment is then applied, and a suspensory bandage adjusted, so as to relieve any dragging upon the cord. Instant relief of pain often follows this procedure, and absorption of the inflammatory induration takes place rapidly.

As a means of hastening the absorption of the products of inflammation, after the acuteness of the attack has subsided, the *dry poultice* will often be found to be most useful. This dressing was described by the writer in a paper read before the American Association of Genito-Urinary Surgeons, at Washington, in 1891, and consists in a moderately thick layer of cotton-wool applied over the inflamed testicle. This is covered by a layer of rubber protective tissue so fashioned as to completely enclose the inflamed organ, with its edges extending onto the healthy skin of the scrotum in a manner to partly overlap but not enclose the healthy side. This is secured by a snugly applied ganze dressing, and the whole held in place by a suspensory bandage.

By insuring protection, heat, moisture, moderate compression, and suspension, this dressing fulfils all the indications to be met in this condition, and will be found to be a great source of comfort to patients whose occupations necessitate any considerable amount of standing or walking.

HYDROCELE.

Diagnosis.—As an easy method of making an accurate diagnosis in cases of suspected hydrocele, the electric illuminator devised by Dr. William K. Otis may be employed. This instrument consists of small incandescent lamp contained in a cylindrical hard rubber hood (Fig.

207). If the patient be examined in a darkened room, and the open extremity of this instrument firmly held against the posterior portion of the scrotal tumor when the current is turned on, the whole cavity of the tunica vaginalis will be brilliantly illuminated, and the exact location, shape, and size of the testicle can be determined.

Treatment.—The injection into the tunica vaginalis of a small amount (minims 10 to 30) of the liquefied crystals of carbolic acid, which was mentioned in the earlier edition of this work, is the method most generally em-

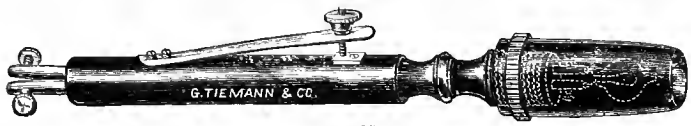

Fig. 207.

ployed at present. The usual manner of employing this agent is the following :

A hypodermic syringe containing the required amount of carbolic acid is inserted through the scrotum into the upper portion of the distended cavity of the hydrocele, and held by an assistant. A large trocar or aspirating needle should then be introduced into the lower and anterior part of the tumor through which the fluid is evacuated. After the complete emptying of the sac, the contents of the hypodermic syringe (the needle of which is still within the cavity of the tunica vaginalis) should be slowly injected, and, after removal of the needle, evenly distributed throughout the entire cavity by gentle massage. The patient should be instructed to remain quietly at home, preferably in the reclining posture, until all reactionary pain has subsided.

With a view to avoiding the double puncture, the writer employs a small trocar and cannula provided with a stopcock and threaded extremity to fit an ordinary hypodermic syringe (Fig. 208). This should be introduced and the fluid withdrawn. The stopcock is then turned to prevent the entrance of air, and the hypoder-

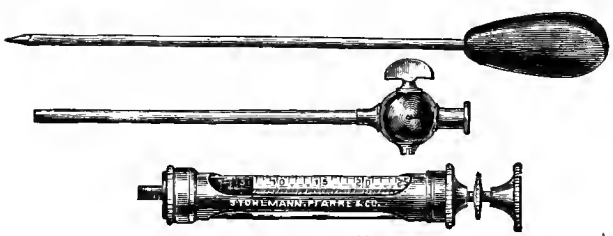

Fig. 208.

mic syringe containing carbolic acid screwed into place ; the stopcock is again opened and the contents of the syringe injected.

Prostate.

Senile Enlargement.—Nothing has been added to our knowledge regarding the causes of this common affection. During the past few years the tendency among progressive surgeons has been toward more radical measures, with a view to the removal of the obstructing portion of the hypertrophied mass. The practice of incising or removing a portion of the bar, which often exists just within the internal urethral orifice, by means of the instruments of Mercier and Gouley, without opening the bladder, has been practically abandoned by most surgeons, owing to the danger attending the operation and the uncertainty of result.

For several years past occasional reports have been published of the successful removal of an hypertrophied third lobe, or obstructing bar at the neck of the bladder, by means of a perineal or supra-pubic opening, with more or less complete restoration of the function of voluntary urination. It was not, however, until the publication by A. F. McGill, of Leeds, and E. L. Keyes, of New York, of their series of cases, that the operation was regarded as a thoroughly justifiable procedure, and the great superiority of the supra-pubic over the perineal method was fully recognized.

Dr. Keyes's method consists in making a supra-pubic opening, and then, by means of the finger-nail, sharp spoon, curved scissors, or rongeur forceps, completely removing all that portion of the hypertrophied gland which surrounds or obstructs the internal urethral orifice, leaving no pocket or pent-up prostatic sinus. The success which has attended the thorough operation advocated by Dr. Keyes would seem to justify the hope that permanent relief may be obtained in, at least, a certain number of these exceedingly annoying and unfortunate cases. For many obvious reasons, the operation in a large number of instances is impracticable, and in these regular catheterization must be employed.

Much has been written upon the great danger of infection attending the first passage of the catheter in cases of chronic retention of urine with atony of the bladder from this cause, and the necessity for unusual care in beginning the " catheter life " of the patient.

Professor Guyon, in the *Annales des Maladies des Organes Genito-urinaires*, for May, 1889, gave the results of a series of experiments upon animals, illustrating the tolerance of the bladder to injected pathogenic organisms when the urine was allowed to pass at regular intervals, and the marked tendency to septic infection which followed even a temporary retention after the introduction of pure cultures of the staphylococcus aureus, streptococcus pyogenes, and the septic bacillus of Clado.

The following method should be employed at the first catheterization of an individual suffering from chronic retention of urine : The patient should remain in bed for at least twenty-four hours after the introduction of the catheter. Previous to its introduction the meatus and glans should be bathed with a solution of bichloride of mercury, 1 to 5,000 ; the urethra, if suppurating, should be injected with a solution of bichloride, 1 to 5,000, or nitrate of silver, 1 to 500 ; if normal, a solution of boric acid, five per cent. will answer. The catheter, if metallic, should be boiled ; if of rubber or gum-elastic, it should be thoroughly washed and treated with seventy per cent. alcohol, followed by a solution of bichloride of mercury, 1 to 1,000. If great distention of the bladder exists, only a portion of the urine should be withdrawn at the first operation, that the circulation may accustom itself to the altered condition of the bladder-walls. Complete emptying of this viscus in extreme cases of distention, should be delayed for eight or ten days. After the removal of the urine a small amount of a saturated solution of boric acid should be introduced and allowed to remain in the bladder. These precautions should be continued until the bladder can be completely emptied without reaction.

Stricture of the Urethra.

The admirable chapter on this disease which appeared in the first edition of this work leaves little to be said on the etiology, pathology, and symptomatology of this condition.

During the past few years the tendency among surgeons has been toward the practical abandonment of divulsion and electrolysis in the treatment of urethral stricture. Regarding the choice of procedures in cases of stricture in the anterior portion of the canal, the same rules will hold as mentioned in the first edition, although it is now the generally accepted belief that internal urethrotomy, when properly performed, offers the only hope of a radical cure in cases of genuine organic stricture. This method has, therefore, become the operation of choice among those surgeons who have to do largely with this class of cases.

The operation advised by Otis is so simple, and, when confined to the anterior portion of the canal, so absolutely devoid of danger, that a brief description of the method of procedure may not be out of place in this connection.

When the stricture occurs at the meatus, or within three-quarters of an inch from the orifice, the operation should consist of an incision made with a straight, blunt-pointed bistoury on the *floor* of the canal; in cases where the stricture occurs at a point deeper than three-quarters of an inch from the external opening, dilating urethrotomy, by means of the Otis dilating urethrotome, should be practised, the cut being made on the *roof* of the urethra. Cocaine is usually employed for anæsthesia. The method of producing cocaine anæsthesia is as follows. By means of an Ultzmann, or long-pointed, syringe, about thirty minims of a four per cent. solution of cocaine is injected into the bulbous portion of the urethra. As the syringe is withdrawn, the lips of the external orifice are gently compressed with the thumb and forefinger. The solution is in this manner retained for ten minutes, which is found to be sufficient to render the entire anterior urethra insensitive, save that portion compressed by the fingers. As this is always the most sensitive part, the hypodermic injection of two or three minims of the solution just below the meatus will render the whole absolutely insensitive to pain. Where this method is fully carried out, the patients rarely complain of pain during the operation. It is necessary to employ ether for anæsthesia only in cases of great nervous irritability, where the sight of blood and the various necessary manœuvres would be followed by disagreeable mental effects, and where the careful exploration of an abnormally sensitive deep urethra or bladder is necessary.

The exact location of the deepest band of stricture is now determined by means of the *bougie à boule*, or urethrometer of Otis, and the dilating urethrotome introduced so that the location of the blade as it emerges from the staff is one-half inch below the stricture. The instrument is then opened until the indicator points to a calibre corresponding to the normal size of the canal, or until the band is stretched to its fullest capacity. The blade is then quickly withdrawn and returned. Each band should be treated in this manner until a full-sized bulb will pass to the bulbo-membranous junction without the slightest obstruction. The hemorrhage is usually slight, and soon ceases by gentle external compression.

Regarding the after-treatment, it has been found that the daily passage of a full-sized sound to the bulbo-membranous junction, during the first four or five days, is by far the most comfortable for the average patient, as the pain attending its passage is always more marked and the hemorrhage more severe after the cut surfaces have been allowed to glue together for two or more days. A sound is usually passed also on the seventh, fourteenth, and twenty-first days after the operation. In cases where an acute urethritis follows the operation, or where the urethra is for any other reason abnormally sensitive, the daily passage of sounds seems often to increase the severity of the symptoms, and in these instances the intervals should be increased to three or four days.

It is rarely advisable to employ cocaine for the passage of sounds during the after-treatment. Where dilating urethrotomy has been practised, the patient should be kept in bed until the danger from hemorrhage has passed, usually from three to five days.

If recontraction of the stricture is to take place, it is usually possible to detect a tendency toward this within fourteen days from the date of the operation. When this is found, further use of the sound should be abandoned, both on account of the severe pain caused by forcing a full-sized sound through an imperfectly divided and recontracting stricture, and also on account of the utter uselessness of attempting to prevent recontraction by means of dilatation. The patient should be allowed to wait until the cut resulting from the first operation has healed, when a second and deeper incision should be made with a view to completely severing the cicatricial band upon which seems to depend the only possibility of a radical cure.

If after three weeks the urethra is healed, and there is no evidence of recontraction of the strictures, the use of the sound may be discontinued, unless the presence of granular patches, an irritable deep urethra, or other similar conditions, calls for its employment. The use of sounds for an indefinite period after an operation, with a view to "keeping the stricture open," is wholly unnecessary. If a stricture is to be cured by urethrotomy, it must be by thorough division, which does away with the necessity of prolonged after-treatment by dilatation.

Regarding the complications which are said to arise so frequently from this operation, the following may be quoted from a paper read by the writer before the New York Academy of Medicine, December 9, 1889, in which an analysis of one hundred and twenty personal cases of internal urethrotomy is reported, and which may serve to call attention to the comparative frequency and treatment of these conditions:

"Among the unfavorable complications which are likely to occur as a result of this operation may be mentioned, first, *severe hemorrhage*. This occurred in six of the one hundred and twenty cases. Of these, three were primary, occurring at or near the time of the operation, and three secondary, occurring after a period varying from one to three weeks. Of the latter, two resulted from a too early indulgence in sexual intercourse; in one it occurred on the ninth day without any ascertainable cause. In but one instance was the hemorrhage alarming, and that was in a case cut on the floor of the urethra.

"In the treatment of hemorrhage it is rarely necessary to institute measures other than rest and gentle pressure applied against the lips of the urethral orifice, as it is only under very exceptional circumstances that the pressure is sufficient to force the blood beyond the compressor urethræ muscle into the bladder. By the use of the perineal crutch properly applied (a procedure first suggested by Dr. F. N. Otis) a more or less constant pressure may be exerted against the deeper portion of the urethra, thereby preventing the backward flow of blood into the bladder, if at any time the action of the muscle seems inadequate. As an effective method of controlling even the most violent hemorrhages from the anterior urethra, Dr. Otis has suggested the introduction of a full-sized endoscopic tube, upon which any amount of pressure may be brought to bear by means of an external bandage. The prolonged application of heat by means of the retrojection of very hot water served in one instance to check a persistent and very annoying hemorrhage.

"It may be stated, I think, with a reasonable degree of certainty, that by careful watchfulness and the employment, when necessary, of these methods, in no case where urethrotomy has been performed need the patient be seriously inconvenienced by loss of blood.

"*Chills and fever* will be mentioned as the second complication likely to follow urethrotomy. This followed the operation in three cases—in one, fever without a chill. In every instance the chill followed the passage of a sound through the deep urethra. The fever without the chill was accompanied by a severe lymphangitis and local sloughing, due to a division of a very narrow meatus during the progress of an acute urethritis.

"*Epididymitis*, as a complication of this operation, occurred in two patients, and in each it followed the passage of a sound through the deep urethra.

"*Infiltration* of urine into the cellular tissue of the penis occurred in one case, where the cut was made on the floor of the urethra. The treatment of this condition consisted in regular catheterization, hot retrojection, and the external application of heat, the object being to prevent its recurrence, to prevent septic infection of the infiltrated tissues, and to promote absorption.

"An *acute urethritis* followed the operation in ten cases. In seven of these the operation was undertaken shortly after an attack of acute gonorrhœa, and was presumably due to the fact that the gonococci had not entirely disappeared from the urethral mucous membrane. In the remaining three cases it could be accounted for only by the use of imperfectly cleaned instruments.

"A slight *ecchymosis* appeared in the skin of the penis in the vicinity of a cut in four of the cases, and is of interest only on account of its relation to a more or less lasting *curvature* of the penis on erection. Of the four cases in which ecchymosis was noted, curvature occurred

in three, or seventy-five per cent. In the remaining one hundred and sixteen patients in which no ecchymosis was noted, curvature occurred but twice, or in about $1\frac{7}{10}$ per cent. of the cases. In but one of the five cases of curvature did the symptoms occasion any marked inconvenience. In this instance the penis, when erect, was bent upon itself at an almost right angle, and was at first extremely painful; this condition continued to a greater or less extent for some seven months. In all five cases, however, the organ eventually became straight and the resulting annoyance was usually slight.

"In three of the five cases of curvature there had been, during the first six or eight days following the operation, an almost entire absence of complete erection of the penis, owing, in two instances, to efforts on the part of the patient to avoid the pain usually attending such an erection. In no instance was there any well-marked induration at the angle of curvature.

"To account for the presence of an ecchymosis of the skin, the escape of blood must have taken place into the loose connective tissue lying between the fasciæ, in closing the cavernous and spongy bodies of the penis. For this to have taken place the cut must have extended through the urethra, the corpus spongiosum, and its fibrous capsule—in other words, the incision was unnecessarily deep. In view of the fact that the large majority of cases of curvature occurred in patients exhibiting an ecchymosis of the skin, it is not irrational to attribute the occurrence of curvature to the same condition, which might easily result in a slight inflammatory thickening of the tissues outside the urethra, or from the presence of an organized clot, either of which would be sufficient to cause a diminution in the elasticity of the tissues which would result in curvature on erection.

"If this view be correct, it is easy to understand how an absence of vigorous erections during the first few days following an operation might favor, while their presence might diminish, the tendency toward formation of inflammatory adhesions.

"In the treatment of this condition use has been made of inunctions of oleate of mercury, of the galvanic current, and of massage. Of these, the latter has proved to be by far the most useful. The method of its application was that suggested by Dr. Frank Hartley, who advises the introduction of a full-sized steel sound; the massage being confined to the neighborhood of the angle of curvature, against the resistance afforded by the sound.

"The prognosis regarding the time necessary to correct this deformity should be extremely guarded; as often, in well-marked cases, a period varying from six months to a year is necessary before the complete disappearance of the symptom.

"Although my records do not furnish an example, *suppression of urine* may occur as a grave complication in cases of urethrotomy. This may arise either from nervous shock, from injury or violence to the deep urethra, or as a result of septic nephritis, and is best avoided by the practice of confining all operative procedure to the anterior urethra, and by the employment of strict antiseptic precautions."

At the close of the paper the following conclusions were drawn, which may fairly be stated as representing the present opinion regarding this operation: "1. That internal urethrotomy as a means of treating stricture of the anterior urethra is a comparatively safe operation, no deaths occurring in my series of cases, and but one case of severe illness, and that directly traceable to my own bad judgment regarding the method of operating. 2. That by the intelligent application of a few well-known measures alarming hemorrhage can in nearly all cases be avoided. 3. That the occurrence of a more or less lasting curvature of the penis after operation is probably due to the extension of the incision beyond the necessary limits, and that a tendency toward this is aggravated by the prevention, by any means, of complete erection of the organ subsequently to the operation. 4. That with the exception of the meatus, the practice of dividing anterior strictures on the floor of the urethra should be condemned as a dangerous procedure. 5. That the passage of instruments through the deep urethra should, if possible, be avoided immediately after the operation. 6. That in a majority of cases, by a thorough and complete division of all stricture bands, a radical cure and complete restoration of the canal to its normal calibre, may be expected. 7. That all attempts to prevent recontraction in imperfectly divided strictures by means of dilatation, are useless."

Resection of the urethra for dense, indurated stricture located in the membranous portion of the canal, has been successfully practised by Heusner, König, and others. Heusner's method consists in first dissecting out the cicatricial tissue. The urethral mucous membrane above and below the stricture is then separated by curved scissors from the submucous connective tissue and the edges united with catgut sutures. The wound is drained and a catheter tied in. By this method it is said that the necessity for constant dilatation after external urethrotomy in these cases is avoided.

Urethritis (Gonorrhœa).

Since the publication of the first edition of this work a very considerable amount of progress has been made in our knowledge of this disease, its causes, its varieties, its general behavior, and its treatment. For several years subsequent to the discovery by Neisser of the gonococcus, the relationship between this micro-organism and the severer forms of urethritis was seriously questioned by the majority of the more conservative members of the profession. This was in part due to the fact that certain views regarding the origin of this affection had long been entertained and taught by many of the most distinguished authorities upon the subject, which were at variance with the conclusions logically following the acceptance of this theory. But the evidence which has been furnished by the pathologists has been so conclusive, and the analogy to other forms of contagious diseases so well marked, that to-day few who have taken the trouble to investigate the subject will undertake to deny the causative relationship which this organism bears to the ordinary contagious form of this affection.

The acceptance of these views has naturally led to a gradual change in nomenclature, classification, prognosis, and treatment. The tendency to abandon the old and etymologically incorrect term *gonorrhœa*, and to adopt the more scientifically correct *urethritis*, has induced the writer to consider the subject under this heading.

Varieties.—*Acute Specific Urethritis*, the so-called true gonorrhœa. A severe, highly contagious inflammation of the urethra, having a distinct period of incubation and characterized by an abundant purulent discharge containing gonococci. This form of disease is invariably caused by contact with the secretions from the diseased organs of a person similarly affected. The duration of this variety, if untreated, is never under four weeks, and usually continues over a period of many months.

Acute Non-specific Urethritis.—A mild contagious urethral inflammation, having a period of incubation characterized by a scanty muco-purulent or purulent discharge, containing no gonococci. This disease has been described by Bockart and others, who attribute the symptoms to infection from micro-organisms contained in the vaginal secretions occurring in leucorrhœa, cancerous disease of the cervix, or during menstruation. The duration of this form of urethritis is seldom over twelve or fourteen days.

Acute Exacerbation of a Chronic Specific Urethritis.—A purulent urethritis, usually mild in character, occurring generally without or with but a brief period of incubation in persons having an uncured urethral inflammation, who, however, may present no outward manifestations of the disease. The secretions usually contain gonococci. Urethritis may also be occasioned by traumatism, by chemical or thermal agents, by rheumatism, gout, and the lesions of tuberculosis, chancroid or syphilis, but these varieties are so infrequent as to render their consideration in this connection superfluous.

Until quite recently the majority of writers upon the subject of venereal disease admit the possibility of an idiopathic urethritis which may be occasioned by the cohabitation of a perfectly healthy man with a perfectly healthy woman, and claim, moreover, that the symptoms, duration, and ultimate results of such a condition differ in no respect from those accompanying the severer and more virulent forms of the disease. Ricord even goes so far as to enumerate, in his now famous "receipt," the conditions of temperament, complexion, the kind and amount of exercise, the diet and the drink which, in his opinion, favor this peculiar and spontaneous evolution of disease.

More evidence, however, must be furnished in support of this theory than that contained in the usual statements that "the man had no discharge" and that the most "careful speculum examination of his companion failed to reveal the slightest trace of disease."

The writer has expended a very considerable amount of time and trouble during the past few years to discover an example of this variety of urethritis, and has investigated with no little care a large number of these supposed cases of "strain," with the result that in no instance was the urethritis to be accounted for in any manner other than by contagion from the gonococci-bearing secretions from some portion of the genito-urinary tract in the female or from the awakening of an uncured urethritis in the male.

In view of our increased knowledge regarding the behavior of gonorrhœal disease in both sexes, no reason exists at present for our accepting this unscientific theory of an idiopathic urethritis.

Diagnosis.—The microscopic examination of the pus derived from a given case of urethritis, with a view to determining the presence or absence of gonococci, furnishes the most reliable data upon which to base an opinion regarding its nature, prognosis, and treatment. If gonococci can be demonstrated in the secretions, we have to do with a case of genuine gonorrhœal or specific urethritis.

The method of making this examination is as follows: A small fraction of a drop of freshly exuded pus is spread into an exceedingly thin layer on a glass slide. This, after drying by passing it rapidly through the flame of an alcohol lamp, is treated with a saturated solution of methyl-blue or gentian violet in aniline water. This is allowed to remain sufficiently long to stain the nuclei of the cells, leaving the surrounding protoplasm clear. The staining fluid should then be thoroughly washed off with distilled water and, after the application of a cover-glass, the specimen examined with a 12th oil immersion. If gonococci be present, they will be seen in clusters in the protoplasm of the pus-cells surrounding the nuclei, as deeply stained, biscuit-shaped diplococci, arranged in pairs or fours. If present in large numbers they may completely fill the cell without exhibiting any special arrangement.

Other varieties of diplococci are said to present appearances so similar to those described above as to render this test alone insufficient to establish a positive diagnosis in a doubtful case. In such instances, use should be made of the test described by M. Gabriel Roux, of Lyons, which is based upon the fact that the gonococcus alone, of all the micro-organisms likely to be found in pus, is not acted upon by Gram's fluid, and consequently loses its color when treated by absolute alcohol.

Roux's test should be made as follows: A specimen of pus should be stained, in the manner above described, with the methyl-blue or gentian-violet, treated with Gram's iodo-iodide solution, mounted, and examined. If diplococci are present in the pus-cells, which wholly disappear after decolorization with absolute alcohol, the organisms are surely gonococci, as all other varieties of cocci retain their stain after this treatment.

Prognosis.—The only point in prognosis which should be added to that contained in the first edition of this work is in regard to the duration of the contagious stage of a specific urethritis. The question is a serious one, especially when considered in its relation to marriage, and should, I believe, be regarded as equal in importance to that of syphilis.

It is not infrequently the experience of physicians to be consulted by young men, a few weeks or months before a contemplated marriage, with a history of one or more attacks of gonorrhœa in former years, and who believe themselves to be well, yet who, upon a careful examination, present the unmistakable signs of a chronic urethritis.

The only evidence of disease remaining in these cases may be, and frequently is, the presence in the urine of small thread-like bodies, to which the name of *Tripperfaden* has been given by the German surgeons who first discovered them and demonstrated their importance. These minute shreds are composed of mucus, pus, and epithelium, and represent the secretions which adhere to any granular patch or area of chronic inflammation remaining on the urethral mucous membrane.

Since the establishment of the relationship of the gonococcus to this disease but one opinion can logically be held by those who accept this theory of gonorrhœal inflammations, and that is, that all secretions containing this micro-organism are capable of transmitting the disease under favorable conditions. In his recently published work upon this subject Ernest Finger emphasizes this point, and states, regarding marriage, that it should be absolutely prohibited in all cases where the existence of a chronic urethritis is evidenced by the presence of the "morning drop" or *Tripperfaden* in the urine, until the following facts have been established: 1, That after from two to four weeks of daily observation the secretions from the urethra are found to be *free from pus and made up wholly of epithelial cells;* 2, that no gonococci can be detected by the microscope, even after a purulent discharge has been established by the employment of irritating injections of corrosive sublimate or nitrate of silver; and, 3, that neither prostatitis nor stricture exists.

Treatment.—The general acceptance of the more modern views regarding the etiology of urethritis has led to the adoption of new therapeutic measures. When we consider that urethritis is a purely local affection, limited during the first few days, at least, to the anterior portion of the urethral mucous membrane, the conclusion is inevitable that the most successful method of treatment will consist in thorough irrigation of the diseased portion of the canal with some agent capable of destroying the germs or, at least, inhibiting their development. Of the remedies employed the most successful have been bichloride of mercury and nitrate of silver.

Bichloride of Mercury.—The first systematic experiments with this agent were made by Dr. William S. Halsted, at the Roosevelt Hospital, in 1884. He found that by irrigating the anterior urethra with a large amount of a very diluted solution of this agent (1 to 40,000) a marked amelioration in the symptoms was at once apparent. His method consisted in allowing from one to two quarts of the solution to pass through the urethra twice daily by means of a fountain syringe and glass nozzle. About the same time bichloride solutions were also employed, though in somewhat more concentrated solutions, by Dr. H. Holbrook Curtis, by means of his hot retrojection apparatus (Fig. 209).

This apparatus consists of a tin pail beneath which is fastened a platform for an alcohol lamp or Bunsen burner. The pail is connected by means of a rubber tube with a No. 14 F. soft-rubber catheter. The patient, seated in front of a slop-jar or pail, introduces the catheter to within one inch of the bulbo-membranous junction. The pail is then elevated, by means of a pulley and cord, to a height of three feet, and the solution allowed to pass rapidly through the urethra from behind forward. The temperature of the fluid is regulated by means of the lamp, and should be gradually raised until it is as hot as the patient can bear.

Some five years ago an opportunity was granted the writer of undertaking a series of experiments at the out-door department of Roosevelt Hospital, with a view to testing the efficacy of the various methods of treating gonorrhœal urethritis. By far the largest number of

cases were treated with bichloride of mercury, for the reason that the results which followed the use of this drug seemed far more satisfactory than those of any of the others. At the end of the first year, by request of the President of the New York Dermatological Society, I reported to that body the results of my work in a paper entitled "Some Observations upon the Modern Treatment of Urethritis." In that communication I limited myself to the consideration of two comparatively new methods of treating this disease, *i.e.*, by continuous irrigation with bichloride of mercury, and by hot retrojection.

From an analysis of about one hundred and fifty cases treated by these methods I felt justified in drawing the following conclusions: 1. That in uncomplicated cases of acute gonorrhœal urethritis, treated by prolonged and

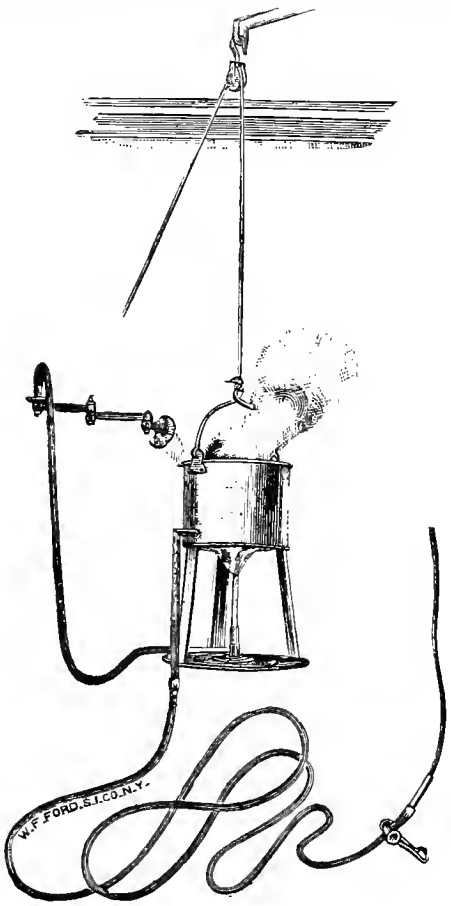

FIG. 209.

frequent irrigation with bichloride of mercury, recovery may be expected within two weeks. That this period may be considerably shortened by the early inauguration of treatment, by absolute rest, and by the avoidance of stimulants; that it may be indefinitely prolonged by irregularity in treatment, by inordinate physical exertion, and by indulgence in alcoholic and venereal excesses. 2. That the retrojection of a hot solution of bichloride possesses all the advantages of the former procedure, and in addition causes a more rapid subsidence of the inflammatory symptoms, a greater feeling of comfort to the patient, and is attended with less annoyance and trouble. 3. That in cases of acute non-specific urethritis the favorable influence of each of these methods is strikingly apparent. 4. That in cases of chronic purulent urethritis no agent produces such rapid and permanent improvement as irrigation, especially when combined with astringents and heat. 5. That the percentage of complications occurring in cases treated by these methods is far below that observed where the ordinary treatment is employed.

At the close of my second year of experiments, at the request of the editor of the *Journal of Cutaneous and Genito-urinary Diseases*, I gave a brief *résumé* of the results in a short contribution to that journal, entitled "Genito-urinary Notes." In this paper one hundred and two additional cases were reported which were treated by the above methods, and at the conclusion of the report the statement was made "that the results obtained were even more satisfactory than at first and fully justify the conclusions with which I closed my first paper."

Regarding the inflammatory complications, I stated that I had encountered but five in over two hundred and fifty cases, or about two per cent., while in three hundred and fifty-two cases treated by other methods, epididymitis alone occurred in sixteen per cent. of the patients.

Cases were occasionally encountered which would not yield to these methods. In all such the urethra was found to be the seat of one or more strictures which rendered its walls rigid and inelastic, thereby preventing the free circulation of fluid within its cavity.

During the past three years I have continued to employ bichloride of mercury in the treatment of this disease at the Vanderbilt Clinic, Presbyterian Hospital, and in private practice, substituting largely the ordinary urethral syringe for the methods by irrigation.

The method adopted in the hospital cases was as follows: As soon as the patient presented himself at the clinic, he was instructed in the proper use of the syringe and given a large amount of a solution of bichloride of mercury, varying in strength from 1 to 16,000 to 1 to 50,000, according to the sensitiveness of his urethra and the stage of the disease. This he was instructed to use twice daily by taking ten injections in the morning and ten at night, holding each one in the urethra one minute, to imitate as nearly as possible the result obtained by irrigation. The patients were usually seen three times a week. As soon as the discharge lost its purulent character the bichloride was suspended and a mild astringent substituted, preferably bismuth suspended in glycerine and water.

Although bichloride cannot be said to be a reliable and abortive agent in the treatment of urethritis, still it undoubtedly exerts a more marked influence in subduing the painful and disagreeable symptoms of this disease than any other remedy at present in use.

Nitrate of Silver.—This agent has long enjoyed the reputation of exerting a most favorable effect in acute and chronic urethral inflammations. Formerly it was largely employed in strong solutions (twenty to forty grains to the ounce) in the early stages, with the idea of aborting the disease.

Quite recently an article appeared in the London *Lancet* describing a method which had been successfully employed by a British surgeon in forty cases of acute urethritis. His method consists in completely removing the pus from the anterior urethra by means of a cotton swab, through an endoscopic tube, and then applying a ten per cent. solution of nitrate of silver over the entire mucous membrane anterior to the bulbo-membranous junction, an extra amount of the solution being used in the fossa navicularis. The patient is then instructed to remain in bed for two days, and employ at intervals a mild astringent injection. The reaction which follows is often quite severe, but of short duration, and no further treatment is required.

Experiments in this country with this method have failed to furnish results as favorable as those reported by this writer.

Guiteras's method of employing this agent consists in administering every second day a single injection of a solution of nitrate of silver, beginning with a strength of one-half to one grain to the ounce of water, and increasing by one grain at each application until the strength of ten grains is reached. Before and after this application the anterior urethra is irrigated with a saturated solution

of boric acid. During the intervals between the injections, which are administered by the surgeon, the patient employs an urethral wash of boric acid, or a mild solution of zinc acetate. This method is at present being tested in a number of clinics, and with no small measure of success.

Posterior Urethritis.

The importance of posterior urethritis as a complication of the acute form of the disease has not until quite recently been fully appreciated. Under ordinary circumstances, in an attack of acute urethritis, the inflammatory process is limited to the pendulous urethra or that portion of the canal anterior to the compressor urethræ muscle. The reason of this is that the membranous urethra, being much less vascular and almost devoid of glands and follicles, offers an effective barrier to the backward progress of the inflammation. When, however, this barrier is passed, and the disease extends to that portion of the canal posterior to the compressor muscle, we have to do with a condition far more grave, not only from the fact that the discomfort to the patient is greatly increased by painful and distressing symptoms, but also from the fact that a much larger extent of the mucous membrane is involved, and the liability of a still further extension to other important organs is rendered probable.

Symptoms.—This complication may occur with practically no subjective symptoms. Generally, however, the patient experiences a heavy feeling in the perineum, accompanied by an increased frequency in urination and pain extending along the course of the urethra at the close of the act. In the severer cases, the calls to urinate may occur every few minutes, and be accompanied by marked dysuria and bladder tenesmus. There is also, generally, marked sexual hyperæsthesia. Not infrequently the last few drops of urine passed will contain blood.

If the urine be examined by means of the two-glass urine test (described under Inflammation of the Bladder) the first portion will contain free pus and urethral shreds, the last free pus, and possibly a certain amount of blood, due to the violent contraction of the prostatic muscle. This condition is often mistaken for acute cystitis. For the differential diagnosis of these conditions the reader is referred to the section on Diseases of the Bladder.

Prognosis.—If the occurrence of this complication is recognized early, before the inflammation has had sufficient time to penetrate the glands and follicles of the prostate, and prompt measures are undertaken for its relief, the duration is often but a few days. If, however, the case is neglected and allowed to become chronic, it presents serious difficulties, and is frequently most rebellious to treatment. The chief importance, however, lies in the fact that it renders the patient far more liable to an extension of the disease to the prostate, seminal vesicles, bladder, and testicles. It is highly probable that none of these complications ever occur without a previous posterior urethritis. The importance, therefore, of an early diagnosis and prompt treatment is patent.

Treatment.—When the diagnosis of an acute posterior urethritis has been established, absolute rest in bed should be insisted upon, and an increased flow of urine brought about by the use of diuretics. The pain and frequency of urination should be controlled by opium or morphine suppositories. The local application of a solution of nitrate of silver by means of the Keyes deep urethral syringe is perhaps the most useful procedure which can be employed in this condition. The strength of the solution should be at first not more than five grains to the ounce of distilled water. Of this, five or ten drops should be deposited in the deep urethra, after the manner described in the earlier edition of this work. Later, the strength should be gradually increased until that of fifteen or twenty grains to the ounce is reached. These applications should be made not oftener than once in three or four days.

The first effect of the treatment is to cause a slight increase in the pain and dysuria. This is later followed by a decided amelioration in all the distressing symptoms. The relief in such cases is often strikingly satisfactory; the most acute and painful seem often to yield most promptly. If the condition becomes subacute or chronic, great benefit often follows irrigation of the posterior urethra and bladder by means of the Ultzmann deep urethral irrigating catheter (described under Chronic Prostatitis in the earlier edition of this work); the solutions found to be most serviceable in this condition being a saturated solution of boric acid, permanganate of potassium (1 to 5,000), and nitrate of silver (from 1 to 2,000 to 1 to 10,000).

Chronic Urethritis.

Practically nothing can be added to the excellent description of chronic urethritis which appeared in the earlier part of this work. In the treatment of this most obstinate condition, however, much has been learned which will be found to be of positive value. These advances have been largely in the line of local treatment.

As perhaps the best method of calling attention to the advances in the therapeutics of chronic urethritis, and of noting the indications for each procedure, the following plan of treatment may be mentioned, which embraces the best of the old methods, together with any new suggestions which have been made during the past few years, and which have been found to be of real value.

When a patient suffering from a chronic urethral discharge presents himself for treatment, the first step is to determine the location of the diseased area from which the secretion arises. This can be accomplished by an ocular inspection of the anterior portion of the canal by means of the endoscope, and by the careful employment of the two-glass urine test.

The next step is to determine the presence or absence of four conditions which are known to prevent or retard the restoration of the mucous membrane to its normal condition of health. These conditions are stricture, the use of alcohol, sexual indulgence, and general ill-health from tuberculosis, syphilis, anæmia, malarial poisoning, etc. If stricture exists it should be removed by urethrotomy or its untoward influence overcome by the use of sounds. The use of alcohol should be prohibited and all sources of sexual excitement removed. The general health, if impaired, should be restored by the use of rational hygienic and medicinal measures. After this has been accomplished local measures must be relied upon to effect a cure.

If the inflammation is limited to the anterior urethra, injections of solutions of the mineral astringents may be employed. Of these, the best are the acetate, sulphate or sulpho-carbolate of zinc, permanganate of potassium, nitrate of silver, or bismuth suspended in glycerine and water. Of all agents used to cause a rapid cessation of a chronic, muco-purulent discharge from the anterior urethra, none can be relied upon to act more happily than injections of the subnitrate of bismuth suspended in glycerine and water, in the proportion of one ounce of bismuth to four ounces of the fluid. This should be well shaken to insure a complete distribution of the bismuth throughout the fluid, and a syringeful slowly injected after each urination. The mixture should be held in the urethra at least sixty seconds, to allow a thorough precipitation of the powder upon the urethral walls.

While the effect of this agent is not always in itself curative, by subduing any co-existing irritation of the canal it not infrequently happens that under its use the chronically inflamed surfaces take on a healthy, reparative action. The use of full-sized sounds to distend the canal once or twice a week, will often be found to be of great value, alone or combined with the local use of astringent agents.

If no improvement follows the careful use of these measures, after a conscientious trial of from ten days to

two weeks, local application should be made upon the granular patches, superficial erosions, or areas of chronic inflammatiou by means of the endoscope and cotton applicator.

Of all the agents employed for topical application nitrate of silver will be found to be the most useful. A strength of two and one-half grains to the ounce should be at first employed, and this gradually increased until a strength of twenty to thirty grains is reached. These applications should be made not oftener than once in every four or five days. It is often advisable to alternate this treatment with that by the passage of sounds.

The duration of the treatment is exceedingly variable. When the disease is of comparatively recent origin, recovery may be expected in two or three weeks. If, however, the process has been going on for months or years, the disease has in all probability penetrated the glands and follicles emptying into the urethra, each of which with its surrounding capillary net-work acts as a miniature incubator for the development of micro-organisms of disease, and exudes at intervals minute drops of germ-laden pus which serve to reinfect the surrounding mucous membrane.

When the disease has involved these glandular structures of the urethra it can be eradicated only by the most persistent measures, and often treatment extending over a period of many months is necessary to effect a cure. If the disease is found to be located in the posterior urethra measures must be employed which insure thorough irrigation of this portion of the canal and the application of astringent or antiseptic agents. This is best accomplished by the use of the deep urethral irrigating catheter and syringe of Ultzmann. The catheter should be introduced as far as it will go, which insures the beak being just beyond the compressor urethræ muscle. A syringeful of the fluid should be rapidly injected and allowed to remain for several minutes in the bladder. This should afterward be passed out by the expulsive efforts of the patient, which insures a double irrigation of the posterior urethra and the therapeutic effect of the substances contained in the injected fluid.

Of the agents employed in this manner may be mentioned carbolic acid, 1 to 100, permanganate of potassium, 1 to 5,000 or 10,000, sulphate of zinc, 1 to 500, and nitrate of silver, 1 to 10,000 to 1 to 2,000. This treatment should be employed every day.

The occasional local use of a stronger solution of nitrate of silver, by means of the Ultzmann or Keyes deep urethral drop-syringe, is often of great value in connection with the plan above described. Five or ten minims of a solution varying in strength from one to twenty grains to the ounce, may be employed once or twice a week.

Dr. Keyes has also successfully employed with this instrument a somewhat larger amount (thirty to forty minims) of a solution of sulphate of copper, thallin, and other astringents.

Sounds are often of the greatest service in the treatment of posterior urethritis. The same rule should govern their employment as in the cases where the disease is confined to the anterior portion of the canal. It not infreqently happens that the introduction of any instrument into the posterior urethra results in marked local inflammation and grave systemic disorders. In these cases the irrigation of the whole urethra and bladder should be accomplished from the meatus by means of the fountain syringe, in the manner described under the treatment of cystitis, the same solutions being employed as with the deep urethral irrigating catheter. These cases are often extremely persistent and annoying, and the treatment should be accompanied by the greatest amount of patience and care, special attention being paid to the removal of all the causes mentioned above as likely to retard the recovery.

Vesiculitis.

An inflammation of the seminal vesicles and their excretory ducts. This complication of urethritis, though an infrequent one, is often most annoying alike to the patient and the physician. The symptoms of the acute stage are throbbing pain in the perineum and rectum, increased by defecation, and a more or less persistent priapism with frequent seminal emissions, accompanied by excessive voluptuous sensation. The fluid ejaculated is brownish in color, and if examined microscopically is found to contain pus, blood, and dead spermatozoa. The symptoms of the chronic condition are chiefly those of a chronic posterior urethritis and sexual neurasthenia, with sterility.

In the acute stage the seminal vesicles can often be felt through the rectum as elongated fusiform, elastic bodies, just above the prostate. These are hot and sensitive to the touch. If the patient be instructed to pass the urine in three glasses, and between the voiding of the first and second specimens the contents of the inflamed sacs be expressed by the finger in the rectum, the second specimen will contain a larger amount of pus than the first or third, and also a number of dead spermatozoa.

The admixture of any considerable amount of pus with the semen almost invariably results in a death of the spermatozoa, or, at least, a serious impairment of their impregnating ability. This condition is, therefore, most important in its relation to marriage.

Treatment.—In the acute stage marked relief often follows the application of leeches to the perineum and hot rectal enemata. The bromides, with digitalis and camphor, in large doses, are useful in subduing the sexual hyperæsthesia. Absolute rest should be enforced, and applications of nitrate of silver be made to the deep urethra.

In chronic vesiculitis local measures are of little value, and dependence must be placed upon hygienic treatment, including sea-bathing, a change of climate, cod-liver oil, iron, and the scrupulous avoidance of stimulants and sexual excitement.

George Emerson Brewer.

GOERBERSDORF. This place is in Silesia, Germany, not far from the city of Breslau. It was here that Dr. Brehmer started, in 1854, his famous establishment for the treatment of consumption by mountain air, cold douches, diet, etc. Goerbersdorf is situated in a fairly well-sheltered valley, and has an elevation of seventeen hundred feet above sea-level. The climate is rather severe in winter, but the admirably arranged buildings permit exercise in pure air at all seasons. Apart from the institution of Brehmer, now in charge of Dr. Achtermann, there are two other sanitaria for diseases of the lungs, neurasthenia, etc., one in charge of Dr. Römpler, the other managed by the Countess of Pückler. The good results obtained at Goerbersdorf are now generally held to be due quite as much to the careful supervision of every individual and the attention to minute details of treatment, as to the climatic advantages of this locality. Season, all the year round.

Edmund C. Wendt.

GOLD. The use of gold as a remedy in disease is of very ancient date, although of late years it has fallen into disuse. Very recently it has been revived, and the various salts are recommended in many forms of nervous disease. Formerly it was used almost solely in the treatment of scrofulous and syphilitic disease. The action of the salts of gold is similar to that of mercury, being even more powerful when administered freely; salivation is produced, and prolonged use gives rise to "aurism," with sweating, increase of urine and saliva, and mental excitement, with delirium and intoxication. It is eliminated by the liver, intestines, and kidneys. It is still used occasionally for syphilitic troubles, and will often produce a cure where mercury and the iodide of potassium have been used without any apparent benefit. It is said to prove most efficient in syphilitic ulceration of the throat, ozæna, diseases of bones, and syphilitic phthisis. Its revival, however, is principally in the treatment of the various neuroses, hysteria, ovarian disease, sterility, impotence, hypochondria, etc. The beneficial effects of the use of the preparations of gold are most evident on the brain and nervous system, which is stimulated and ren-

dered more active, and, when the use is persisted in, the symptoms of this stimulation continue to increase until the toxic condition supervenes. The use of gold is indicated whenever there is depression of the central nervous system, and should be avoided when cerebral hyperæmia is present.

Auri et sodii chloridum, the official salt of the U. S. Pharmacopœia, has shown itself of service in nervous dyspepsia, in doses of one-twentieth grain, three times a day. Amenorrhœa from torpor of the ovaries, and chronic metritis with scanty menses, are often relieved. Bartholow has recommended it in sterility due to functional debility of the sexual organs. It has been used in the treatment of progressive general paralysis, in which affection it increases the patient's powers of resistance and retards the progress of the disease. It is given in doses of one-thirtieth grain, morning and evening. Every fortnight the dose is to be increased until one-sixth grain is reached. This amount is continued for another fortnight and then stopped for a month. This salt of gold was recently brought into prominence by its reported value as a means of treating pulmonary phthisis. Its use for this purpose was introduced by Dr. Heneage Gibbs who, with Dr. Shurley, had experimented upon animals and used it very extensively in their practice, and found it to prove of decided value. Its use is combined with the inhalation of chlorine gas and the hypodermic injections of iodine. The chlorine gas may be obtained from chlorinated lime by the addition of dilute hydrochloric acid, from one-half to six drachms of the former and from one to three drachms of the latter, in an open vessel in a closed room. Before the gas is produced the air should be impregnated with a spray of chloride of sodium, about two ounces in a compartment of five hundred and fifty cubic feet. The patient should only remain in the room for ten minutes at first, but this may be increased to twenty or thirty minutes. It may be repeated two, three, or four times a day. In laryngeal phthisis, or when it may prove more convenient, the gas may be evolved in an inhaler. The iodine and gold are introduced by means of an hypodermic syringe in the gluteal region. Iodine is used in one-twelfth grain doses daily, to begin with, and gradually increased until one-half to one grain is reached. The gold and sodium is then used, and hypodermics of one-thirtieth to one-twentieth grain daily are administered at first, the dose being gradually increased until one-fifth or one-third grain is reached. It is often necessary to discontinue one or the other, as "iodism" or "aurism" is threatened. They may also be used alternately. It is found that the combination of gold with the iodine allows a much larger amount of the latter drug to be administered without causing toxic symptoms. At first, loss of weight and increase of temperature and other signs of disturbance follow its use, but these soon disappear, and a marked improvement takes place. The authors of this remedy base their hopes of a successful treatment of this disease upon the view that consumption is not the same as general tuberculosis, and is not due to the generally recognized bacillus. They consider that phthisis pulmonalis is a local affection of the lungs of an inflammatory character, the progress of which is accompanied by the production of chemical substances which possess a toxic action. The object of the treatment is to neutralize these poisonous substances, allay the inflammatory process, and restore the vital powers. Chlorine, iodine, gold, iodoform, liq. potassæ, potassic permanganate, iron arseniate, the mercurial salts, were all found to possess these valuable properties, but the first three were selected as being the most efficacious and least disturbing to the system.

Auri chloridum occurs in long orange crystals. It is very hygroscopic and readily soluble in water, alcohol, and ether. It is a powerful caustic and enters into the composition of many cancer-pastes. As a caustic for epithelioma, one-sixth to one-quarter grain in powder may be rubbed into the affected part or applied in solution. A case of lupus is reported as having been successfully treated with the hypodermic use of chloride of gold and cyanide of potassium, a solution of the strength of one per cent. of each being employed. Nearly the whole face and forehead were involved, and tubercle bacilli were found to be present. Six injections were given in the course of eleven days, the dose varying from one-thousandth to one-hundredth grain. On the second day the symptoms showed signs of improvement; on the third day the swelling of the face subsided, some old scars began to shed cuticle, and a labial ulcer decidedly decreased; by the twelfth day several ulcers were soundly healed, and the remaining ones were clear and covered with healthy granulations. On the fourth day of treatment a mild intoxication, drowsiness, and a slight rise of temperature were noticed, but they rapidly disappeared.

Auri Bromidum.—This combination has been utilized to secure the combined effects of gold and bromine on the central nervous system. It is a dark brown, non-deliquescent powder, soluble in water and ether; dose, one-fortieth to one-hundredth grain, to be increased to one-fifth grain, well diluted. The solution should not be exposed to light. It has been used in hysteria, epilepsy, migraine, and the various affections of the nervous system in which the action of these drugs is indicated. In epilepsy it has acted very satisfactorily: the action of the drug was rapidly manifested, the fits becoming reduced in force and number, and in some cases they were completely checked. The introduction of this remedy caused Dr. Shtcherbok to undertake a series of experiments with the cerebral cortex exposed, to ascertain the action of the drug, its effect as compared with other bromides, and in what quantities it should be given. The drug was administered by intravenous injection, by hypodermic injection, and through an œsophageal tube into the stomach. It was found that artificially induced epilepsy could be averted by the intravenous injection of one-twelfth grain for each thirty-two ounces of body weight. Larger doses were required when used by hypodermic injection, and by the stomach one and one-half to three grains were needed. No cumulative action was detected. The drug seemed to affect mainly the tracts of communication between individual motor-cells, as well as those between remote areas of the cerebral cortex. Bromide of gold appeared more active than the commonly used bromides in the proportion of ten to one.

Other compounds, as the cyanide, iodide, oxide, etc., have also been tried for the treatment of syphilis, but with uncertain results. *Beaumont Small.*

GONORRHŒAL RHEUMATISM. Since the publication of the REFERENCE HANDBOOK many investigations and observations have been made to determine more accurately the pathology of this affection. The results have not been very decisive, except, perhaps, to settle more firmly the dependence of some of the cases upon the gonococcus. A number of investigators have found the micro-organisms not only in the urethra but in the joints as well, whither they had been carried by means of the lymphatics, the blood circulation, and possibly the white corpuscles. There is still reason to believe that some of the cases partake more of the character of ordinary septicæmia, although differing from it in certain particulars; while some are still, on any theory so far advanced, inexplicable.

In the management of this affection it has been proven more conclusively that it is necessary to remove all points of irritation in the urinary mucous membrane, even to the relief of stricture, that may have caused the affection, as a first step to its cure. Iodide of potassium as an internal remedy is still popular, as well as mercurials in moderation. Some advocate the latter in quantities sufficient to produce their constitutional effect promptly, at the beginning of the attack.

Counter-irritation over the inflamed joints by blisters and the actual cautery are becoming more popular, as are also stimulating embrocations, and heat.

In the original article on this subject, the violent breaking of old, false anchyloses, long after their formation, was commended as rational. Less has been done

in this line than was to have been expected. The measure deserves to be more often employed. On rational grounds it has much to commend it; the anchylosis is due to fibrous deposits; at most, rupture of this material should result in producing some débris of soft substance that is readily absorbed, and after it possibly a slightly roughened surface; and roughened joint surfaces after the disappearance of causative pathological processes, and with good nutrition, tend to disappear. Sepsis is, of course, impossible, except with a very low condition of vitality of the patient. Dr. B. E. Brodhurst declares that he has operated on a large number of cases of fibrous anchylosis in this manner without a single accident, such as fracture, dislocation, or inflammation. He forcibly breaks up the adhesions under chloroform. If contractures of muscle have occurred, he cuts the tendons before forcing the adhesions, and if the contracture is extreme, he waits for the skin punctures to heal before doing the joint operation. After the operation, passive motion must be resorted to to keep what has been gained.

Norman Bridge.

GOUT. In attempting to compile, in the form of a supplement, such facts and suggestions of importance concerning gout as have been developed by clinical and experimental investigators since the publication of the third volume of the REFERENCE HANDBOOK, containing the excellent article by Dr. Mendelson, I find nothing necessary to add regarding the history, varieties, and symptomatology of the disease. The additional materials relate almost wholly to its etiology, pathology, and therapeutics. To show more clearly the true relations and practical bearing of such new materials I have felt the necessity of repeating or restating many items that are to be found in the original article by Dr. Mendelson, instead of making frequent references to the same, which would be less convenient for the reader as well as for myself. Such restatements are chiefly in the beginning, and seemed desirable as an introduction to the mere facts that follow. The causes of gout, as of most other diseases, are conveniently divisible into predisposing and exciting causes. The first include all such influences as either aid in developing the direct exciting cause or in lessening the power of the system to resist the action of such cause. The second embraces only such agents or influences as are capable of directly exciting the active symptoms of the disease. The more important of the predisposing influences are: heredity; alcohol, especially as existing in fermented liquors, such as beers and wines; excess of food, especially of the nitrogenous class; deficient physical exercise; deficient ventilation; excessive mental exertion and depressing emotions, such as grief and anxiety; and lead. A careful study of the *modus operandi* of these various causes will render it apparent that heredity and continued severe mental activity produce their predisposing influence by increasing the susceptibility and lessening the vital resistance of the living tissues; while all the others act chiefly in the direction of lessening the internal respiration, or, in other words, the distribution of oxygen from the pulmonary to the systemic capillaries, and thereby interfering with the metabolic processes on which the formation of natural excretory products depends. That depressing mental emotions, deficient exercise, and poorly ventilated and overcrowded dwellings lessen the fulness and activity of respiration, and in the same ratio diminish the internal distribution of oxygen, has long been well known. That alcohol, by its action on the hæmoglobin and albuminous elements of the blood, still more directly diminishes the internal distribution of oxygen and thereby lessens the natural metabolic processes, has been abundantly demonstrated. It is not, however, diminished distribution of oxygen alone that favors the development of gout, but it is the co-existence of an abundant supply of oxidizable or fermentable material in the blood, such as is derived from overeating or the drinking of such fermented drinks as contain sugar, free acids, and other fermentable materials. Therefore it may be correctly stated that it is neither deficiency of oxygen alone, nor excess of either alcohol or fermentable material alone, but the co-existence of all three, that most directly favors the formation in the blood and tissues of an excess of uric acid and urates, and consequently most actively predisposes to attacks of gout.

The direct exciting cause of gout is very generally conceded to be the presence in the blood or tissues of an excess of uric acid, generally in combination with sodium in the form of bi-urate. Since the valuable paper of Dr. Garrod in 1848, much additional knowledge has been gained through the investigations of J. Mortimer Granville, W. Ebstein, A. Haig, Sir William Roberts, Cammerer, and others. As the uric acid in the form of urates of sodium and potassium constitutes a natural constituent of the fluids of the body, it is of great practical importance to know by what processes it is developed, through what channels it disappears, and the conditions under which it accumulates in abnormal quantities in the system. Uncombined uric acid ($C_5N_4H_4O_3$) is a crystalline substance, extremely insoluble, and derived from nitrogenous metabolism. Whether its evolution and combination with sodium and potassium takes place at some stage of the digestive and assimilative processes, or in some part of the retrograde tissue changes, cannot be regarded as definitely determined. Dr. Garrod, and perhaps a majority of writers on the subject since his original essay, have regarded the uric acid as only one stage of the processes by which nitrogenous tissues are resolved into urea for elimination. The uric acid being less oxidized and much less soluble than the urea, its accumulation was regarded as the result of incomplete oxidation of the products of tissue metabolism; a view strongly supported by the fact that very many of the conditions and circumstances that are known to retard the internal respiration or distribution of oxygen to the tissues are accompanied by an increase of the uric acid or urates. J. Mortimer Granville, however, claims that the uric acid is formed chiefly in the liver, from imperfect duodenal digestion. Regarding more particularly the clinical phenomena preceding and accompanying attacks of gout, he sees evidence of inactivity of the liver by which less bile passes into the duodenum to co-operate with the pancreatic fluid in saponifying the food-elements. In consequence of this defect the food-elements are taken up in only an emulsified condition and carried by the portal vessels to the liver, which so alters its glycogenic and other functions as to lead either to the "excessive formation of uric acid or to the arrest of the subsequent processes by which the acid should be converted or destroyed." On the other hand, W. Ebstein, of Göttingen, in his valuable treatise on the nature and treatment of gout, claims that the production of the greater part of the uric acid found in the living system takes place in the muscular structures, and to some extent in the marrow of the bones. In support of this claim he refers to the fact that such kindred bodies as kreatin, sarkin, and xanthin were found in muscular structures; to the deposits of uric acid in birds and reptiles, and to the guanine gout in pigs; and he might have added the presence of uric acid in cases of splenic leucocythæmia. That the production of uric acid in the system is increased by nitrogenous food, by such disorders of digestion as are accompanied by acid fermentation, and by whatever lessens the distribution of oxygen from the pulmonary to the systemic capillaries, has been well shown by the recent investigations of Dr. A. Haig, Lehmann, Sir William Roberts, and others; which renders it certain that it is derived from either nitrogenous food-elements or from the nitrogenous tissues, or more probably from both. And a careful review of all the facts within our reach leads to the conclusion that the uric acid is not exclusively the precursor of urea, but an independent product of nitrogenous metabolism undergoing elimination largely in the form of soluble urates, but in a lesser degree also as urea. The natural or physiological condition of uric acid in the body is that of a quadri-urate (Roberts), and not in a free or uncombined state. So long as it remains in the form of quadri-urate it is freely soluble in the blood-serum, synovia, and tissue fluids, and undergoes ready elimination through the kidneys, and consequently

it causes no disturbance or symptoms of disease. Concerning the history of uric acid in the living body, both in the normal and in the gouty state, Sir William Roberts, in his third Croonian lecture recently delivered before the Royal College of Physicians of London, says: "It has been shown that in normal urine uric acid always exists as a quadri-urate; and that in animals which eliminate their nitrogen as uric acid, like birds and serpents, the urinary secretion is composed entirely of the same combination. Proof has also been furnished that in liquids containing alkaline carbonates—such as the serum of the blood and its derivatives, lymph and synovia—uric acid passes into solution in the first instance as a quadri-urate. From these considerations it may be inferred that in the normal state uric acid is primarily taken up in the system as as quadri-urate, that it circulates in the blood as a quadri-urate, and that it is finally voided with the urine as a quadri-urate. In perfect health the elimination of the quadri-urate proceeds with sufficient speed and completeness to prevent any undue detention or any accumulation of it in the blood. But in the gouty state this tranquil process is interrupted, either from deficient action of the kidneys or from excessive introduction of urates into the circulation, or from some other cause, and the quadri-urate lingers unduly in the blood and accumulates therein. The detained quadri-urate, circulating in a medium which is rich in sodium carbonate, gradually takes up an additional atom of base and is thereby transformed into bi-urate. This transformation alters the physiological problem. The uric acid, or rather a portion of it, no longer circulates as the more soluble and presumably easily secreted quadri-urate, but as bi-urate, which is less soluble, and probably also less easy of removal by the kidneys."—(*The Lancet*, July 9, 1892.)

Pathology and Pathological Anatomy.—Assuming the correctness of the claim that sodium bi-urate constitutes the direct cause or disturbing element on which the various symptoms and forms of gout depend, what are the pathological processes and changes induced by its presence in the fluids of the body? It has been shown, both by experimental research and clinical observation, that the soluble quadri-urate naturally existing in the blood-serum and tissue fluids is readily changed into a less soluble bi-urate by failure of the kidneys to eliminate it, or by whatever will lessen the alkalinity of the blood-serum (Roberts), and by such food and drinks as either contain an excess of acid material, or give rise to acid fermentation in the digestive organs (A. Haig), thereby favoring the precipitation of such less soluble bi-urate in the tissues which are most favorable for its accumulation. That such precipitation does take place in all the more active forms of gout is readily demonstrable by both chemical and microscopic detection of its presence in the synovial and tissue fluids of the articulations affected, in addition to the well-known fact that it is the chief constituent of the tophi or gouty concretions found in the more chronic cases. According to Sir William Roberts, the precipitated bi-urate is always found in crystalline form, and is "distributed through the implicated tissue in the form of delicate needles aggregated in tufts, bundles, and stars." And he adds: "The arthritic incidents of gout may be said, not improperly, to be simply incidents pertaining to the precipitation of these crystals in the structures of the joints. Without the occurrence of this precipitation the gouty paroxysm could not take place, nor could the more chronic changes in the joints, with their train of attendant symptoms, follow after." From this we must infer that the offending bi-urate produces its effects by a primary irritating action, either upon the nervous structures or the fibrous tissues, or by mechanically obstructing the capillary vessels; or, perhaps, by all these modes simultaneously. When the quantity of bi-urate present is small and the precipitation slight, the chief symptoms are those of a neuralgic and erratic character without local tumefaction or febrile disturbance. If, however, its formation takes place more rapidly and it accumulates in greater excess, the precipitated crystals appear to penetrate all the tissues of the part involved, and to cause rapid tumefaction, intense pain, and general fever. In other words, it excites a true inflammation of all the structures permeated by its crystals. And if they are not subsequently redissolved, they become permanent obstructions inducing all the phenomena and changes incident to chronic gout. While the majority of investigators, including Garrod, Granville, Haig, and Roberts, regard the inflammation and other gouty symptoms as the result of the urate precipitation in the part, Dr. W. Ebstein claims to have traced, by numerous experiments and dissections, evidences of the direct irritative action of the sodium urate, both in the kidneys and other internal organs, and in the articular cartilages, fibrous structures, and the connective tissue between the muscles, thereby claiming to have proved the diffused primary action of the irritant conveyed in the blood before actual crystalline precipitation occurred. Consequently he regards the first stage of the disease as "an inflammatory process, set up by the uric acid, leading to foci of necrosis, and then deposits of urates in the cavities thus formed." He further endeavors to show that inflammatory necrosis in any tissue causes an acid reaction in the part, which acidity in turn determines the precipitation of urates in the necrotic foci.

The order of development of the pathological processes described by Ebstein necessitates a distinct stage of inflammation, or at least tissue poisoning, with its accompanying tumefaction and pain, before the precipitation of urates can take place, while careful and multiplied clinical observations seem to demonstrate the presence of the precipitated urate coincidently with the first manifestation of local symptoms. It appears, therefore, more correct to regard the necrotic foci described by him as resulting from the obstruction and irritation of the crystalline precipitate, instead of the latter resulting from the former. The more remote and full development of tissue changes induced by repeated attacks of gout are well set forth in the following account of a post-mortem examination by Hudelo, presented to the Anatomical Society of Paris (*Annual of Universal Medical Sciences*, vol. i., 1889), the subject having died from gout in the Hôpital de la Pitié, in the service of Troisier: "In the upper extremities tophi existed in the right hand at the base of the metacarpo-phalangic articulations of the index, medius, and ring fingers, and also at the base of the articulations of the second and third phalanges of the index and medius, and at the base of the thenar eminence. An incision through the integument near the thenar eminence exposed a soft, pulpy substance infiltrating between the muscles, and at the level of the fingers it filled the sheaths of the tendons without communicating with the articulations. By extending the incisions the uratic infiltration was found in the tendon sheaths of the palm of the hand. The articular cartilages of the phalanges and the metacarpal phalanges were covered with a whitish layer of urates. The periarticular bony contour was uneven, ragged, and in places presented osteophytic projections. The lesions were greatest at the base of the radio-carpal articulation. At the right elbow a subcutaneous tophus of the size of a hen's egg filled the olecranon pocket. The elbow-joint was filled with a mixture of synovia and urates. The hand, wrist, and elbow of the left extremity presented pathological and anatomical changes very similar to those described in the right. In the lower extremities the phalangic, metatarso-phalangic articulations of the tarsus and metatarsus of both feet were affected in the same manner as the corresponding parts of the upper extremities, the uratic infiltrations being most prominent in the articulations of the great toe. Both knee-joints were filled with the uratic deposit; the articular surfaces of both tibia and femur were diseased, their contour rough and irregular, with large osteophytes attached to the femurs. The surfaces of the patellas were also rough with osteophytic projections. The organs in the cranium and thorax were natural except the heart, which was large, its walls pale and thin, with dilated cavities, but without valvular deposits. Of the viscera of the abdomen, the liver was harder and more granular than natural, the pancreas contained a whitish substance re-

sembling the uratic infiltration, but not crystalline, and the kidneys were enveloped in an excess of fatty tissue, notably diminished in volume, the capsules easily removed, leaving the surface uneven, but with no appearance of cysts. Incisions showed marked atrophy of the parenchyma inclosing some fatty tissue. In the centre of the papilla was a series of whitish layers parallel to the collected tubes of the pyramids, but not extending more than six or seven millimetres into the parenchyma." It is thus seen that while the characteristic deposits and structural changes are most abundant in the less vascular structures entering into the articulations of the extremities, they may be found in less degree in nearly all the tissues and organs of the body. The deposits are always in the crystalline form, and composed almost exclusively of sodium bi-urate. Of the internal viscera, the kidneys suffer most, particularly from chronic interstitial nephritis characterized by the existence of an increased amount of interstitial connective tissue, with a corresponding atrophy of the secreting cells, thereby rendering the organs progressively less efficient in the performance of their natural function.

The changes in the fluids of the body during the existence of gout, are most noticeable in the blood, synovia, and urine; and chiefly consist of an increase of uric acid in the form of sodium bi-urate, instead of the natural sodium quadri-urate, as more recently determined by Sir William Roberts. Dr. Garrod has shown that an appreciable quantity of uric acid is pretty uniformly present in the blood-serum of chronic cases of gout. And Cammerer (see *Deutsch. Medicin. Wochenschrift*, March 5, 12, 1891) states that while the amount of uric acid in healthy blood is only 2.8 to 100 of urea, in those affected with gout it averages 3.1 to 100 of urea. M. Mollière, in a communication to the Lyons Medical Society in 1888, not only recognizes the increase of uric acid or urates in the blood in gout, but claims that it is antagonistic to both pyogenic micro-organisms and the bacillus tuberculosis; and alleges this as the reason why the gouty are so generally exempt from tuberculous disease. In most cases the hæmoglobin and red corpuscles are diminished. The synovia in affected articulations is often found turbid from the presence of urates.

The quantity of uric acid excreted in the healthy urine, in twenty-four hours, is about 0.5 gramme (grs. viij.), the greater part in combination with sodium. It has been shown by many investigators that for a day or two preceding, and at the commencement of, acute attacks of gout the urine is less acid and contains less urates than in health, but subsequently they appear in excess, especially at the crisis of the disease. Dr. A. Haig suggests that the diminished excretion of the urates at the commencement of acute attacks is owing to the fact that they are then being stored or precipitated in the tissues.

Such diminished excretion, extending even to a few days prior to the attack, may be further explained if we regard the views of Sir William Roberts as correct, when he states that the uric acid in healthy urine exists and is excreted in the form of soluble sodium quadri-urate, while in gout it has been changed to an insoluble bi-urate, and instead of continuing to be excreted, it is first retained and then precipitated in the tissues, and can only reappear abundantly in the urine after resolution, during the middle and advanced stages of the disease. To further emphasize this order of development, the same active investigator has designated the preliminary stage, while the quadri-urate is being changed into bi-urate in the blood-serum, synovia, etc., as the condition of *lithæmia*, and the succeeding precipitation into the tissues as *uratosis*.

Emil Pfeiffer, in a communication to the Seventh Congress of German Physicians, at Wiesbaden, 1888, claimed to have demonstrated that the uric acid in the urine of those affected with gout, even in the more chronic and latent conditions, could be separated in larger quantity by a certain process, while urine from non-gouty subjects did not yield any such increase: which, if true, would afford a valuable means of diagnosis, especially in the more obscure cases. His method consisted in obtaining all the urine passed in twenty-four hours, filtering it through paper and dividing it into two parts. One of the parts was again passed through a filter on which had been placed some chemically pure uric acid. The other part was not so treated. One hundred cubic centimetres from each of these parts were taken into separate vessels and acidulated with strong hydrochloric acid, and allowed to rest until the precipitated uric acid had completely separated. Then both precipitates were collected on previously weighed filters, washed with distilled water, dried, and weighed. If the urine had been passed by a person not affected with gout or urolithæmia, the two filters containing the dried products would show the same amount of uric acid; but if passed by a person affected by any stage of gout, the specimen that had been treated with the pure uric acid would show a notable increase of the dried product. Sir William Roberts subsequently repeated the experiments of Pfeiffer, and came to the conclusion that the test proposed was entirely unreliable. To this Pfeiffer has replied that the experiments of Roberts having been made with the urine of healthy persons, the results were not applicable, as the sole basis of his test was on the greater readiness of the urine of persons subject to gout to part with its uric acid. And as proof of such greater readiness of separation he alleges that, while from one hundred cubic centimetres of the urine of healthy persons the uric acid is only extracted by 2.0 or 3.0 grammes (30 to 40 grains) of uric acid, from the urine of gouty persons it is withdrawn by 0.2 or 0.5 gramme (3 to 8 grains). In this connection it is proper to state that Dr. C. J. Rademacher (see *American Practitioner and News*, Louisville, Ky., June 21, 1890) claims to have discovered a new acid in the urine of persons suffering from an attack of gout, which is precipitated almost immediately after having been voided, and which he regards as the direct exciting cause of the disease. He says, "this acid is only found in the urine during an attack of gout, and always in a free or uncombined state, while the uric acid remains in the urine as a urate and in solution."

His method of obtaining his new substance in separate form is as follows: "The precipitate in the urine was collected in a filter and washed with distilled water. It was then transferred to a beaker and neutralized with a dilute solution of caustic soda, and filtered through animal charcoal. The filtrate was treated with pure dilute hydrochloric acid, the precipitated acid again washed with distilled water, redissolved in a solution of caustic soda, and again precipitated with pure dilute hydrochloric acid, washed and dried. This acid, prepared by the above process, is a white crystalline powder but sparingly soluble in water. Its aqueous solution has a decided acid reaction to litmus (which uric acid has not); its formula, from ultimate analysis, is $C_5H_8O_4N_4$, its molecular weight 200, and it contains 28.28 per cent. of nitrogen." The value or correctness of the claim by Dr. Rademacher remains to be tested by further investigation.

Dr. Edward Grün, in *The Lancet*, London, January 23, 1892, makes the statement that "in three consecutive cases of acute gout he found the blood to be swarming with a long encapsuled bacillus, side by side with which numerous crystals of bi-urate of soda are to be seen," and promises more information in a future communication.

Treatment.—If the views presented in the preceding pages concerning the etiology and pathology of gout are correct, the objects to be accomplished by its treatment are easily inferred and capable of being clearly stated in few words.

The first object is to prevent the accumulation or retention of an excess of the normal sodium quadri-urate in the blood or tissue fluids long enough to favor its conversion into the less soluble sodium bi-urate, and thereby prevent the formation of the essential cause of the disease. The second object is to render the sodium bi-urate already formed in the blood and tissues more soluble and, consequently, more easy of elimination. The first object is essentially prophylactic or preventive, and the

means for its accomplisliment are almost exclusively hygienic in their character; while the second is directly curative or to relieve existing attacks, and the means for its accomplishment include the administration of such remedial agents as will increase the solubility of the biurate and facilitate its elimination through the natural channels, and such as may lessen its irritative action on the nervous and fibrous structures of the body. Few things within the domain of both clinical and social observation are better established than the fact that individuals and whole communities who have been trained from childhood to a fair amount of out-door muscular exercise, to the use of a fair variety of vegetable and animal food, and to total abstinence from alcoholic drinks, both fermented and distilled, are absolutely exempt from attacks of any form of gout. The only apparent exceptions to this rule are found in such individuals as have *inherited* a very strong predisposition from their parents. Such individuals, though habitually living within the hygienic conditions just stated, may be found to suffer occasionally with some form of neuralgic gout, but the number is very small.

The facts presented by Dr. A. Haig in his inaugural thesis, as well as those presented by many other writers, seem to show conclusively that a diet largely of animal food is accompanied by the excretion in the urine of less uric acid and urea than a diet chiefly of vegetables. Consequently the former is supposed to encourage the retention and storage in the tissues of the sodium urates, while the latter promotes their elimination, and has been generally regarded as more efficient in preventing their retention in such quantity as to endanger an attack of the disease. A careful study of such results of investigations and clinical observations as are on record seems to show that it is not profitable to attempt to adopt an arbitrary rule regarding the quantity or quality of food, at least so far as it relates to its nitrogenous or non-nitrogenous character.

The most important requisite is that the food shall be such as the individual eating it can most perfectly digest and assimilate without being accompanied with gaseous or acid fermentations, and yet will contain all the elements necessary for the repair of the solids and fluids of the body. That a mixed diet, composed of a reasonable proportion of meats, vegetables, and fruits, and taken not more frequently than three times in twenty-four hours, is that best adapted to promote the health and longevity of the human race, admits of little or no doubt.

The relative proportion of the three kinds of food, and the gross quantity to be taken, must be adjusted to the needs and capacities of each individual. And even when the food is thus adjusted, still another condition is necessary for its assimilation and normal uses in the living system, namely, the reception of the proper quantity of pure air, and the active distribution of its oxygen from the pulmonary to the systemic capillaries. Without this neither the metabolic processes concerned in digestion and nutrition, nor those of tissue metamorphosis and excretion, can be maintained in a strictly natural condition.

Consequently, constant access to fresh air and daily muscular exercise, not merely of the back and lower extremities, as in walking, but also of the chest and arms, by which fulness of respiration and freedom of pulmonary circulation are secured, are among the most efficient means for rendering the internal oxidation processes concerned in retrograde tissue metamorphosis complete, and thereby preventing the accumulation of an excess of sodium urates in the blood or tissues.

In addition to the proper regulation of the food, air, and exercise, still another hygienic condition is necessary to render the development of gout practically impossible, namely, the total abstinence from alcoholic drinks. The fact that the presence of alcohol in the blood so modifies the hæmoglobin as to diminish its internal distribution of oxygen and retard tissue metabolism, and so modifies the secreting functions of both liver and kidneys as to strongly favor the formation and retention of sodium urates in the system, is so fully established, both by experimental and clinical investigations, that it is not necessary to adduce the proofs here.

Neither is it important to enter upon the inquiry whether one kind of alcoholic drink *is* more injurious than another. All admit that the use of beers and wines is practically more efficient in producing and perpetuating gout than the use of distilled spirits, and for two obvious reasons: First, those who use chiefly the fermented drinks, use them more uniformly from day to day, and in much greater bulk; second, they take with them a greater amount of acids, sugar, and imperfectly fermented materials that directly encourage gastric, hepatic, and renal disorders. It is true, as so fully stated by Dr. A. Haig and others, that the use of food or drink containing free acids, sugar, and other readily fermentable materials, even without any alcohol, by persons already possessed of a strong gouty diathesis, either hereditary or acquired, may be sufficient to provoke a more acute attack. But, as already stated under the head of Ætiology, there is no proof that the use of any kind or amount of free acids, saccharine matter, or nitrogenous food will produce an acute attack of gout *de novo*, or develop the characteristic gouty diathesis without the coincident use of alcohol in some form. It is proper to insist, therefore, that entire abstinence from alcoholic drinks is necessary, both for effectually preventing the primary development of gout and for overcoming the diathesis when previously established. The medical treatment of gout in all its aspects should be directed for the accomplishment of three objects: first, to render the retained sodium urates more soluble; second, to hasten their elimination; and, third, to lessen the patient's pain and suffering while the two preceding objects are being accomplished.

For many years past there has existed a very general belief that certain natural saline or mineral waters, used freely for both drinking and bathing, were among the most efficient remedies for promoting the solubility of the urates concerned in the production of gout. Consequently several natural springs, both in this country and Europe, have become popular places of resort for the gouty invalid, and saline waters, artificial as well as natural, have been much prescribed by members of the profession.

Some, however, who have had ample opportunities for observation, deny their efficiency entirely, and attribute the improvements that patients frequently experience while attending at some of the most noted places of resort, to the change of air, diet, exercise, and rest from their usual occupations. Sir Mortimer Granville insists that the use of the same quantity of pure water is more efficacious as a solvent of urates than any water containing the salts of sodium, potassium, magnesia, or lithium. The correctness of his position is fully demonstrated by the results of an extensive series of experiments illustrating the chemistry and therapeutics of uric acid gravel and gout, by Sir William Roberts, as stated in his third Croonian lecture before the Royal College of Physicians of London, 1892, to which reference has previously been made. It is shown in the lecture that distilled water at the temperature of 100° F. will hold in solution 1 part of sodium bi-urate to 1,000 of the water, while water at the same temperature, holding in solution 0.50 per cent. of sodium chloride, and 0.20 per cent. of sodium bicarbonate —being about the same proportion naturally existing in blood-serum and synovia—would hold in solution less than 1 part of sodium bi-urate to 10,000 parts of the water. The experiments were so varied as to clearly demonstrate the fact that, the more salts having for their base sodium, potassium, magnesium, or lithium were contained in water at a given temperature, the less sodium bi-urate would be dissolved or retained in solution. And the result was the same whether the saline solutions yielded an acid or alkaline reaction with litmus. Similar experiments performed with the natural blood-serum and synovia led to exactly the same results. The important practical inference is, that the same liberal use of pure water, both for drinking and bathing, as is now made of the most popular mineral waters, would be productive of much

greater benefit, especially to all invalids of the gouty class.

For the speedy relief of paroxysms of acute gout colchicum has long sustained a high reputation. It should be given in as large doses as the stomach and bowels will tolerate, and repeated at intervals of from one to three hours until the pain and active symptoms begin to abate, when the doses may be diminished gradually, and finally withdrawn as soon as the relief is complete. If it acts too quickly on the bowels, as is sometimes the case, ten or fifteen minims of the acetated tincture of opium may be added to each dose. On the other hand, if the attack has been preceded by constipation, coated tongue, and scanty urine, from five to ten grains (0.31 to 0.61 gramme) of calomel may be given at once with benefit to the patient. As soon as acute symptoms have disappeared the further management of the case should be in accordance with the hygienic principles already stated for the removal of the gouty diathesis and the prevention of acute relapses, and only such medicines should be continued as may be necessary to maintain a healthy condition of the digestive and urinary organs. Dr. W. Ebstein, in treating acute symptoms gives, instead of colchicum, lithium salicylate in doses of 0.66 to 1.00 gramme (grs. x. to xv.), every two or three hours, until relief is obtained. Sir Mortimer Granville gives preference to the use of iodine, either in the form of tincture, iodoform, di-iodo-hydriodide of caffeine, or hydriodic acid, and claims that it unites with the sodium of the bi-urate and facilitates its elimination from the system. But he very properly says, it should not be administered in combination with sodium or potassium. Dr. C. J. Rademacher declares that a combination of colchicia, decandria, and solanin with iodine, constitutes a reliable specific remedy for gout.

The most recent remedy that has been highly recommended is piperazine. Dr. Schweninger, of Germany, is represented as having obtained most excellent results from its use in both acute and chronic cases (see *Journal of American Medical Association*, September 24, 1892). Drs. Biesenthal and Schmidt (*La Semaine Médicale*, No. 4, 1892) bear equally strong testimony as to its efficacy. It should be taken in dilute solution in pure water. One gramme (gr. xv.) may be dissolved in three hundred grammes (1 pint) of water, and the whole drunk during the twenty-four hours. At the beginning of acute cases, a larger quantity may be taken during the first day, but subsequently it should be continued for a considerable time in nearly uniform moderate doses, as its chief efficacy is supposed to consist in its power to increase the solubility and elimination of the sodium urates, and thereby counteract the tendency of the disease to continue in a chronic form, and to develop permanent arthritic uratic concretions.

Dr. Thomas A. Edison has reported a case of such chronic concretions successfully treated by electricity; while Dr. A. D. Rockwell reports one or more cases in which the use of electricity only hastened the dissolution of the tissues covering the concretions, instead of diminishing the latter. He has found electricity beneficial only in the chronic nervous manifestations of the disease.

Nathan S. Davis.

GRANVILLE. A sea-bathing resort on the coast of Normandy, and facing the shore of Brittany. It is a picturesque settlement, and, like many of the sea-side resorts in France, is divided into an upper new town and a lower old one. The principal hotels are the *Grand Hôtel du Nord*, *l'Hôtel des Trois Couronnes*, *l'Hôtel de France*, *l'Hôtel de Paris*, *l'Hôtel du Soleil*, and *l'Hôtel de la Boule-d'Or*, all of which are in the Rue Lecampion, and almost all of which have the same tariff of prices—viz., from 7 fr. to 8 fr. a day. The *Casino* of Granville is called *La Cabane*, and is a pretty, unpretentious little building in wood, on a terrace at the base of a high cliff. The beach, which lies immediately below this terrace, is of fine white sand, and terminates on the town side by a high, sombre-colored and picturesquely jagged cliff (Baughan, "The Northern Watering Places of France")

Steamboats ply between Granville and the Island of Jersey. Season, June to September. There are many fine walks and drives at and near Granville. The place is French, rather than international.

Edmund C. Wendt.

GRASSE. A winter health-resort on the Riviera, which has recently been made popular by the sojourn there of the Queen of England. The writer, after a personal inspection of the place, described it about as follows in the *Medical Record* of May 28, 1892:

Grasse is picturesquely perched on the southern slope of Mount Rocavignon, which rises some seven hundred feet above it. It is twelve miles by rail in a northerly direction from Cannes. The inhabitants, to the number of some fourteen thousand five hundred, are chiefly given over to the production of perfumery. Rose, cassia, heliotrope, violets, jasmine, verbena, jonquil, tuberose, orange, mignonette, and other blossoms are made use of in vast quantities for the purposes of this industry.

Grasse gets plenty of sunshine, but being inland and about twelve hundred feet above the level of the sea, its climate is tonic and soothing, rather than stimulating and exciting. It is a little colder than the Mediterranean coast places, but the rise and fall of the thermometer is less abrupt. It enjoys a more equable temperature than do some of the better known and more fashionable resorts of the Riviera. Grasse faces the sea, and enjoys a charming view over the lowlands running down to Cannes.

Spurs of the Esterel Mountains extend to the northwest, and in a northeasterly direction there rise the peaks of the Maritime Alps. The dust and mistral are less trying at Grasse than at neighboring winter stations, though the mountains back of the village fail to give it that complete protection which has been claimed for it. It will nevertheless be seen that Grasse possesses certain advantages that entitle it to be more patronized than it has been, at least by real invalids.

Not much has been done in the way of recent sanitary improvements. But the cesspool system is always less objectionable in small villages than in large settlements, where human beings are herded together in close quarters.

The Grasse drinking-water, while not absolutely irreproachable, comes from two good sources. It is conducted in canals, one of which is covered. It is safer to boil it before drinking, but it is less calcareous than much of the Riviera water. The two sources are known as *La Foux* and *Le Foulon*, and the supply is more than abundant. From the excellent little guide to Grasse, published by "An English Resident," the following table is taken:

ANALYSIS OF GRASSE DRINKING-WATER.—One litre of water taken at the sources contains:

	Foux.	Foulon.
Degree hydrometric	18.2 c.c.	18 c.c.
Organic matters calculated as oxygen from permanganate of potash	7.2 mg.	0.48 mg.
Chlorides	traces	traces
Nitrites and nitrates	nil	very slight traces
Combined ammonia and albuminoids	0.2 mg.	0.003 mg.
Oxygenation	8.5 c.c.	8.22 c.c.

The Grand Hôtel has been quite recently put in good sanitary condition by Mr. Best, of London. Board and lodging are cheaper in Grasse than at the more favored resorts. Many interesting walks and excursions offer themselves to the tourist. But apart from that there is very little "going on." It may be for this reason, perhaps, that so few Americans spend the winter at Grasse.

Invalids who do not prosper at the sea-side will do well to try the inland air of Grasse; and for some cases of nervous break-down the very dulness of the place should be a strong recommendation.

Cases of chronic laryngitis, pharyngitis, chlorosis, anæmia, and early cases of phthisis generally do very well at Grasse. Asthmatics and gouty patients are also benefited there.

Edmund C. Wendt.

GROUND ITCH. A disease so often met with deserves, at least, to be described and named. We can find no reference to it in the works on practice, on skin diseases, in encyclopædic handbooks, or the "Index Catalogue" of the Surgeon-General's Office; yet there is scarcely a boy raised in the coast districts of South Carolina who has not been a sufferer from this affection.

As it involves invariably one or more of the toes, seldom extending beyond them, and possesses the characteristics of eczema, there need be no difficulty in giving it its correct scientific designation. We would suggest the compound name, Eczema phalangis pedis.

Cause.—It is generally found in those going without shoes, and is popularly ascribed to walking barefoot in the sand, dew, and wet grass, and therefore generally affects boys.

It is met with extensively along the seaboard, in the Pineland residences, and elsewhere, also on Sullivan's, Pawley's, and other islands; and in these localities are found certain grasses armed with spines or prickles, which are highly irritating, though no complaints are made of them. Those of cleanly habits are not exempt from the disease.

Symptoms.—There may be at first moderate redness or subacute inflammation, followed by papules or vesicles which burst. This is accompanied by intense itching and burning, only partially relieved by scratching; the result being a sore with whitish ulceration around and between the toes, with a moisture characteristic of eczema. There is no rash, fever, or chill; no extreme swelling or sloughing.

It is analogous with an affection known as "stone bruise," quite common in the upper and more rocky districts.

The disease we are describing is neither camp nor prairie itch, nor is it embraced under any of their synonyms, which are all contagious and generalized over the whole surface of the body, whereas ground itch is strictly localized and never contagious.

A correspondent who is a high authority on dermatology suggests that "it is possible that it may be due to the attack of the pulex penetrans (sand-flea or jigger). This attacks the neighborhood of the toes, but is not commonly met with outside of tropical countries, although it has been reported from time to time as met with in the Southern States. Even though it be an eczema, it must, from your note, have peculiar features." We are inclined to dissent from this opinion, though we have heard the affection ascribed to some minute insect. Were the pulex the cause, it would be more readily recognized, for the female, which is generally regarded as a true flea, penetrates the thin skin between the toes or about the toe-nails, and then swells up to the size of a flea, forming a bag of eggs, and this becomes plainly visible. This causes much irritation, which often results in suppuration, followed by open ulcers.

Treatment.—There are many popular remedies, as, for example, bread-and-milk poultices in the early stages; soaking the feet in hot water is said to arrest the disease; applications of the leaves of the gourd or calabash (*Cucurbita lagenaria*) heated; a hot decoction of the yellow gerardia (*Gerardia flava*), which grows abundantly here and is considered a sovereign remedy. We have experienced good results from the application of a powder of aristol, bismuth, and oxide of zinc, equal parts. A combination of campho-phenique and oil or vaseline, equal parts, also gives great relief, and we have seen benefit follow the application of an ointment given us by the late Dr. Valentine Mott, of New York, for eczematous affections, viz.:

℞. White precipitate of mercury..... ʒ j.
Oil of tobacco .... gtt. x.
Lard..... ʒ j.

Iodoform in the moist stage is a useful application; and a strong solution of soda, frequently applied, relieves the itching temporarily.

When the suppuration is subsiding any drying powder, such as calamine, subnitrate of bismuth, oxide of zinc, or powdered cinchona bark, will prove useful. A medical friend finds equal parts of ichthyol and vaseline the most efficient remedy. Carbolic acid is sometimes employed as an ointment, with lard or vaseline.

The disease is often very refractory, the itching and burning being very severe. A patient, under constant supervision, is now in the sixth week of the disease.

F. Peyre Porcher.

GUAIACOL. This compound constitutes from sixty to ninety per cent. of creasote, and may be separated by fractional distillation, the portion passing over between 200° and 205° C. being collected. Chemically it is monomethyl pyrocatechin, with the formula of $C_6H_4OHOCH_3$. It is a colorless liquid with a strong, aromatic odor, very slightly soluble in water, 1 part in 85, but readily soluble in alcohol and ether. Specific gravity at 60° F., 1.117; boiling-point, 200° to 202° C. Guaiacol may also be formed from guaiacum resin by distillation. Many of the guaiacols of commerce are contaminated with various impurities, which give it a lower specific gravity and boiling-point; they are darker in color, and spoil by exposure to light. With concentrated sulphuric acid the pure guaiacol gives a faint yellow coloration, which is changed to a yellow red by the addition of a small quantity of acetone; the impure guaiacol gives a more or less red color with the acid alone. A characteristic test for guaiacol is the addition of a trace of ferric chloride to an alcoholic solution: this gives a blue color which changes to green with the presence of a greater proportion of the salt. Guaiacol is excreted with the urine, the saliva, and the perspiration, and may be detected as early as half an hour after its administration. It may be demonstrated by distilling the secretion with diluted sulphuric acid. The product is placed in a test-tube and to it is added a small quantity of highly dilute solution of liquor ferri sesquichlor. (two or three drops to a test-tube of water). In the presence of guaiacol a reddish-brown color is gradually developed, the intensity of which is in proportion to the amount present.

The value of guaiacol in the treatment of tubercular disease was pointed out by Professor Max Schueller, of Berlin, in a work published in 1880.[1] The author had made numerous trials, with various drugs, upon animals affected with tuberculosis. Extract of guaiacum wood, guaiacol, creasote, benzoate of sodium, and many other substances had been experimented with, and he had selected guaiacol as the most serviceable. In 1891 a second treatise was issued,[2] reviewing his work during the intervening years and explaining in detail his method of employing the drug in general and in surgical tuberculosis. Dr. Schueller administers it continuously for a long period in moderate doses; he does not think large doses are of any special value. An improvement shows itself quickly, but the remedy must be continued throughout the course of the disease, and when recovery takes place its use must be persisted in for some time longer. He particularly insists upon it being given for some months after the bacilli have disappeared. He has recorded eighteen cures of pulmonary tuberculosis; some of the patients have been free from symptoms of returning disease after several years have elapsed.

In pulmonary tuberculosis he gives it in doses of two or three drops to children, and three to five drops to adults, four times daily. He gives the drug without any preparation, in a glass of water, to which a little table salt has been added to facilitate solution and cover the taste; or it may be given in milk, wine, or spirits. He does not like the use of pills or capsules. This method, he thinks, allows it to be present in the stomach in a too concentrated state, but where such are given, large quantities of water should be used before and after to facilitate solution and dilution. Guaiacol is well borne by the stomach, and its disagreeable odor and taste are soon overcome to such an extent that patients rarely complain.

Dr. Schueller has also used it extensively in surgical tuberculosis with equally satisfactory results. It is admin-

istered internally as in pulmonary disease, and injected into the site of the local trouble. He also uses the guaiacol in combination with iodoform for the local treatment. Enlarged glauds, tubercular deposits, and skin affections in which caseation has not commenced, he has seen disappear with simply the constitutional treatment, and many threatened joint affections have been averted. In tubercular disease of the bones, when caseation and destruction have taken place, he considers that the diseased tissue should be removed, and the local use of guaiacol and iodoform then proceeded with to promote repair and prevent the return of the disease.

Guaiacol has been very extensively used as a substitute for creasote, and has been found to be easily taken and retained. It is also of a more definite strength than creasote, and free from any deleterious effects. The dosage varies, and many follow the method of Sommerbrodt with creasote, in giving large doses and pushing it with the idea of saturating the system. It is generally given in solution in preference to other ways, and tincture of gentian, tincture of cinchona, and wine, are favorite menstrua with which it may be combined, to disguise its taste and increase its tonic action. If for any reason it cannot be administered in the ordinary way, it may be given in the form of an enema, and for this purpose the following formula may be adopted: Guaiacol, 7 grains; sweet almond oil, 1½ drachm; gum acacia, ¾ drachm; distilled water, ½ pint.

Iodoform in combination with guaiacol, as an improvement upon the latter alone, was introduced by Professor Picot, of Bordeaux.[3] A solution of the two drugs in sterilized olive oil is prepared and used subcutaneously. The dose he advocated was very small, viz., one-sixth grain of iodoform and one grain of guaiacol, daily, to be increased gradually until three times that amount is reached. He selected the supra-spinous fossa as the most suitable place for the injection, as it does not bear the weight of the body when the patient lies on his back. No local reaction followed its use, but from twenty to thirty minutes after the injection signs of a general reaction were evident; there was profuse perspiration of the face and chest, which was followed by a lowering of temperature. The digestion was not affected, but in some cases colic and diarrhœa were complained of. No effect on the urine was noticed. Twenty-five cases of tubercular phthisis and pleuritis were treated, and Professor Picot had never obtained such favorable results in any other line of treatment as he observed in these cases. He sums up as follows: The injections improve the general condition, and lessen cough and expectoration. In certain cases they dry up cavities and favor their cicatrization. In the second stage of phthisis they make cough and expectoration disappear, while causing the cessation of fever and night-sweats. They also diminish the number of bacilli in the sputum. Professor Picot, at a later date,[4] reported the results of forty-two cases treated with the same satisfactory results, and without any unfavorable symptoms accompanying the injections.

Dr. R. Robertson, at the British Medical Association, 1891,[5] gave the result of his experience. He used it after the manner of Professor Picot. The small dose was commenced with, at the seventh day it was doubled, and at the twenty-first day the full quantity was begun. He employed the remedy in twenty-five cases of consumption and three of empyema. He concludes, 1, that in empyema with free drainage the treatment does good in improving the general condition and in diminishing the discharge from the pleural cavity, but that without free drainage it is of uncertain value; 2, that in pyrexic phthisis, whether the disease is small in extent or so extensive that the case seems almost hopeless, it is not an absolutely certain antipyretic, but it is commonly of decided advantage, if persevered with, in reducing the fever, and by so doing in diminishing the activity of the disease; 3, that even where it fails within a reasonable time to modify the fever, it is still serviceable in most cases in diminishing expectoration and in modifying the cough; 4, though it is serviceable in limiting waste by reducing temperature and by diminishing expectoration, it cannot be said that this treatment is specially favorable to increase in body weight; 5, the treatment is without risk with ordinary precautions; 6, its use does not prevent the development of other tuberculous outbreaks or extensions of tuberculous mischief, for meningitis, pleurisy, hæmoptysis, have been shown to occur after many injections; 7, in interpreting the mode of action of these remedies, their antiparasitic action should not exclusively be thought of; it must not be forgotten that both remedies act upon the patient himself, even in small doses, as a sedative, as a stimulant of the mucous membrane, and as an astringent.

Benzosol.—A crystalline salt of guaiacol in which an hydrogen atom of the hydroxyl group is replaced by benzoyl. It is the benzoate of guaiacol. The chemical formula is $C_6H_4OCH_3OCOC_6H_5$. It is a colorless crystalline powder, almost devoid of taste and odor, insoluble in water, readily soluble in alcohol, ether, and chloroform. It contains fifty-four per cent. of guaiacol. The boiling-point should not be below 44° C.

Benzosol is acted upon by the alkaline secretions and gradually decomposed, guaiacol and benzoic acid being formed. It does not cause any irritation to the digestive tract nor give rise to eructations or any other disagreeable symptom. Its advantage over guaiacol is the absence of any odor and taste. In addition to its use as a substitute for guaiacol in the treatment of phthisis, it is also recommended as an intestinal antiseptic where such is required. The dose is four grains, to be gradually increased to twelve grains, three times daily.

Guaiacol Carbonate was also introduced[6] because it afforded a better means of administering guaiacol than the employment of the parent liquid afforded. It has the advantage of being more definite in composition and perfectly free from any adulteration. Although termed a carbonate its formula is $CO(OC_6H_4OCH_3)_2$. It forms in neutral crystals, is tasteless and without odor, and is insoluble in water. Its melting-point is 86° to 90° C. It is not affected by the gastric juices, but in the alkaline secretions of the intestines it is decomposed and guaiacol set free. If the stomach is deranged and the seat of putrid fermentation, the decomposition of the salt will take place and produce its beneficial action. It is also used to replace guaiacol and creasote in phthisis. The dose is six to eight grains, gradually increased, three times a day. As much as ninety grains have been given without producing disturbance of the digestive organs.

Guaiacol Salicylate, also called guaiacolic salol. Its chemical formula is $C_6H_4OHCOOCH_4OCH_3$. It occurs in white, odorless crystals, with a melting-point of 65° C. It is insoluble in water. This compound is introduced for the same purpose as the above salt, and is also said to be much superior to salol for all purposes in which that salt is employed. The dose and modes of administering are the same as for salol.

Beaumont Small.

[1] Experimentelle und Histologische Untersuchungen, etc. Stuttgart: F. Enke, 1880.
[2] Eine neue Behandlungsmethode der Tuberkulose, besonders chirurgischen Tuberkulosen, von Professor Max Schueller. Wiesbaden: J. F. Bergmann, 1891.
[3] La Semaine Médicale, March 4, 1891.
[4] La Semaine Médicale, August 5, 1891.
[5] British Medical Journal, November 14, 1891.
[6] Berlin. klin. Wochen., 1891, No. 52.

HÆMOGALLOL. A patented article prepared by the reducing action of pyrogallol on the coloring matter of the blood, It is a brownish-red powder, very soluble, and more readily absorbed than any other preparation of iron. It is very well borne by the most delicate stomach, and when absorbed is easily transformed into the blood coloring matter. The dose is from two to eight grains, three times a day. As much as fifteen to thirty grains have been given without any inconvenience.

This compound was introduced by Professor Kobert, Director of the Pharmacological Institute of Dorpat University, as the result of a series of experiments upon the assimilation of iron salts. He considers that ferruginous preparations, if they are of any value, should be excreted

with the urine, not immediately, but after the lapse of a few days, and should appear as a definitely formed urate of iron. None of the usual preparations of iron answer to these conditions. When introduced into the blood they are excreted to the extent of forty per cent. in an unchanged condition, which would indicate that the assimilation of these salts is very uncertain. The new preparation answers to all the above conditions, and clinical experience has shown the most favorable results, both in chlorosis and anæmia.

Hæmol is a similar preparation, obtained by using zinc-dust in the place of pyrogallol as the reducing agent. The dose is the same as that of hæmogallol, the action is very similar, and the same favorable results have been obtained. This preparation contains a trace of zinc, which is considered a rather desirable combination, as it exerts a beneficial action where there are lesions of the stomach or intestines. *Beaumont Small.*

HAND, DEFORMITIES OF. ATHETOSIS.—No local treatment, either mechanical or operative, of the deformity associated with athetosis has given satisfactory results. Relapses have invariably occurred after even prolonged immobilization, and after section of the tendons deformity has soon recurred and become steadily worse. Only excision of the cerebral cortical centres, which, of course, paralyzes the part, affords any relief to the deformity.

DROP-WRIST.—Very many cases of drop-wrist that obtain little, if any, benefit from other forms of treatment, go on to a partial, and not infrequently complete, cure when the nerve inflammation has subsided, by being persistently kept for a very long time in an over-corrected position.

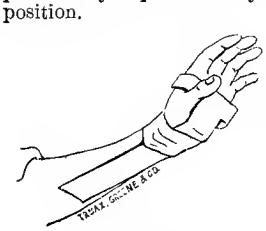

FIG. 210.

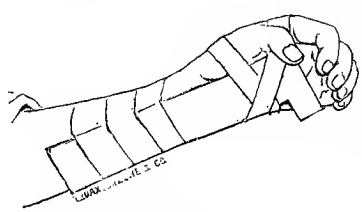

FIG. 211.

FIGS. 210 and 211.—Splint for Drop-wrist.

The hand is fully extended on the forearm and held by a simple metal splint applied to the palmar aspect, from the elbow to the carpo-phalangeal articulation. This position is maintained, without being even once relaxed, for from twelve to eighteen months. Structural shortening, the result of the position, seems to take place in the extensor muscles, and even if voluntary motion in them is not regained, the deformity is cured, and the flexor muscles act to a greater advantage, while a more comely and useful hand is the result.

INFANTILE HEMIPLEGIA.—In some cases treatment is of no avail; in others much restoration of function can be gained. If the deformity can be readily overcome, and the hand placed in the extreme opposite deformity without discomfort to the patient, it should be so placed and held by a suitable splint, without change of position, for from twelve to eighteen months. This overcomes the shortening of the flexor muscles and permits the slack of the extensor to be taken up by structural shortening. If the hand cannot be easily and comfortably placed in hyper-extension, division of all shortened tissues should be made, and the hand at once placed in the desired position and held there as already directed. A permanent gain in position may always be anticipated, and in a few cases there has been considerable restoration of voluntary movement. *John Ridlon.*

HASTINGS AND ST. LEONARD'S. Popular sea-side resorts and winter stations in Sussex, England. Hastings and St. Leonard's are practically one. They are at present fashionable winter stations rather than summer resorts, although the beach is remarkably fine. According to Black ("Watering-places of England, Scotland, and Ireland") the "ridge of hills that runs through the centre of Sussex divides at Hastings, as it approaches the sea, into several spurs, enclosing valleys, from within which begin the houses of Hastings and St. Leonard's, and extend to the beach, where they all join into one almost continuous frontage of about two miles. This frontage begins at St. Leonard's on the west, with one range after another of fine mansions, till Hastings is reached. Along the whole of this front extends one almost unbroken promenade. Behind, at various distances, are the cliffs, which are much lower at St. Leonard's; but from thence, gradually though irregularly, they increase in height till they attain the magnificent elevation, at or little beyond the eastern extremity of Hastings, of five hundred and sixty feet."

The east winds are at times very trying, but in general the climate is mild and equable, and for this reason many consumptives spend the winter there. There is comparative absence of fogs, and the porous soil quickly absorbs moisture. The drainage and drinking-water are good. The sanitary condition of the towns is excellent, the annual death-rate being only about sixteen to seventeen per thousand. There is a large pier at Hastings, with conveniences for exercise under glass-covered promenades. According to Savery ("Hastings and St. Leonard's, their Meteorology and Climate"), the whole number of fine days is 189. They advance with great regularity from their minimum in January to their maximum in July, and then as steadily decrease. The cloudy-fine days number 46; the cloudy, 52; the fine-rain, 42; and the cloudy-rain, 30.5; while the rainy days only amount to nine in the year. From this it is evident that the number of days on which the invalid cannot get out on account of the weather is very small; and those on which he may enjoy the rays of the sun, so conducive to health and vigor, are 280. To these must be added 52, which are dry though overcast; hence there are 332 days in which a person may enjoy a walk. The regularity of these results, and the small amount of variation year after year, is very remarkable, and has much surprised him, as the fickleness of the weather in England has passed into a proverb. Dr. Mantell claims that it is not necessary for the invalid, however delicate, to be confined to the house for any length of time. Apart from Torquay, few English resorts are better adapted for an invalid's winter residence than Hastings and St. Leonard's. Many excursions can be conveniently undertaken from these resorts. There are the usual concerts, assemblies, and other amusements. The hotels are good; the *Queen's* on the Parade, facing the sea, the *Albion*, and the *Castle* are the best. At St. Leonard's, the *Royal Victoria* and *South Saxon* are the best. *Edmund C. Wendt.*

HEADACHE. Since the appearance of the REFERENCE HANDBOOK very little has been added to our knowledge of the pathology of headache. There has been a good deal of speculation, and some ingenious theories have been suggested in explanation of some of the phenomena; many facts have been observed and classifications made without giving grounds for much change of views as to the nature of the trouble.

It is pleasant to note that so painstaking a student as C. L. Dana, after a thorough review of the whole subject, holds, with the original article on this subject, that we have no proof that headache may have its seat in the brain, although there is no proof that it may not. The cortex "may be the seat of headache, but then it is a psychical pain and in the nature of an hallucination." There can be no subjective difference between a genuine pain and one founded on an hallucination; to the patient they are identical.

Most headaches are doubtless in the nature of neuralgias of the nerves of the dura mater or of the tissues covering the skull. Of course this includes the tri-facial

nerves, the upper cervical nerves, and some sensory branches of the vagus.

The explanation of reflex headache has, like that of all reflex phenomena, been unsatisfactory. Why, for example, does an irritation of the stomach produce headache, instead of a pain in the foot? Dr. Dana suggests the theory that the first irritation being received by the vagus and transmitted to the brain is easily "shunted off or diffused" from the seat of original irritation to the nerves most obnoxious to pain. This theory is rational so far as it goes, but does not explain the special irritability of the headache nerves.

The explanation of migraine is still sought in the assumed discharge of nerve-force occurring periodically, a most unsatisfactory theory, but perhaps the best one at present. As illustrating the protean forms in which migraine appears, one author quotes ten cases—cases occurring at random—in which were represented the following symptoms: Concentric retraction of the field of vision, aphasia, hemianopsia superior, numbness of one arm, vertigo, agraphia, scintillating scotoma, hemiparesis, hemianæsthesia, difficulty of speech, amaurosis, and epileptiform convulsions.

Dana classifies two hundred cases of non-migrainous headache, and attributes thirty-five per cent. to poisons and poverty of the blood, such as anæmia, dietetic states, infections, uræmia, lead, alcohol, tobacco, etc.; twenty-five per cent. to reflexes from the digestive organs; ten per cent. to other reflexes; five per cent. to local organic disease, and twenty per cent. to neurotic states.

Much has been insisted of late on dull frontal and diffuse headache as resulting from catarrhal states of the upper part of the nasal passages, but I am satisfied that this is a much over-estimated cause.

The character of the headache doubtless indicates to some degree the causation; for example, the throbbing headache, aggravated by a jarring of the body, is more likely to be migraine, while the dull, steady pain is more likely to result from dyspeptic disturbance and toxæmia. The hot, burning, sore headache is often alleged to be due to anæmia, but frequently results from neurotic conditions incident thereto, and to uterine disorders. The intense, boring pain (clavus) is nearly always a hysterical symptom; while the occipital pain is often caused by eye-strain.

Weir Mitchell has wisely emphasized the fact that headaches probably often persist long after the causes of them, such as eye-strain, have been removed, as though from a habit of pain. They are more likely to persist when they have come on during the period of youth.

Sunstroke leads often to persistent tendency to headache, always aggravated by heat, and especially by the sun's heat. There can be no doubt that in some of these cases, as well as in cases following injuries, spots of meningeal thickening occur which through pressure on nerve-fibres and abbreviation of the movements of the brain substance, as well as possibly by reflex action, lead to almost constant pain.

Each year fresh evidence develops of the manifold headaches due to eye-strain from various optical defects of the organs of vision, the variations of hypermetropia and astigmatism being the most common. Defects of the extra-ocular muscles probably also cause headache. Observers differ as to the proportion of cases due to these causes all the way from a modest figure up to seventy-five per cent. or more. A misleading circumstance is the fact that in some of the worst of such cases there are no ocular symptoms of pain or discomfort.

Experience shows that oculists have not yet found the way to correct by glasses all cases of headache due to optical defects. Many cases must be tested repeatedly and experimented with in the use of various degrees of correction before the right fit is found; and sometimes the right fit is not found, suggesting that such cases are not due to the eyes. This conclusion is less tenable since numerous such cases have, by later methods and more careful testing, been entirely relieved.

The claim has been lately put forth, and defended with zeal, that headaches, as well as other nervous troubles, including epilepsy, are often due to inequality or asymmetry in tension of the extra-ocular muscles, for which graduated tenotomy is recommended. Many operations of the kind have been made, but the results have not been such as to commend either the theory or the remedy to the majority of students of the subject. That there is a measure of truth in the theory is probable, but its advocates have unquestionably claimed too much for it.

Within a few years a remarkable series of coal-tar products of the chemical laboratory have come into use in the treatment of headaches, as well as of neuralgias in general. Antipyrine has been used most extensively, while antifebrin, or acetanilid, and phenacetine, have been used very widely. Exalgine has been used to a limited extent. Various secret and proprietary preparations, which are mostly compounds of some of these medicines with various modifying agents, have also been extensively employed. So common has the use of this new class of agents come to be in the United States, that many people purchase and use them on their own responsibility as freely as quinine is used for so-called malaria. Notwithstanding the wholesale use of such medicines, very few unfortunate results have been recorded.

Antipyrine is a fine crystalline white powder, highly soluble in water, while antifebrin is offered in coarser crystals, and is sparingly soluble in water; phenacetine is similar in appearance, and is also sparingly soluble in water.

These agents were first introduced as antipyretics, but were found to exercise a potent influence upon the nervous system, particularly in the presence of simple neuralgias, especially those that are produced by reflex influences and aggravated by the lowering of vital tone.

Antipyrine has been used in doses of two to twenty grains, and but few instances have been recorded of injury from this larger dose. Occasionally a large dose produces a sense of prostration, evidence of heart weakness or some skin eruption, but in general it may be said that in tentative quantities the drug is a safe one, even in the hands of the laity. The proper dose of antipyrine for headache in an adult is five grains, which may be repeated every half hour or hour until relief has been obtained, or until enough doses have been taken to prove that the drug is ineffective.

People differ widely in their susceptibility to the remedial influence of the drug for headache, but most persons experience benefit from one to three doses of five grains each; but some seem not to be affected by any safe quantity of the drug. Doubtless the cause of the headache determines to some degree the susceptibility to the remedy; thus true migraine headaches, produced by digestive derangement and fatigue of the eyes, are more likely to be benefited than headaches due to nephritis, anæmia, nervous exhaustion, and cerebral syphilis. One trial of the drug will nearly always determine for each patient its constant effect upon him. A headache relieved by a certain dosage for a particular patient may be expected thereafter to yield, to some degree, to the remedy, but migraine patients have found that they acquire a tolerance for the drug that makes it, after repeated trials, ineffectual except in large quantities; so that many, after a year's trial of it and more or less benefit, have rejected it as unsatisfactory. This has been, however, the experience of such patients with every drug known to affect the disease.

Antipyrine seems specially applicable to cases of headache produced by gastric disturbance; in many cases it corrects the stomach disorder as well as the headache; and if taken at the first appearance of the premonitions of a migraine it may cut these symptoms short and prevent the appearance of the paroxysm. An effective and convenient way to administer the drug is by means of compressed tablets.

Antifebrin should be given in smaller doses than antipyrine. It produces much the same effect, but is less soluble in the stomach, and, given in large quantities, as twenty or thirty grains within a few hours, it is liable to produce a cyanosis, due to an effect upon the superficial capillaries. This condition is known not to be specially

dangerous, but is generally alarming to lay people who observe it. This drug has not given the satisfaction to patients with headache that has been experienced from antipyrine and phenacetin. Probably one explanation of this fact is the sparing solubility of the remedy. The drug is much more soluble in hot water than in cold, and may well be given in a hot solution where its prompt action is important.

Phenacetin produces fewer unpleasant symptoms than antifebrin, is very popular with patients who have used it for headache and neuralgias, and may be given in about the same doses as antipyrine. It produces more perspiration in febrile cases than either of the other drugs named; and in large doses may produce decided cyanosis. It is unwise, however, because of its sparing solubility, to give this drug in the shape of compressed tablets, if there is any considerable catarrh of the stomach. I have known such tablets given in typhoid fever for headache to pass in large number through the alimentary canal undissolved.

Just how these drugs act is something of a mystery. Antipyrine is believed by some to reduce intra-cranial blood-pressure, and that it should never be used when spasm of the blood-vessels exists—if it can be known certainly when that occurs, of which there is often some doubt.

There is no reason to think that any of these new remedies induces a lessening of the tendency to regular recurrence of migraine paroxysms. *Norman Bridge.*

HEART, THE. The vertebrate heart arises in two distinct ways, each of which is intimately associated with the origin of the blood-vessels in general. In the lower vertebrates its first appearance is in the form of a single tube on the ventral median line of the embryo, quite near the head. Fig. 212 is a section of a salamander embryo in which the heart is just beginning to form. The body cavity *lh* is composed of two lateral halves (see *Cœlom*) separated from each other by a median septum. It is in this septum that the heart first makes its appearance. The two layers which contain this septum become separated, and the opening soon becomes lined with a layer of cells, *end*, the endocardium. The cells of the septum surrounding the opening give rise to the muscle-walls of the heart.

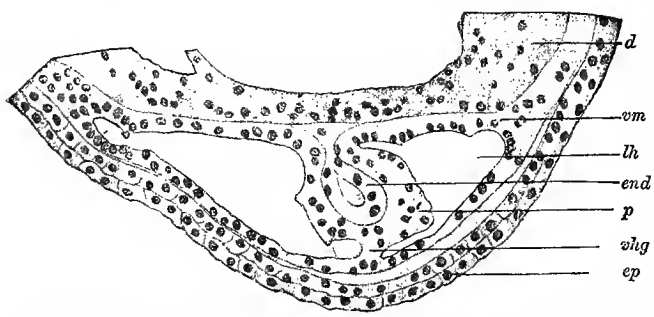

FIG. 212—Section through a Salamander Embryo, to Show the Origin of the Heart. (From Hertwig, after Rabl.) *d*, yolk; *vm*, pericardium; *lh*, body cavity; *end*, endocardium; *p*, muscle layer of the heart; *ep*, epidermis.

In higher vertebrates the heart is first formed by the union of two tubes arising from what might practically be called the outside of the body. Fig. 213 is a surface view of quite a young rabbit embryo in which the heart is beginning to form on either side. The omphalomesenteric veins on either side run toward the ventral median line, and later on unite. Their appearance is such, however, that before they are united they may be spoken of as two hearts. Fig. 214 is a section through an embryo of the same stage as that pictured in Fig. 213. The neural canal, *rf*, is just beginning to close and in the splanchnopleur on either side there is a large fold, *ahh*,

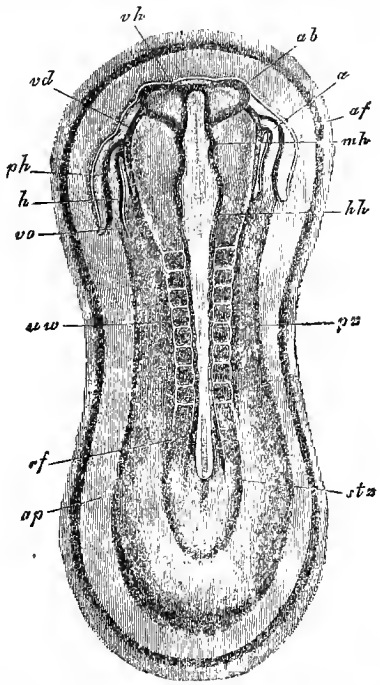

FIG. 213.—Rabbit Embryo of the Ninth Day. (After von Kölliker.) × 10 times. *h*, double origin of the heart; *ab*, optic vesicle; *vh*, forebrain; *mh*, mid-brain; *hh*, hind-brain; *rf*, medullary groove; *uw*, myotomes; *h*, heart; *vo*, vena omphalo-mesenterica.

which already contains the endothelial tube coming from the omphalo-mesenteric vein. The tubes grow toward the median lines, but before uniting each has its descending aorta, as shown in Fig. 215. The rudimentary hearts are formed between the splanchnopleur and entoderm, and as the former surrounds the heart to form its muscular layer the heart protrudes into the cœlomic cavity (Fig. 214), much as does the unilateral heart of lower vertebrates (Fig. 212). Soon the two halves unite as indicated in Fig. 215, and then we have a single heart with two veins entering from behind and two arteries, aortæ, leaving from in front. Although this primary division has nothing whatever to do with the later separation of the heart into its two halves, yet before the two primary hearts are united into a single tube the position of the ventricle is already marked (Fig. 215, *h*). So, to sum up, in the lower vertebrates the heart appears as a single tube which in general remains such during the life of the animal, and it must be viewed as the primative form of heart.

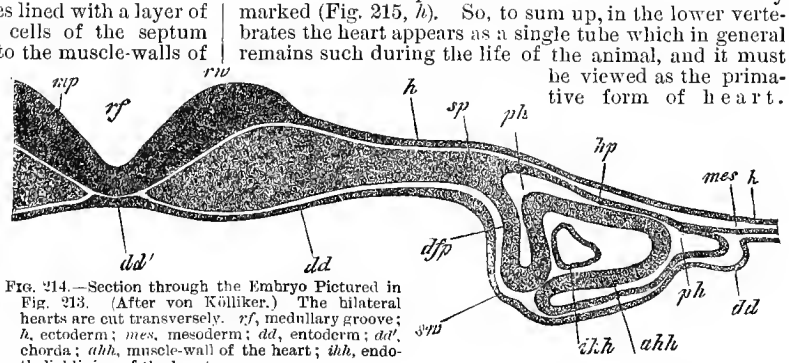

FIG. 214.—Section through the Embryo Pictured in Fig. 213. (After von Kölliker.) The bilateral hearts are cut transversely. *rf*, medullary groove; *h*, ectoderm; *mes*, mesoderm; *dd*, entoderm; *dd'*, chorda; *ahh*, muscle-wall of the heart; *ihh*, endothelial lining of the heart.

Higher up the scale the heart arises before the foregut is formed, from that portion of the splanchnopleur which later on lies in the median line of the embryo. It is this part which is to give rise to the heart, and in the higher

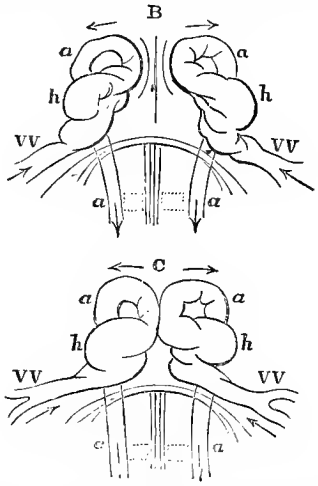

Fig. 215.—Sketches Showing the more Advanced Condition of the Bitubular Heart of the Rabbit. 22 times. (After Allen Thomson.) *C* is more advanced than *B*. *VV*, omphalo-mesenteric veins; *h*, heart; *a*, aorta; the arrows indicate the direction of the circulation.

animals the heart arises before the lateral parts have reached the median line (Hertwig). The two hearts then unite into a straight tube which is destined to become separated into the right and left hearts of the adult.

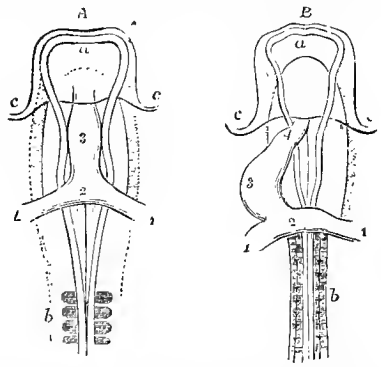

Fig. 216.—Outlines of the Anterior Half of the Chick Viewed from the Ventral Side, Showing the Heart in its Earlier Stages of Development. × 20 times. (From Qnain, after Remak.) *A*, thirty hours; *B*, forty hours; *a*, anterior cerebral vesicle; *b*, myotomes; *c*, cephalic fold; 1, omphalo-mesenteric veins; 2, 3, 4, the heart.

Fig. 216 is a ventral view of two chicks just after the two primary tubes of the heart have united. It is seen that the veins (1) enter from behind, but the relation is soon changed by the heart becoming bent as is already indicated in Fig. 218.

Fig. 217 shows the general form of the heart in a very young human embryo. The front of the thorax has been cut away, cutting also through the transverse septum and opening the body cavities. The entrance of the veins still lies behind, and the aorta in front, but the heart has already formed one complete loop, making of it an S. Fig. 218 is a profile of the same embryo, and the heart is indicated as a cast of its cavity. It shows the variations in calibre of the tube throughout its length. At a somewhat later stage the heart is bent upon itself more, and its walls have also become thickened. Figs. 219 and 220 are ventral and lateral views of a reconstruction at this stage. The profile view again gives a cast of the heart cavity, which now shows the beginning of the auricle

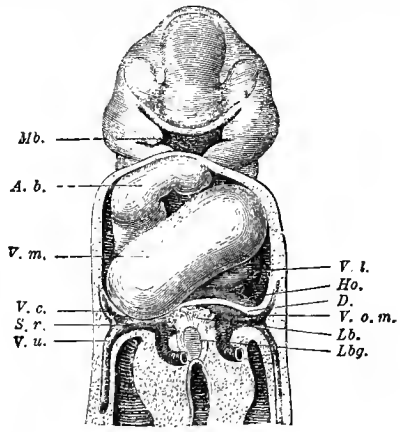

Fig. 217.

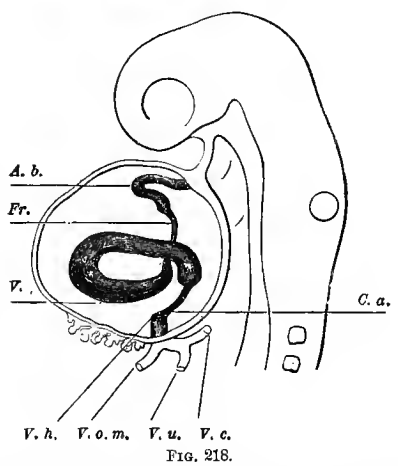

Fig. 218.

Figs. 217 and 218.—Ventral and Profile Reconstructions of His's Human Embryo, Lg. × 40 times. (After His.) In the profile view only the outline of the cavity of the heart is shown. *V.*, ventricle; *A. b.*, bulbus aortæ.

(*V.h.*) At this time the heart is partly tilted over and the veins enter on the dorsal side. Viewed from in front, the auricles, which are just appearing, cannot be seen because they now lie on the dorsal side. A stage later

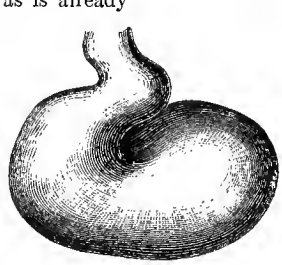

Fig. 219.

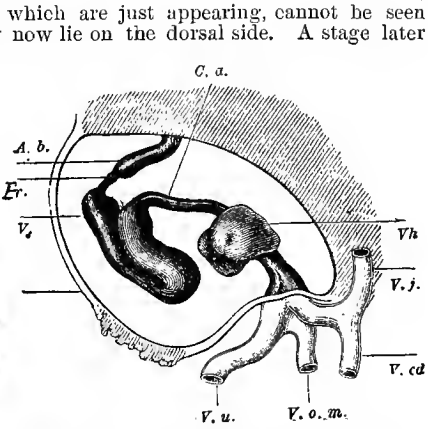

Fig. 220.

Figs. 219 and 220.—Ventral and Profile Reconstruction of His's Embryo, Lr. × 40 times. (After His.) *V*, ventricle; *Vh*, auricle; *A. b.*, bulbus aortæ.

(Figs. 221 and 222), the adult form can already be recognized. The heart has undergone a half revolution in addition to the S-formation. The veins enter nearer the head and the artery arises behind, or away from the head. The aorta lies upon the ventral side and the auricles clasp it from the dorsal. Fig. 222 shows the great irregularity of the cavity.

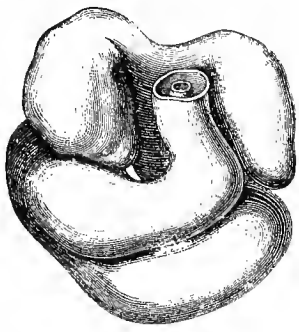

FIG. 221.

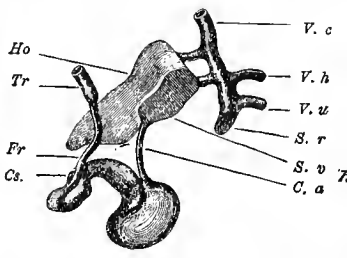

FIG. 222.

FIGS. 221 and 222.—Ventral and Profile Reconstruction of His's Embryo, Bl. × 40 times. *Ho*, auricle; *C.a*, auriculo-ventricular canal; *Tr*, aorta.

A profile view of a heart of this stage is shown in Fig. 223, which shows the relation of the heart to the surrounding organs. The auricle (*A*) is now in front and the ventricle (*V*) behind. The larger veins enter on the dorsal side by one common opening into the right side of the auricle, the future right auricle.

After the heart has once reached this stage it is only to be separated into its right and left tubes to produce the mammalian heart. In some of the lower animals this never takes place, and in others it is only partial. In

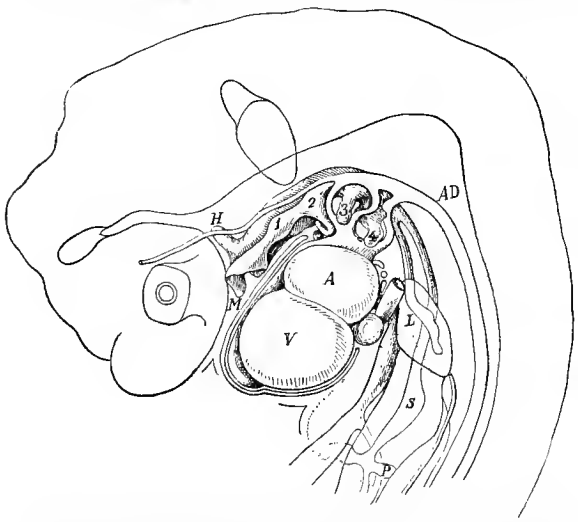

FIG. 223.—Reconstruction of a Human Embryo enlarged sixteen times, and viewed from the left side. *H*, hypophysis; 1, 2, 3, and 4, branchial pockets; *M*, mouth; *A*, auricle; *V*, ventricle; *AD*, descending aorta; *L*, lung; *S*, stomach; *P*, pancreas.

cases of arrested development the human heart in the adult may show any of its embryological forms, as, for instance, an open foramen ovale.

Figs. 224 and 225 show the interior of two stages of early human hearts, taken from models made by His. In Fig. 224, the auricle is quite enlarged and the vein enters on the right side. The ventricle is considerably smaller and its walls are much thicker than those of the auricle. This is usually the case with the hearts of embryos, as they die with the ventricles contracted and the auricles filled with blood. Between the two there is a narrowed auriculo-ventricular canal and with a corresponding constriction on the outside of the heart. Fig. 225 shows a more advanced stage. The general state of the heart is much as it is in the Fig. 224, only that the auricles are "shoved" into the ventricle. This is of considerable importance, as we shall later on see. In both cases the aorta arises from the right side of the ventricle, and in its further development one-half of it must be transferred to the left side in order to produce the aorta proper, while the half which remains becomes the pulmonary artery.

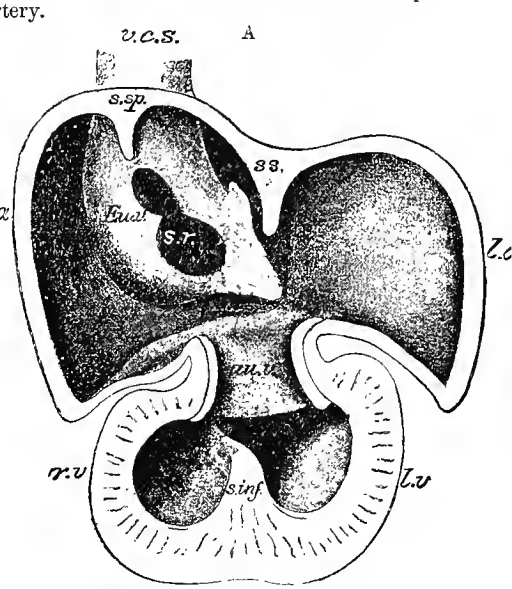

FIG. 224.

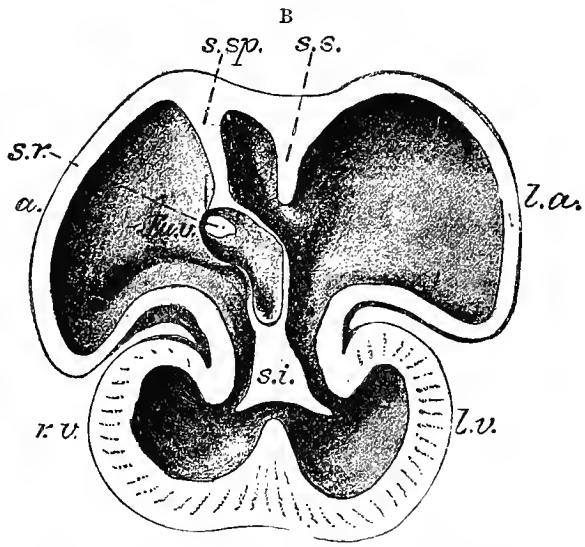

FIG. 225.

FIGS. 224 and 225.—Two Stages in the Formation of the Septum Intermedium in the Heart of the Human Embryo. (From Quain, after His.)
In *A* the septum is represented as growing from a triangular area to the left of the sino-auricular orifice; in *B* it has coalesced with the endocardial cushions, and lies like a stopper in the auricular canal.
r.a. and *l.a.*, right and left auricle; *r.v.* and *l.v.*, right and left ventricle; *s.r.*, sinus reuniens; *Eu.v.*, Eustachian valve: *s.sp.*, septum spurium; *s.s.*, septum superior; *s.inf.*, septum inferior; *s.i.*, septum intermedium; *v.c.s.*, vena cava superior dextra.

The first important change in the separation of the heart into its two lobes is the formation of two septa, one arising in the auricle, *S.s.*, which grows backward, and one in the ventricle, *S.inf.*, which grows forward. At the same time that these are growing toward each other, a cushion of connective tissue, *s.i.*, is formed upon the two lips of the slit-like auriculo-ventricular opening

which aids to complete the septum of the heart. This cushion, or septum intermedium, soon separates the auriculo-ventricular opening into two canals, the right and the left, to become the right and left auriculo-ventricular canals, respectively.

The septum of the auricle is completed by the septum superior growing backward to unite with the septum intermedium. Before this takes place, however, several changes take place in the septum (Figs. 226, 227, and 228).

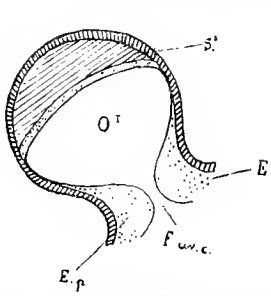

FIG. 226.

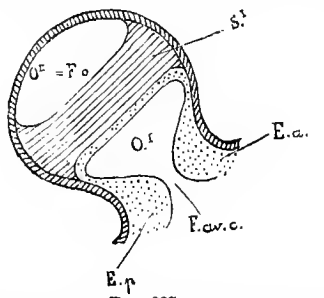

FIG. 227.

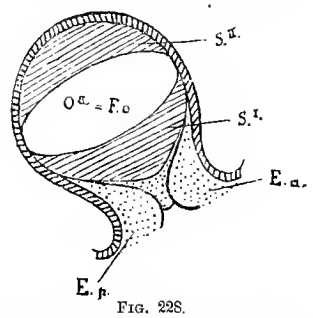

FIG. 228.

FIGS. 226, 227, and 228.—Side views of three stages, to show the formation of the foramen ovale. (After Born.) *S'*, first portion of the superior septum; *S''*, second portion of the superior septum; *O'*, first foramen ovale; *O''*, secondary opening or true foramen ovale; *E.p.*, endothelial cushion in the auriculo-ventricular opening.

These figures represent three stages of a lateral view of the two septa above named, with the opening between them. In Fig. 226, the septum superior is forming, but the *S.* intermedium is not yet complete. It was at first thought that the opening between them, *O'*, produced the foramen ovale, but later observations by Born showed that there is a secondary rupture in the septum superior which is destined to become the true foramen ovale (Fig. 227, *O''*). The portion of the septum superior which has been cut off by the formation of the foramen ovale, unites with the septum intermedium as shown in Fig. 227. The secondary septum, *S''*, later on forms the limbus of Vieussens, and the first, *S'*, the valve of the foramen ovale.

A partial septum of the heart is first met with in certain classes of ganoid fishes (Dipnoi), where it arises by a union of muscle-columns in the auricle. This is a very incomplete septum, which is gradually increased in the amphibia. In neither of these cases has the septum reached the auriculo-ventricular opening. This gives us the former it is multiple, and in the latter, as a rule, single. It is therefore seen that the formation of a secondary or true foramen ovale, as described by Born, is confirmed by the comparative anatomical evidence (see Born, *Arch. f. mik. Anat.*, Bd. 33, and Röse, *Morph. Jahrbuch*, Bd. 15 and 16).

The opening of the vein is guarded by two folds of the walls of the heart, which really form a complete bicuspid valve (Fig. 225). An additional fold extends to this from in front, the septum spurium, *S.sp.* Later on, the orifice enlarges to incorporate a portion of the veins into the auricle, but the right lip of the opening remains permanently as the Eustachian valve. The pulmonary veins are formed later. They grow from the lungs to the left auricle.

Returning to a stage of heart as represented in Fig. 225, we notice that the common ventricle shows a constriction on the outside which corresponds to a septum forming on the inside. As this septum from the inside, the septum inferius, grows toward the S. intermedium, it must also grow toward the aorta to join a septum aorticum which is forming there. Figs. 229–231, show how this is brought about. Fig. 229 represents a stage in which the auricles empty wholly on the left side and the aorta arises wholly on the right. As the inferior septum arises the auriculo-ventricular opening moves, as it were, toward the aorta; and when the septum inf. unites with the S. intermedium it cuts the auriculo-ventricular opening in such a manner, that the blood coming from the

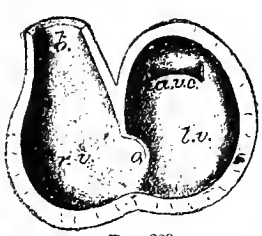

FIG. 229.

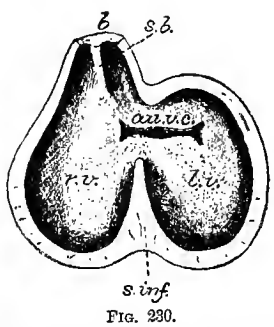

FIG. 230.

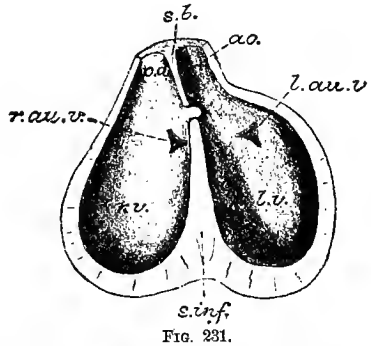

FIG. 231.

FIGS. 229, 230, and 231.—Diagrams to Show the Formation of the Septum of the Ventricles and Bulb, and the Mode of Division of the Common Auriculo-ventricular Aperture. (From Quain, after Born.) *r.v.* and *l.v.*, right and left ventricles; *s.inf.*, inferior septum; *b.*, bulb of aorta; *s.b.*, septum bulbi; *au.vc.*, auriculo-ventricular canal; *ao.*, aorta; *p.a.*, pulmonary artery.

an auricle partly divided, both compartments communicating with each other, and through a common opening with a single ventricle, much as is shown in the heart of the human embryo pictured in Fig. 224. In the reptiles the septum is complete, and we have two distinct auricles communicating independently with the ventricle. We can view this as the completion of the second stage, *i.e.*, a complete union of the septum superior and the septum intermedium. In birds and mammals, however, there is a secondary rupture of the septum of the auricle; in right auricle passes to the right ventricle, and the blood from the left auricle to the left ventricle. A small opening exists for quite a while between the two ventricles, but, later on, this is closed by a membrane of connective tissue. Before the ventricles are completely separated from each other, a view of the septum appears much as is shown in Fig. 232. The aorta is already completely separated into two vessels: the one which communicates with the right ventricle, communicating above with the fifth aortic arch, and the one from the left with the

fourth. The fourth is destined to become the aorta, and the fifth the ductus arteriosus from which the pulmonary artery arises.

At an early stage the tissue of the ventricle walls becomes spongy on the inside. These meshes and columns play a very important part in the formation of the valves,

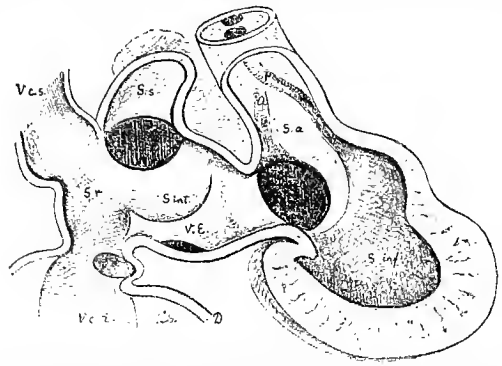

FIG. 232.—Opened Heart of a Human Embryo Seen in Profile. × 33 times. (After His.) *p.*, pulmonary artery; *a.*, aorta; *S.a.*, septum aorticum; *S.inf.*, septum inferior; *S.s.*, septum superior; *S.int.*, septum intermedium; *v.e.*, Eustachian valve; *S.r.*, sinus reuniens; *V.c.i.*, vena cava inferior; *Lb.*, liver; *D.*, diaphragm.

musele-columns, and the tendons to the valves. We have seen that the septum intermedium is formed in the auriculo-ventricular canal and divides it into a right and a left half. When this is complete a section of the heart gives a picture as shown in Fig. 233. At the same time

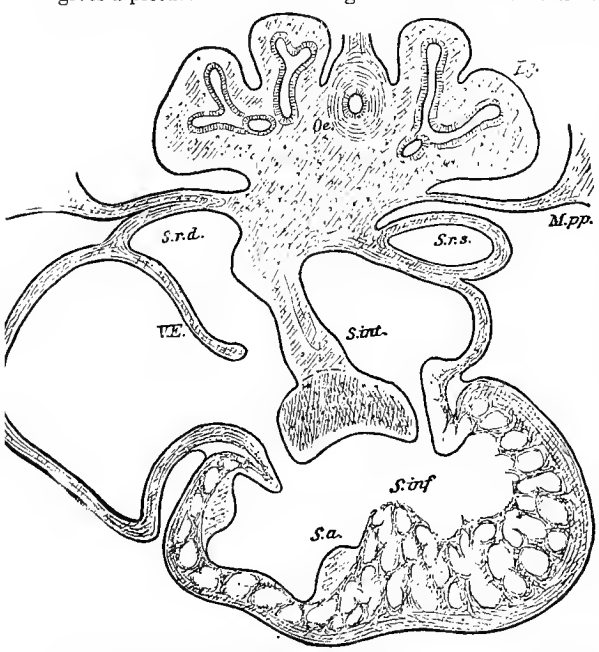

FIG. 233.—Section through the Heart of a Human Embryo to Show the Formation of the Columnæ Carneæ. × 36 times. (After His.) *Oe.*, œsophagus; *Lg.*, lung; *M.pp.*, membrana pleuro-pericardiaca; *S.r.d.* and *S.r.s.*, right and left horns of the sinus reuniens; *V.E.*, Eustachian valve; *S.int.*, septum intermedium; *S.inf.*, septum inferior; *S.a.*, septum aorticum.

a portion of the auricle is, as it were, pushed into the ventricle, as the figure shows. This invagination takes with it a portion of the epicardium, to be incorporated in the formation of the valve. Connective tissue is incorporated in the formation of the valve at its beginning, although the great bulk of the valve is at this time composed of muscular fibres. The burrowing of the ventricle walls includes also the valves, and in this way, as the figure indicates, the primitive chordæ tendineæ are formed. Soon, however, the bands lose their muscle-fibres, in the portions which form the chordæ, and in other portions, farther away from the valve, the muscle-fibres increase to form the papillary muscle. The valves have therefore a double origin: (1) Peripheral, and (2) from the septum intermedium. According to His, the tendons attached to the valves arising from the periphery, have their permanent attachment to the valve from the beginning, while a portion of those passing to the valve and arising from the septum intermedium may possibly shift their valvular attachment.

The muscle-walls of the two ventricles are at first of the same thickness, but later on that of the left becomes heavier than that of the right. The spongy layer in the ventricle is covered with endocardium, and from this layer the columnæ carneæ arise.

Distinct muscle-tissue is not present until the heart is quite well formed, although it begins to beat long before this. The nerves grow into the heart from the spinal ganglia, at a much later period, as shown by Onody and by W. His, Jr. *Franklin P. Mall.*

HEREDITY. The progress of our knowledge in pathology and etiology constrains me to curtail the boundary of hereditary diseases since the former article under the above title was written. I am now satisfied that leprosy should be dropped from the list, and that heredity figures little in tuberculosis. Bacteriology has made good its claim on both diseases, and both are found to be transmissible in direct ratio with facilities for communication in the recognized habit of contagious maladies. The bacilli of the two diseases are strikingly similar, both morphologically and in tardiness of growth and multiplication.

Leprosy is never congenital and is never developed until months, and sometimes years, after contagion has had time to do its work. It is most prevalent among people whose habits of life bring them into closest social relations, and segregation of those affected is the most effectual mode of checking its spread. There is even less difficulty in tracing the probable or possible source of contagion than exists in the case of searlatina and measles, though it is vastly less communicable.

Congenital tuberculosis has been found in a very few instances within the last five years, and congenital pneumonia has been reported in at least one instance. The bacillus tuberculosis is sometimes found in the blood, associated with diffused miliary tuberculosis as causative of the latter. It is conceivable that a woman affected with this form of the malady might communicate it to her unborn child through the placenta; but it is not in accordance with the accepted etiology and known progress of tuberculosis, to presume that its bacilli, taken into the blood of a fœtus, may remain latent, with or without reproduction, and the usual local effects be postponed for many years. It is quite reasonable that the opportunities for infection afforded by the close social relations of kindred dwelling together have been mistaken for heredity in this disease, as in leprosy. On the other hand, we have the experiment of Sanchez-Toledo, of Paris, who has injected pure cultures of Koch's bacillus tuberculosis into the jugular vein of pregnant guinea-pigs, but failed to find the bacilli in the blood or organs of the progeny, though the mothers became tuberculous.

Uncured syphilis in either parent at time of procreation, or during gestation in the mother, is quite apt to be transmitted to the fœtus, but may be controlled by active treatment of the mother before parturition. Thorough eradication of the syphilitic virus by prolonged treatment terminates its transmissibility.

As to gout, rheumatism, goître tending to cretinism, scrofula, cancer, and the various neuroses, heredity figures as a predisposing factor in some obscure way. In the case of tuberculosis, predisposition probably means unusual susceptibility to the admission or action of the bacilli; perhaps extraordinary delicacy of epithelium in the respiratory or intestinal tract, which may be inherited. We might even suppose a duplex inherited predisposition to syphilis, consisting in a delicate epithelium associated

with a propensity for promiscuous sexual indulgence. Whether such conjunction be most apt to occur in the sanguine temperament, is a point for investigation by the numerical method. *S. S. Herrick.*

HEREDITY IN THE OVUM AND SPERMATOZOÖN.[1]

The purpose of this article is to give a summary of recent researches upon the structure and relations of the male and female germ-cells in connection with the phenomena of reproduction and heredity.

Much progress has been made of late years in the knowledge of the stages through which the ovum and spermatozoon pass before and after union, and in the abnormal effects produced by experimental, chemical, and mechanical disturbances. The latter bear directly upon teratology. Speculation and investigation upon heredity have kept pace with embryological research, and at the present time the marvellous transformation of an infinitesimal speck of protoplasm (the fertilized ovum) into the adult body with its hereditary structure and tendencies, is under the focus of researches in the following branches of biological science:

A. DEVELOPMENT OF THE RACE.—*Heredity.*—1. *Speculative*, including theories of *Pangenesis* and *Continuity of Germ-plasm*, Darwin, Weismann, etc.

2. *Anthropological*, including data from human anatomy and anthropology, teratology, etc.

3. *Comparative*, including data from the evolution of lower types of animals (palæontology).

4. *Experimental* (or experimental evolution), including influences upon offspring of experiments upon the structure, function, or environment of parents. Systematic researches in this line have just begun.

B. DEVELOPMENT OF THE INDIVIDUAL.—*Embryology.* 5. *Normal*, including the phenomena of ovogenesis and spermatogenesis, fertilization, histogenesis, intercellular action, as derived from study of lower types of animals and plants.

6. *Experimental*, the diversion of normal phenomena by mechanical, chemical, and thermal experiments upon different stages of development.

It will be seen that the two objects of investigation are

The Body-cells, or Soma, = the expression of Heredity.

The Germ-cells = the potential vehicles of Heredity.

The many problems resolve themselves into the simple questions:

How do the parent germ-cells transform into the offspring body, and how does the latter influence the new germ-cells, or, what are the total relations between the body-cells and germ-cells?

A. DEVELOPMENT OF THE RACE.—1. *Speculative Heredity.*—In a valuable summary of the past theories of heredity [2] J. A. Thomson distinguishes three general problems, which are often confused. 1st. What characters distinguish the germ-cells from other cells of the body? 2d. How do the germ-cells derive these distinguishing characters? 3d. How shall we interpret "particulate" inheritance, or the reappearance of single peculiarities in the offspring?

The various theories may be grouped under two heads, "Pangenesis of Germ-cells" and "Continuity of Germ-cells," according to the dominating idea in each.

a. Pangenesis.—The idea pervading pangenesis was first expressed by Democritus that the "seed" of animals was derived by contributions of material particles from all parts of the bodies of both sexes, and that like parts produced like. Two thousand years later, Buffon revived this conception of heredity in his "molecules organiques." In 1864 Herbert Spencer suggested the existence of "physiological units," derived from the body-cells of the parent, forming the germ-cells and then developing into the body-cells of the offspring. This theory is designed to explain how changes in the body-cells of the parent can be transmitted to the offspring. ("Use-inheritance, or "inheritance of acquired characters").

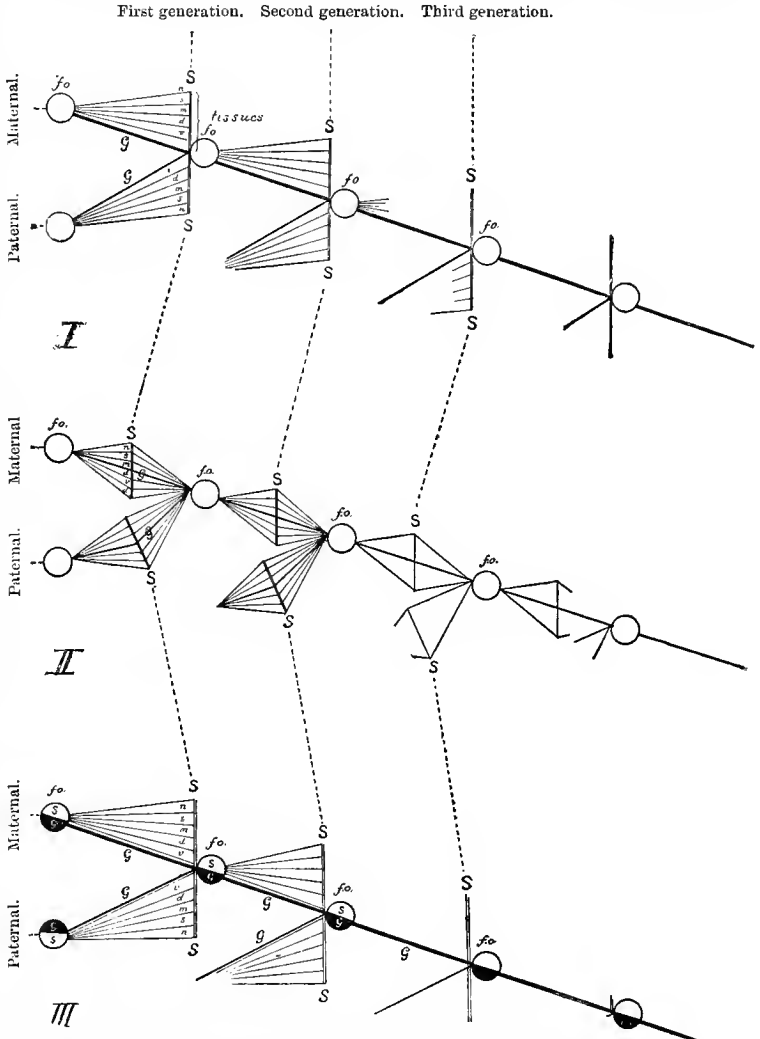

FIG. 234.—Illustrating, I. Normal Histogenesis; II. Theory of Pangenesis; III. Theory of Continuity of Germ-plasm. The fertilized ovum (*f.o.*) contains the maternal and paternal characteristics. This expands into the adult body, or Soma (*S*), composed of *somatic cells* (*n*, *s*, *m*, *d*, *r*) constituting the nervous, secretory, muscular, digestive, and other tissues, besides the *germ-cells* (*G*) of the reproductive organs. I. Histogenesis.—Showing the successive rise, *G*, and union, *f.o.*, of the maternal and paternal germ-cells by direct histogenesis. II. Pangenesis.—Showing the tissues of the body *S*, contributing to the germ-cells *G*, so that each *f.o.* is composed of elements (gemmules) from both the somatic and germ-cells. III. Continuity of the Germ-plasm.—Showing the division of the embryo, *f.o.*, into somatoplasm, *s* (from which arise the body-cells), and germ-plasm, *G* (which passes direct to the germ-cells), establishing a direct continuity.

It is interesting to note the course of Darwin's thought upon this matter in his published works and in his "Life and Letters." He was at first strongly opposed to the views advanced by Buffon, by Erasmus Darwin, and ex-

panded by Lamarck, that changes in the parents are transmitted to offspring, as the main cause of evolution. But gradually becoming convinced that his own theory of natural selection could not account for all the facts of evolution, he unconsciously became a strong advocate of Lamarck's theory and contributed to it a feature which Lamarck had entirely omitted, namely, a theory of heredity expressly designed to explain the transmission of aequired characters. Darwin's "provisional hypothesis of pangenesis"[3] postulated a material connection between the body-cells and germ-cells by the circulation of minute buds from each cell; each body-cell throws off a "gemmule" containing its characteristics; these gemmules multiply and become especially concentrated in the germ-cells; in the latter they unite with others like themselves; in course of development they grow into cells like those from which they were originally given off (see Fig. 234).

Galton,[4] who has always been doubtful in regard to use-inheritance, while advancing a theory of "continuity," partly approved Darwin's pangenesis idea in the cautious statement: "Each cell may throw off a few germs that find their way into the circulation and thereby have a chance of entering the germ-cells." At the same time Galton contributed very important experimental disproof of the existence of "gemmules," and, in fact, of the popular idea of the circulation of hereditary characters in the blood, by a series of carefnl experiments upon the transfusion of blood in rabbits; he found that transfused blood did not convey with it even the slightest tendency to transfer normal characteristics from one variety of rabbit to another.

Professor Brooks,[5] of the Johns Hopkins University, then contributed an original modification of pangenesis in which the functions of the ova and spermatozoa were sharply differentiated. (1) He regarded the ovum as a cell especially designed as a storehouse of hereditary characteristics, each characteristic being represented by material particles of some kind; thus hereditary characters were handed down by simple cell division, each fertilized ovum giving rise to the body-cells in which its hereditary characters were manifested, and to new ova in which these characters were conserved for the next generation (this portion of Brooks's theory is very similar to Galton's and Weismann's). (2) The body-cells have the power of throwing off "gemmules," but this is exercised mainly or exclusively when its normal functions are disturbed, as in metatrophic exercise or under change of environment. (3) These gemmules may enter the ovum, but the spermatozoön is their main centre. According to this view the female cell is rather conservative and the male cell progressive; the union of these cells produces variability in the offspring, exhibited especially in regions of the offspring corresponding to the regions of functional disturbance in the parent. This hypothesis was well considered, and while that feature of it which distinguishes the male and female germ-cells as different in kind has been disproved, and the whole conception of gemmules is now abandoned, the fact still remains that we shall nevertheless be obliged to offer some hypothesis to explain the facts disregarded by Weismann for which Brooks provides in his theory of the causes of variation.

b. Continuity of Germ-cells.—The central idea here is an outgrowth of our more moderu knowledge of embryogenesis and histogenesis, and is, therefore, comparatively recent; it is that of a fundamental distinction between the "germ-cells," as continuous and belonging to the race, and the "body-cells," as belonging to the individual. Weismann has refined and elaborated this idea, bnt it was not original with him.

Richard Owen,[6] in 1849, Haeckel,[7] in 1866, Rauber,[8] in 1879, in turn, dwelt upon the distinction which Dr. Jaeger, now of manufacturing fame, first clearly stated:

"Through a great series of generations the germinal protoplasm retains its specific properties, dividing in every reproduction into an ontogenetic portion, ont of which the individual is built up, and a phylogenetic portion, which is reserved to form the reproductive material of the mature offspring. This reservation of the phylogenetic material I described as the continuity of the germ protoplasm. . . . Encapsuled in the ontogenetic material the phylogenetic protoplasm is sheltered from external influences, and retains its specific and embryonic characters." The latter idea has, under Weismann, been expanded into the theory of isolation of the germ-cells.

Galton introduced the term "stirp" to express the sum total of hereditary organic units contained in the fertilized ovnm. His conception of heredity was derived from the study of man, and he supported the idea of continuity in the germ-cells in order to account for the law of transmission of "latent" characters; it is evident from this law that only a part of the organic units of the "stirp" become "patent" in the individual body; some are retained latent in the germ-cells, and become patent only in the next or some succeeding generation. For example, the genius for natural science was "patent" in Erasmus Darwin, grandfather of the great naturalist, it was "latent" in his son, and reappeared intensified in his grandson, Charles Darwin.

Weismann has carried the hypothesis of continuity to its extreme in his simple and beautiful theory of heredity, which is fonnded upon the postulate *that there is a distinct form of protoplasm, with definite chemical and molecular properties, set apart as the vehicle of inheritance; this is the germ-plasm, G, quite separate from the protoplasm of the body-cells or somatoplasm, S.* Congenital characters arise in the germ-cells and are therefore *blastogenetic*, while acqnired characters arise in the body-cells and may be called *somatogenetic*.

To clearly understand Weismann's hypothesis, let us follow his history of the fertilized ovum in the formation of the embryo. It first divides into *somatoplasm* and *germ-plasm* (see Figure 234, III.); the somatoplasm supplies all the tissues of the body—*n*, *s*, *m*, *d*, *v*, nervous, muscular, vascular, digestive, etc.—with their quota of hereditary structure: the germ-plasm is kept distinct, throughout this early process of embryonic cell-division, until it enters into the formation of the nuclei of the new reproductive cells, the ova or spermatozoa of the next generation. Here it is isolated from the changes of function in the somatoplasm, and in common with all other protoplasm is capable of unlimited growth by cell-division without loss or deterioration of its past store of hereditary properties; these properties are lodged in the nucleus of each ovum and spermatozoön, and these two cells, although widely different in external accessory structure (because they have to play an active and passive part in the act of conjugation), are exactly the same in their essential molecular structure, and the ancestral characters they convey differ only because they come along two different lines of descent. When these cells unite they carry the germ-plasm into the body of another individual. Thus, while the somatoplasm of each individual dies, the germ-plasm is immortal and simply shifts its abode from one generation to another; it constitutes the chain from which the individuals are mere offshoots. Thus the germ-plasm of man is continuous with that of all ancestors in his line of descent, and we have an explanation of the early stages observed in development in which the human embryo passes through a succession of metamorphoses resembling the adult forms of lower types of animals (Von Baer's law).

In order to emphasize, as it were, the passage of the germ-plasm from one generation to another without deterioration in its marvellous hereditary powers, Weismann added the idea of its *physiological isolation*. Not only does he repudiate the pangenesis notion of increment of germ-plasm by addition of gemmules, but he believes that it is unaffected by any of the normal changes in the somatic or body-cells. As this continuity and isolation would render impossible the transmission of characters acquired by the somatoplasm, Weismann began to examine the evidence for such transmission, and coming to the conclusion that it was insufficient, in his notable essay on "Heredity," in 1883, he boldly attacked the whole Lamarckian theory, and has continued to do so in all his subsequent essays.

Being forced to explain evolution without this factor, he claimed that variation in the germ-plasm was constantly arising by the union of plasmata from different lines of ancestral descent which occurs in fertilization, and that these variations are constantly being acted upon by Natural Selection to produce new types. He thus revived Darwin's earlier views of evolution, and this in part explains his strong support by English naturalists.

Weismann admits the general principle of *ovum sanum in corpore sano*, but denies that any local specific disorders or changes in the parent body *which are not congenital* (*i.e.*, in the parental germ-plasm) ever result in similar specific localized disorders or changes in the offspring body. The mutilation of a parent will not reappear in the loss or abnormal development of the same structure in the child. The effects of use and disuse are not inherited. In these opinions of Weismann, Kölliker, His, Pflüger, Ziegler, and other eminent anatomists and physiologists concur.

Speculative Heredity has not yet produced a satisfactory theory of hereditary transmission. Weismann's "germ-plasm," as a distinct substance, is disproved by recent embryology—there is no such continuous and specific form of protoplasm confined to certain cells. (See Histogenesis.)

We conclude this section by a brief statement of what is required in a complete working theory of heredity. The matter of first importance in life is *the repetition and preservation of type*, the principle which insures the unerring accuracy and precision with which complex organs are built up from the germ-cells; the force of regression and the more remote forces of reversion all work in this conservative direction.

The matter of second importance, but equally vital to the preservation of races, in the long run, is *the formation of new types* adapted to new circumstances of life.

In the following table are placed some of the facts of human evolution, and as they are part of inheritance, they also constitute the main external phenomena of heredity

PHENOMENA OF HEREDITY.

Conservative (toward past type).	*Neutral.*	*Progressive* (toward future type).
a. Repetition of parental type.	Fortuitous and	*a.* Definite Variation in single characters, by accumulation =:
b. Regression (in many characters) to contemporary race type.	Indefinite	*b.* Definite Variation in many characters (from contemporary race type).
c. Reversion (mainly in single characters) to past race type.	Variability.	

2 and 3. *Anthropological and Comparative Heredity.*—The bearing of these branches of study upon heredity is as follows: Is there any proof that definite changes in the body, whether due to physiological and anatomical effects of certain trades or occupations, or to accidents, or to pathological changes, produce corresponding changes in the ova and spermatozoa, so as to reappear in offspring. The supposed influences of certain occupations has, for example, been discussed by Arbuthnot Lane, in a series of papers in the *Journal of Anatomy and Physiology*; he maintains the theory of inheritance of functionally produced modifications.

If such inheritance does take place there must be some interchange of material (as implied by *Pangenesis*) or of forces between the parent body and the reproductive cells.

a. Physiological Data.—There are three phenomena about which there is much scepticism, to say the least, which bear upon the question of *a possible interchange of forces between the body and the germ-cells.* These are the inheritance of mutilations, the influence of previous fertilization, and the influence of maternal impressions. They are all in the quasi-scientific realm, which embraces such mental phenomena as telepathy. That is, we incline to deny them simply because we cannot explain them.

a. Mutilations.—Since the publication of Weismann's essays the subject of inherited mutilations has attracted renewed interest. I would first call attention to the fact that this matter has only an indirect bearing, for a mutilation is something impressed upon the organism from without; it is not truly "acquired;" the loss of a part by accident produces a sudden but a less profound internal modification of the organism than the loss of a part by degeneration. Most of the results are negative; many of the so-called "certain" cases prove upon investigation to be mere coincidences. Weismann[9] himself experimented upon white mice, and showed that nine hundred and one young were produced by five generations of artifically mutilated parents, and yet there was not a single example of a rudimentary tail or of any other abnormality in this organ. The cases of cleft ear-lobule have recently been summed up.[10] Israel reports two cases of clefts in which the parents' ears were normal. Schmidt and Ornstein report affirmative cases. His shows that an affirmative case, cited by V. Zwiecki, is merely an inherited peculiarity. The entire evidence is unsatisfactory, and, upon the whole, is decidedly negative.

Not so, however, in cases where the mutilation results in a general disturbance of the normal functions of different organs, as in the experiments conducted by Brown-Séquard[11] upon guinea-pigs, in which we see "acquired variation" intensified. In these, abnormal degeneration of the toes, muscular atrophy of the thigh, epilepsy, exophthalmia, etc., appeared in the descendants of animals in which the spinal cord or sciatic nerve had been severed, or portions of the brain removed. It was also shown that the female is more apt to transmit morbid states than the male; that the inheritance of these injuries may pass over one generation and reappear in the second; that the transmission by heredity of these pathological results may continue for five or six generations, when the normal structure of the organ reappears. These cases, which are incontestable, at first sight appear to establish firmly the transmission of acquired characters; they were so regarded by Brown-Séquard. These lesions act directly upon the organs, and the abnormal growth in these organs appears to be transmitted. But can they not be interpreted in another way, namely, that the pathological condition of the nerve-centres has induced a direct disturbance in those portions of the germ-cells which represent and will develop into the corresponding organs of the future offspring?

b. Previous Fertilization.—Consider next the influence exerted upon the female germ-cell by the mere proximity of the male germ-cell, as exhibited in the transmission of the characteristics of one sire to the offspring of a succeeding sire, observed in animals, including the human species, also in plants. The best example is the oft-quoted case of Lord Morton's mare, which reproduced in the foal of a pure Arab sire the zebra markings of a previous quagga sire.

Some physiologists have attempted to account for these remarkable indirect results from previous fertilization or impregnation, by the imagination of the mother having been strongly affected, or from interchange between the freely inter-communicating circulation of the embryo and mother, but the analogy from the action in plants (in which there is no gestation but early detachment and development of the fertilized cells) strongly supports the belief that the proximity of male germ-cells acts directly upon the female cells in the ovary. All that we can deduce from these facts is that in some manner the normal characteristics and tendencies of the ova are modified by the foreign male germ-cells without either contact or fertilization.

c. Maternal Impression.—The influence of maternal impressions in the causation of definite anomalies in the fœtus is largely a matter of individual opinion.

It is denied by some high authorities, led by Bergmann and Leuckart. Many medical practitioners, however, believe in it, and I need hardly add that it is a very general popular belief, supported by numerous cases. The bearing which this mooted problem has upon the discussion is this: if a deviation in the development of a child is produced by maternal impression, we have a proof that deviation from normal hereditary tendencies can be pro-

duced without either direct vascular or nervous continuity.

We see that there exists an analogy between the experiments of Brown-Séquard and Obersteiner, the influence of the previous sire and the influence of maternal impressions. These three classes of phenomena all tend to show that the hereditary forces which normally reproduce organs in their typical and perfect form may be checked or diverted by other forces which exert a profound abnormal influence upon the body, chiefly through the nervous system. This diversion of the normal direction of heredity, in the opinion of the writer, compels us to assume that there is some functional and structural connection between the body-cells and the germ-cells, the nature of which is at present wholly unknown. Our ignorance as to the nature of this connection between the body-cells and germ-cells does not compel us to deny that it exists. To discover this link is now one of the chief ends of biology.

β. *Morphological Data.*—We must keep in mind that the body-cells (somatoplasm) and germ-cells (germ-plasm) were originally one, as in all single-celled organisms like the amœba. In course of evolution the separation of these two kinds of cells proceeded gradually, and *comparative heredity* shows that the power of reproduction may not be confined to the germ-cells but may extend in a feebler degree into the body-cells as well.

a. The *separation of the germ-cells* is in the regular order of evolution upon the principles of physiological division of labor. The unicellular organisms combine all the functions of life in a single mass of protoplasm, that is, in one cell. In the rise of the multicellular organisms the various functions are distributed into groups of cells, which specialize in the perfecting of a single function. Thus the reproductive cells should fall into the natural order of histogenesis, and the theory of their entire separation is more consistent with the laws governing the other tissues than the theory which we find ourselves obliged to adopt, that while separate they are still united by some unknown threads with the other cells. (Fig. 234, *I.*)

The structural separation of what we may call the race-protoplasm becomes more and more sharply defined in the ascending scale of organisms. Weismann's contention as to the absolutely distinct specific nature of the germ-plasm and somatoplasm has, however, to meet the apparently insuperable difficulty that in many multicellular organisms, even of a high order, the potential capacity of repeating complex hereditary characters, and even of producing perfect germ-cells, is widely distributed through the tissues.

For example, cuttings from the leaves of the well-known hot-house plant, *Begonia*, or portions of the stems of the common willow-tree, are capable of reproducing complete new individuals. This would indicate either that portions of the germ-plasm are distributed through the tissues of these organisms, or that each body-cell has retained its potential quota of hereditary characters. Among the lower animals we find the same power; if we cut a hydra or bell-animalcule into a dozen pieces, each may reproduce a perfect new individual. As we ascend in the animal scale the power is confined to the reproduction of a lost part in the process known as recrescence. As we well know, in the group to which the frog and salamander belong, a limb or tail, or even a lower jaw, may be reproduced. The only logical interpretation of these phenomena is, that the hereditary powers are distributed in the entire protoplasm of the organism, and the capacity of reproduction is not exhausted in the original formation of the limb, but is capable of being repeated.

There has been considerable discussion of late as to the seat of this power of *recrescence*. It seems not impossible that, in the vertebrates, it may be stored in the germ-cells, and it would be very interesting to ascertain experimentally whether removal of these cells would in any way limit or affect this power; we know that such removal in castration or ovariotomy sometimes profoundly modifies the entire nature of the organism, causing male characters to appear in the female, and female characters to develop in the male.

So far as man is concerned it has been claimed by surgeons that genuine recrescence sometimes occurs; for example, that a new head is formed upon the femur after exsection; Dr. V. P. Gibney informs the writer that this is an exaggeration, that there is no tendency to reproduce a true head, but that a pseudo-head is formed, which may be explained upon the principle of regeneration and individual transformism by use of the limb.

Pflüger's opinion is that recrescence does not indicate a storage of hereditary power, that there is no pre-existing germ of the member, but that the re-growth is due to the organizing and distributing power of the cells at the exposed surface, so that, as new formative matter arrives, it is built up gradually into the limb. This view would reduce recrescence to the level of the *regeneration* process which unites two cut sections of the elements of a limb in their former order. It is partly opposed to the facts above referred to, which seem to prove the distribution of the hereditary power. Yet it seems quite consistent to consider these three processes—*a*, reproduction of a new individual from every part; *b*, recrescence of a new member from any part; *c*, regeneration of lost tissues—as three steps indicating *the gradual, but not entire withdrawal of the reproductive power from the body-cells into the germ-cells.*

Among the reasons for believing in the complete separation of the germ-cells in man are the following: The very early differentiation of these cells in the embryo, observed with a few exceptions in all the lower orders of animals, and advancing so rapidly in the human female that several months before birth the number of primordial ova is estimated at seventy thousand, and is not believed to be increased after the age of two and a half years. The most patent practical proof is that we may remove every portion of the body which is not essential to life and yet the power of complete reproduction of a new individual from the germ-cells is unimpaired. Among the many reasons advanced for pensioning the crippled soldiers of our late war we never hear it urged that their children are incapacitated by inheritance of injuries. The strongest proof, however, rests in the evidence which may be cited from heredity of the extraordinary stability of the germ-cells which is the safeguard of the race.

b. The *specific nature of the germ-plasm* must be considered before we consider its relations. Wherein lies the conservative power of the germ-plasm, and in what direction shall we look for its transforming forces? You see at once that marvellous as is the growth of cells in other tissues, the growth of the germ-cell is still more so.

We find it utterly impossible to form any conception of the contents of the microcosmic nucleus of the human fertilized ovum, which is less than $\frac{1}{25}\frac{1}{0}\frac{1}{0}$ of an inch in diameter, but which is, nevertheless, capable of producing hundreds of thousands of cells like itself, as well as all the unlike cells of the adult organism. We can only translate our ideas as to the possible contents of this nucleus in the terms of chemistry and physics.[1]

According to the general law the germ-cell is considered as matter potentially alive and having within itself the tendency to assume a definite living form in course of individual development. The nucleus must be extraordinarily complex, for it contains within itself not only the tendencies of the present type, but of past types far distant. The supposition of a vast number of germs of structure is required by the phenomena of heredity: Nägeli has demonstrated that even in so minute a space as $\frac{1}{1}\frac{1}{0}\frac{1}{0}\frac{1}{0}$ cub. millimetre, 400,000,000 micellæ must be present.

Speculation has also been active in this field. Spencer[2] assumed an order of molecules or units of protoplasm lower in degree than the visible cell-units, to the internal or polar forces of which, and their modification by external agencies and interaction, he ascribed the ultimate responsibility in reproduction, heredity, and adaptation. This idea of biological units seems to the writer an essential part of any theory; it is embodied in Darwin's "gemmules," in Haeckel's "plastidules," yet, as Lankes-

ter says, the rapid accumulation of bulk is a theoretical difficulty in the material conception of units. In the direction of establishing some analogy between the repetition power of heredity and other better-known functions of protoplasm, Haeckel and Hering have likened heredity to memory, and advanced the hypothesis of persistence of certain undulatory movements; the undulations being susceptible of change and therefore of producing variability, while their tendency to persist in their established harmony is the basis of heredity. Bertbold, Gautier, and Geddes[13] have speculated in the elaboration of the idea of metabolism; the former holding the view that "inheritance is possible only upon the basis of the fundamental fact that in the chemical processes of the organism the same substances and mixtures of substances are reproduced in quantity and quality with regular periodicity."

We have merely touched upon these speculations to show that the unknown factors in heredity are also the unknown factors in operation in living matter. All we can study is the external form, and conjecture that this form represents matter arranged in a certain way by forces peculiar to the organism. These forces are exhibited or patent in the somatic cells; they are potential or latent in the germ-cells.

4. *Experimental Heredity.*—We must refer here again to the experiments of Brown-Séquard and of Obersteiner upon guinea-pigs, and to work which is now being instituted in France, and to some extent in England and Germany. This promises to be a most fruitful field of research by which the truth or falsity of Weismann's theory of heredity will be finally established.

Experimental evolution or heredity seeks to determine chiefly whether modifications produced in the parent, or a series of parents, are transmitted to offspring. To test the supposed inheritance of mutilations, Weismann has cut the tails off nine successive generations of mice without producing the slightest diminution of the tail in later generations. It will be possible to test the problem of maternal impressions, and the firmly established belief of breeders, that an ill-bred sire injures all the subsequent offspring of well-bred sires. Thus far no absolutely satisfactory results of this kind of experimental work have been recorded.

B. The Development of the Individual. — 5. *Normal Embryology.*—The structure and physiology of the germ-cells will ultimately yield the *physical* basis of the science of heredity. After all, the data which may be gathered from the four branches of heredity above considered are only indirect, the direct data must come from embryology. In the actual material and dynamics of the germ-cells and their relation to body dynamics we look for the physical basis of the following phenomena: *a*, Repetition of parental characters; *b*, variations from parental characters; *c*, reversion to ancestral characters; *d*, prepotency of one sex over the other; *e*, causes of determination of sex; *f*, causes of anomalies, monstrosities, abnormal births, multiple births. Some of these latter phenomena (*e*, *f*,) occur in course of development of the embryo; others can be traced directly back to the germ-cells in their earliest stages.

The Sexes.—We have naturally come to look upon the two sexes as fundamentally distinct. As regards heredity and our present study, they are fundamentally similar. Unlike as the male and female, the ovum and spermatozoon, are in external appearance, all the material and mechanism of inheritance is exactly the same in each. Sex is a secondary distinction, both in evolution and in the development of the individual.

The causes finally determining sex may come surprisingly late in development, and, according to the investigations of Düsing, and the experiments of Yung and of Giron,[15] are directly related to nutrition. High feeding favors an increase of the percentage of females, while, conversely, low feeding increases the males. In Yung's experiments with tadpoles the following results were obtained:

	Females.	Males.
Normal percentage	57	43
High nutrition	92	8

Geddes expresses this principle in physiological terms of metabolism, that anabolic (constructive) conditions produce females, while katabolic (destructive) conditions produce males.

I think we may now safely eliminate the factor of sex from our calculations upon the problem of heredity, and thus rid ourselves of one of the oldest and most widespread fallacies. We shall thus, in using the terms "paternal" and "maternal," imply merely the distinction between the qualities of two lines of ancestral descent.

Asexual Conjugation. — Let us, therefore, first consider Reproduction (Conjugation and Development) in those lower single-celled organisms in which there is no sex—such as the *Amœba*, or the somewhat higher types of Ciliated Infusoria. Of the forms described below, *Stylonichia* is an animalcule varying in diameter from one-eleventh to one-third millimetre; it is free, swimming in stagnant water, or it sometimes creeps on the surface of plants. *Glaucoma* is also found in ponds, and swims by means of five cilia upon its ventral surface.

Maupas on Conjugation among the Infusoria.[14]—Among the newer researches which throw light upon this old problem, those of Maupas are certainly the most brilliant. After a most exact and arduous research, extending over several years, he collected his results in two memoirs, published in 1889 and 1890.

His experiments were first directed upon the laws of direct multiplication by fission, or *direct division of the cell.* These revealed a complete cycle of life without conjugation in the single-celled Infusoria, and showed that after a long period this mode of reproduction becomes less vigorous, then declines, and finally ceases altogether unless the stock is rejuvenated by union with individuals of different broods, or *conjugation.* In other words, these broods of minute organisms grow old and die unless they are enabled to fertilize each other by an exchange of hereditary substance altogether analogous to that observed in the higher multicellular organisms.

The cultures were made in a drop of water upon a slide, and feeding was adapted either to the herbivorous or carnivorous habits of the species. Under these conditions it was found that the rate of fission, or direct reproduction by division, varied directly with the temperature and food, rising in some species (*Glaucoma scintillans*) to five bipartitions daily. With the optimum of conditions this rate, if sustained for thirty-eight days, would produce from a single individual a mass of protoplasm equivalent to the volume of the sun. This rate was, however, found to be steady for a time, and then the offspring decline into "senescence," in which they appear at times only one-fourth the original size, with reduced organs and degenerate nuclear apparatus. This is reached sooner in some species than in others; *Stylonichia pustulata* survives three hundred and sixteen generations by fission, while *Leucophrys patula* persists to six hundred and sixty generations. Finally, even under the most favorable conditions of environment, death ensues.

Death does not ensue where conjugation is facilitated by mingling the offspring of different broods in the same fluid, as in the natural state. Maupas soon discovered that exhaustion of food would hasten conjugation between members of mixed broods. He thus could watch every feature of the conjugation process, and determine all the phases in the cycle of life. These differed, as in the longevity of the species. In *Stylonichia*, for example, "immaturity" extended over the first one hundred bipartitions; "puberty," or the earliest phase favorable to conjugation, set in with the one hundred and thirtieth bipartition; "eugamy," or the most favorable conjugation phase, extended to the one hundred and seventieth; then "senescence" set in, characterized by a sexual hyperæsthesia in which conjugation was void of result or rejuvenescence, owing apparently to the destruction of the essential nuclear apparatus.

Conjugation begins with the approach of two individuals, and adhesion by their oral surfaces. There is no fusion, but an immediate transformation in the cell contents of each individual sets in, concluding with an interchange of nuclear substance. In each cell Maupas

distinguishes between the (*M*) *meganucleus* (Fig. 235; the macronucleus, nucleus, endoplast of authors), which presides over nutrition and growth, and divides by constriction, and the (*m*) *micronucleus* (paranucleus, nucleolus of authors), which presides over the preservation of the species. The latter contains chromatin; it is the seat of rejuvenescence, the basis of heredity, it divides by mitosis, showing all the typical stages of karyokinesis excepting the loss of the cell membrane.

The transformation in each of these copulating cells first affects the centres of hereditary substance, viz., the micronuclei; they divide three times; thus the micronuclear substance is reduced to one-fourth of its original bulk. It is contained in two surviving micronuclei (the others being absorbed or eliminated), one of which migrates into the adjoining cell; the other remains stationary. This migration is followed by a fusion of the migrant and stationary micronuclei; this fusion effects a complete interchange of hereditary substance, after which

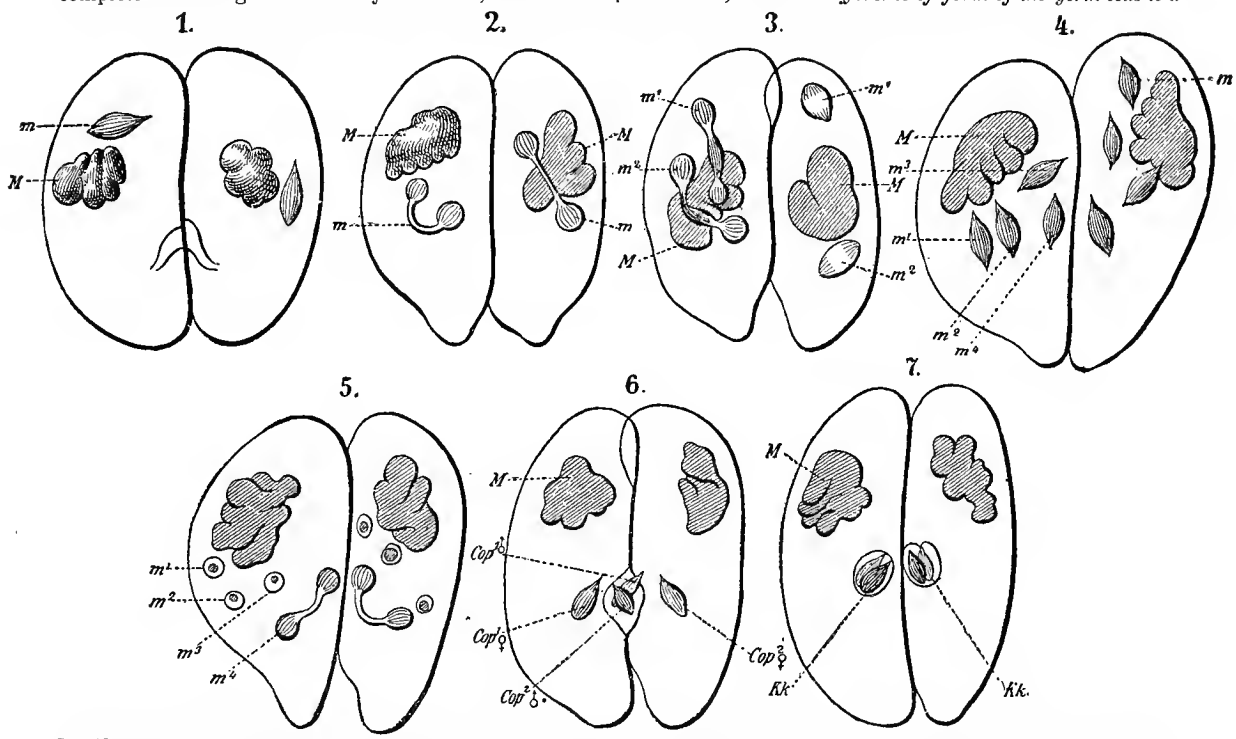

FIG. 235.—The Conjugation of Infusoria. (From Weismann, after Maupas.) 1, Two infusoria copulating; *M*, meganucleus; *m*, micronucleus; 2–5, successive divisions of micronuclei; 6, fertilization by the migration of one of the persisting micronuclei from each infusorian into the other; 7, union of the interchanged micronuclei.

the two infusoria separate and enter upon a new life cycle. Meanwhile the meganucleus breaks up and is reconstituted in each fertilized cell.

Maupas gathers from these interesting phenomena additional proof that the chromatin of all cells bears the inherited characteristics, and that the cytoplasm and nucleoplasm, or achromatin, is the dynamic agent, because the micronuclei bearing the chromatin * are the only structures which are permanent and persistent, all the other structures — nucleoplasm, cytoplasm, etc. — being replaced and renewed. The reduction of the chromatin is purely quantitative, the eliminated and fertilizing micronuclei being exactly equivalent; after the chromatin has been quartered the cell becomes incapable of further activity until it is reinforced by chromatin from the other copulating cell.

No Distinction between the Sexes in Heredity.—The three laws which underlie these phenomena are: 1. That fertilization consists in the union of the hereditary substance of two individuals. 2. That before union the hereditary substance in each is greatly reduced. 3. That there is no real line between male and female, the conjugating cells are simply in a similar physiological condition wherein a mingling of hereditary characteristics affords a new lease of life. As Maupas says:

"Les différences appelées sexuelles portent sur des faits et des phénomènes purement accessoires de la fécondation. La fécondation consiste uniquement dans la réunion et la copulation de deux noyaux semblables et équivalents, mais provenus de deux cellules distinctes."

In this conclusion as to the secondary and superficial, rather than fundamental, difference between the two sexes, Maupas simply confirms the views of Strassburger the botanist, Hensen, R. and O. Hertwig, Weismann, and others, namely, *that sex has evolved from the necessity of cell conjugation; that even in the higher forms the cells born by the two sexes are absolutely neutral so far as sex is concerned; the wide difference of form of the germ-cells is a result of physiological division of labor*—the mass and yolk of the *ovum* having been differentiated to support the early stages of development, while the *spermatozoon* has dispensed with all these accessories and acquired an active vibratile form for its function of reaching and penetrating the ovum. The evidence of the Infusoria is paralleled among some of the plants, in which conjugation between entirely similar cells is observed.

Sexual Conjugation.—As noted above, in higher types of animals in which the sexes are different, the ovum and spermatozoon differ widely in external form; this is because the ovum is a food-carrier and is passive while the spermatozoon is active, and, so far as we know, merely a carrier of hereditary substance. The ovum is sometimes found a million times larger than the spermatozoon, but the materials concerned in heredity in each are now believed to be exactly equal.

The various processes through which these two cells pass before and after conjugation are technically known as:

1. Ovogenesis and Spermatogenesis-Reduction of Here-

* For the meaning of these terms see the following section.

ditary Substance: Preparation of male (sperm) and female (ovum) cell for conjugation.

2. Fertilization-Union of Hereditary Substance: Union of certain elements in male and female cells into a new single cell. Or union of maternal and paternal hereditary elements.

3. Embryonic Development-Distribution of Hereditary

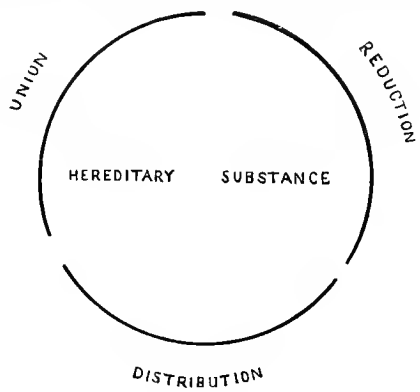

FIG. 236.

Substance: Division of the fertilized ovum (oösperm) into the cells of the tissues.

This is a complete cycle of changes, for among the embryonic cells from the oösperm soon appear the germ-cells in which we observe a fresh ovogenesis or spermatogenesis. Now what elements enter into these changes? The older topography of the ovum as a typical cell is very well known; there is first the (*a*) *cell-wall*, and within this the cell-protoplasm or (*b*) *cytoplasm*. In the centre of the cell is the (*c*) *nucleus*, containing its protoplasm or (*d*) *nucleoplasm*. Flemming was the first to show that suspended in the nucleoplasm is a special highly staining form of protoplasm which he called (*e*) *chromatin*, and still more recently it has been found that on one side of the nucleus, in the cytoplasm, are suspended one or two small special centres or (*f*) *centrosomes*.

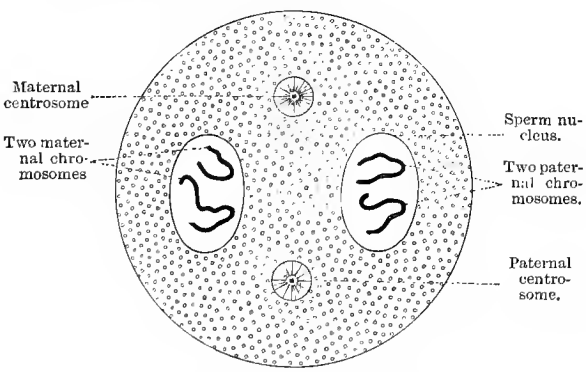

FIG. 237.—Oösperm prior to Union of Maternal and Paternal Elements.

The *chromatin* presents the appearance of a fine network in the interior of the nucleus when the cell is quiescent, but when the cell is dividing it is drawn out into a number of fine compact threads or *chromosomes* (Waldeyer), as shown in the accompanying figures. An equal quantity of chromatin is found in the ovum nucleus and sperm nucleus, and this is now believed to be the *material basis of heredity*. The chromosomes are concerned in all cell life, and are considered qualitative.

The *centrosomes* are specific bodies lying in the cytoplasm outside of the nucleus, and moving to its opposite poles only during division. As proved in "polyspermy," these bodies are also found in both ovum and sperm-cells; they are now believed to represent the *active dynamic and regulative material* of the cell. The centrosome is apparently the active agent in every cell division throughout life.

We may begin at any point in the cycle of development. In order to understand most clearly the respective

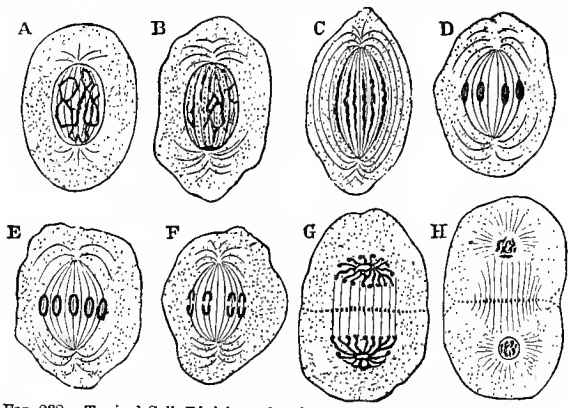

FIG. 238.—Typical Cell Division, showing the Distribution of Chromatin. (From Parker, after Carnoy.) A–C, arrangement of the chromatin; D–E, formation of the chromosome rods and loops; F, splitting of the loops; G–H, retraction of the chromatin into the two daughter-cells.

functions of the *chromatin* and *centrosomes* let us first consider embryonic development and observe the mechanism by which the chromatin is evenly distributed to every cell of the body.

a. Distribution of Hereditary Substance.—The starting-point of distribution is the oösperm (fertilized ovum). This contains chromatin and centrosome elements from each parent, as shown in the accompanying figure. The chromatin is contained in four chromosomes (the number characteristic of the species); two of these chromosomes come from the sperm-cell and two from the ovum-cell. These chromosomes are kept separate in the first stages, and then united in one coil, Fig. 239. The centrosomes

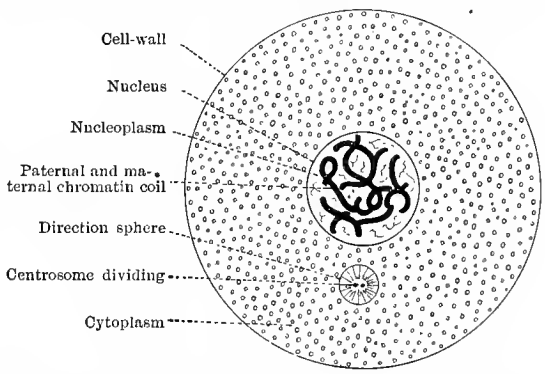

FIG. 239.—First Stage after Union of Maternal and Paternal Elements.

are believed to unite and combine maternal and paternal elements from the start.

The phenomena of karyokinesis which attend the division and distribution of this hereditary substance throughout the whole course of embryonic and adult development are well illustrated in Carnoy's figures (Fig. 238). First we have the quieseent period, in which the chromatin presents the appearance of a coiled, tangled thread; surrounding this is the clear nucleoplasm (or achromatin) bounded by the nuclear membrane; the extra-nuclear substance, or cytoplasm, is apparently undifferentiated. As soon as cell division sets in, however, radiating lines are seen in the cytoplasm above and below the nucleus, these are called the centrosomic filaments, since they pro-

ceed from the two centrosomes (Fig. 240). As the activity becomes more intense the filaments are seen to diverge from a centre—the plasmic *centrosome*—which lies just without the nucleus at either pole; this radial display of

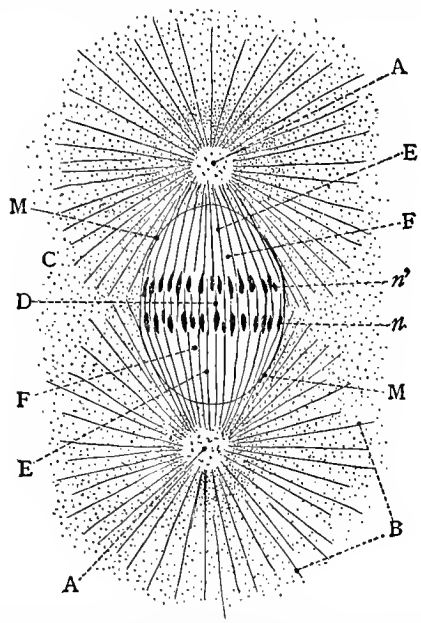

FIG. 240.—The Central Portion of a Tissue-cell during Division. Differentiation of the Cytoplasm and Nucleus of a Squid Embryo, Loligo. (After Watase.) M, the nuclear membrane; F, achromatin or nucleoplasm; C, cytoplasm or protoplasm outside of the nucleus; A–A, the two centrosomes; B, extra nuclear centrosome filaments; E, intranuclear centrosome filaments attached to *n*, *n'*, the chromatin rods.

cell-forces suggested the term "asters" to Fol, and "spheres attractive" to Van Beneden; they may here be called *direction spheres*. The behavior of the chromatin, or hereditary substance, under these forces, is

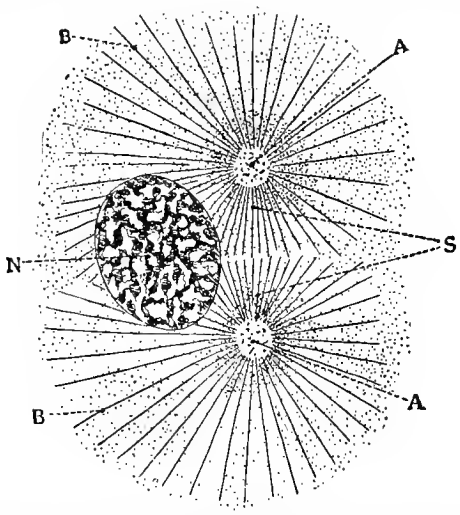

FIG. 241.—After Division. Interior of a Daughter-cell in the Squid. (After Watase.) Division has just taken place and the daughter-nucleus, N, shows the chromatin coil. The daughter centrosome is just forming two new centrosomes, A–A, by direct division.

shown in Carnoy's diagrams (Fig. 238). First, the nuclear wall breaks up, then the chromatin coil unfolds into lines of vertical striation which become thread-like (hence the term mitosis), and then more compact, until finally a number of distinct vertical rods, chromatin rods, or *chromosomes*, are formed.

A remarkable and significant fact may be noted here, that *the number of chromosomes* varies in the cells of different species, and even in the cells of different varieties (as in the thread-worm of the horse—*Ascaris megalocephala*), *but in each variety the same number is constant in all the cells of each individual through all stages*; thus the same number of chromosomes appears in the first segmentation of the fertilized ovum as in all the subsequent cell division in the tissues.

Carnoy next indicates the vertical splitting of each rod into a loop or link preceding the horizontal splitting; thus we may conceive of a thorough redistribution of the chromatin before it passes into the daughter-cells. The split loops are each retracted toward a centrosome, suggesting to some authors a contractile power in the centrosomic filaments; each chromasome being apparently withdrawn by a single filament. The chromatin is again retracted into two coiled threads, each the centre of the daughter-nucleus with a single centrosome beside it. But when the line of cleavage is drawn between the two cells (Fig. 238), the single centrosome in each cell divides so that each daughter-cell is now complete with its chromatin coil and two centrosomes. This process has been well figured by Watase[1] (Figs. 240 and 241).

It thus appears that both the chromatin and centrosome are permanent elements of the cell, such as we formerly considered the nucleus; the apparently passive chromatin is divided with great precision by the active centrosomes, then the centrosomes simply split in two to resume their cleavage function. Each chromosome and each centrosome is separate—these two elements are apparently passed down distinct from generation to generation.

The theoretical meaning of this distribution process will now be discussed. The whole process can be very clearly followed in Figs. 237, 239, 240, 241, 242, 243.

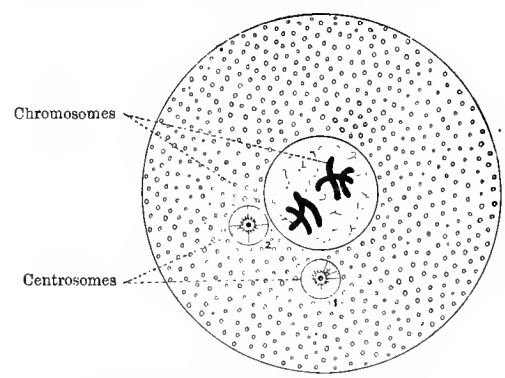

FIG. 242.—Second Stage. Division of Centrosome.

The Nature of the Hereditary Substance in each Body-cell.—There still remains to be considered the relation of the hereditary substance to the future development of the individual. There is some reason to believe that each cell of the body contains not only the characters of the special tissue to which it belongs, but other characters. There is first the astonishing fact that, as the chromatin goes on dividing, its mass or volume remains apparently undiminished. That is, there is apparently as much chromatin in one of the many million active cells of the body as in the original fertilized ovum, and we face still the enigma as to the nature of this chromatin and its functions.

1st. In plants De Vries[16] and others believe that all or by far the greater number of cells in the plant body contain the total hereditary characters of the species in a latent condition. Kölliker[17] has fully discussed this question and called attention to Müller's early views that, in spite of the physiological division of labor producing the tissues, the properties of all the tissues can be derived

from the nuclear substance of a single tissue, as proved by experiments upon the lower animals. According to this idea there is only a *quantitative* distribution, the chromatin increases in bulk, and each tissue only calls forth certain of its powers. Weismann, on the other hand, has held that the course of development is marked by a constant *qualitative* distribution of his germ-plasm or hereditary substance, so that each tissue finally contains only the hereditary substance which belongs to it and the total hereditary substance or germ-plasm goes only to the new ova and spermatozoa. Kölliker opposes this idea and maintains that the hereditary substance, or "idioplasm," passes into all cells, in which it divides in course of development; step by step, from the embryonic layers to the tissues, the constructive processes are under the direction of the nuclei containing this hereditary substance; it remains in every nucleus for a long period unaltered, in order to finally, here earlier, there later, impress its peculiar constructive forces. In certain elements, as in blood-corpuscles, epidermal scales, etc., it disappears, as the last product of division.

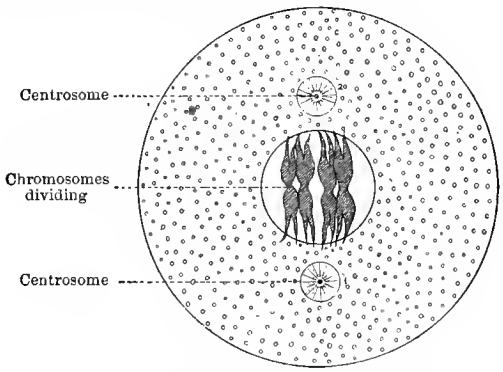

FIG. 243.—Third Stage. Division of Chromosome.

Hertwig takes a similar view; since embryonic and adult cell division is differential there must be a form of differentiation in the nucleus, but this does not consist in the total elimination of some qualities and survival of others, nor of a reduction in mass. The mass and the properties remain the same in every cell, the differentiation consists in the activity of certain elements in certain tissues. The potential of the nuclear substance is differently exerted at different points. Here, again, we have the idea of patent and latent hereditary elements, such as appear in the entire individual upon a larger scale.

In the following paragraph Hertwig expressed his view of nuclear control and cytoplasmic differentiation:

"As I saw in the transformation of the nucleus during fertilization proof that it is the bearer of hereditary substance I recognized a great advance in the fact that the nucleus leaves in the same form in every cell, and in its vesicular capsule is somewhat removed from the metamorphoses of the cells. As Nägeli spread his idioplasm as a net-work throughout the whole body, so, according to my theory, every body-cell contained in its nucleus its quota of hereditary substance, while its specific histological peculiarities were to be regarded as its plasma-products."

2d. The next question *is the fate of the maternal and paternal contributions to the embryo:* are they fused or do they lie side by side? Here there is a wide difference of opinion.

We have seen that in the oösperm (Fig. 237) the maternal and paternal chromosomes are entirely separate, but as soon as this cell divides into two, the maternal and paternal chromatin forms an intimate net-work. On the one side Van Beneden is the leader of those who regard each cell of the body as in a sense hermaphrodite; as we have seen, his views of maturation and the significance of the exclusion of the polar bodies were colored by this theory, for he regarded the germ-cells as hermaphrodite until one sex was eliminated. But now that the researches of Hertwig have given the last blow to Van Beneden's theory, and it follows that there can be no sexual difference in chromosomes, there remains room for the analogous view that the maternal and paternal chromosomes remain distinct throughout the course of development, not as sexual elements but as substances with different hereditary tendencies. Rabl, an eminent embryologist, shares this view, and it is supported by Boveri upon the observation that in each division the paternal and maternal elements are kept distinct, and in *Ascaris*, for example, two of the chromosomes of each division figure are paternal and two are maternal. In favor of this hypothesis we may place the following facts: 1st, That there are an even number of chromosome rods in all cells; 2d, that the number is constant throughout all the subsequent changes in the tissues; 3d, that the number is fixed for each species or variety; 4th, that the number is the same in each sex.

Against this *non-fusion* hypothesis we must consider

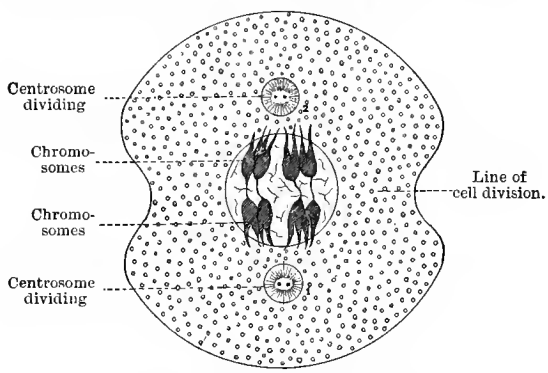

FIG. 244.—Fourth Stage. Division of Cell-wall.

the extreme complexity of the division process, and the long-intermediate resting, or thread stage, in which the chromatin lies in a confused coil. Hertwig advocates a *fusion* hypothesis and argues that if the elements are distinct we should find some evidence that the maternal or paternal part is atrophied or replaced, or excluded from the nucleus, for both parts cannot share alike in the control of the cell. Such are his grounds for supporting the "Versehmelsungstheorie," or *fusion* theory, also advocated by Waldeyer, to the effect that by the complete union of the maternal and paternal substance a new product is formed; in this fusion the law of prepotency may come into play, causing one or other of the parental tendencies to predominate, or there may be an even redistribution, whereby, as expressed by Hensen, "the hereditary substance of the son is not that of the father plus that of the mother, but is his own, with a new hereditary form resulting from the combination."

While suspending judgment between these two views as to the fusion or non-fusion of the hereditary substances, we may appeal to the external phenomena of heredity for light upon the probabilities in the question. First, we have the very decided opinion of Francis Galton in regard to particulate inheritance; he is so impressed with the fact that we are made up bit by bit of separate structures derived from different ancestors that he has even suggested that the skin of the mulatto may represent not a fusion of white and black but an excessively fine mosaic in which the colors are so distributed as to give the appearance of blending. We do sometimes observe patches of color as evidence of uneven distribution. As Galton distinguishes two types of structures with reference to inheritance, viz., those which blend and those which do not blend, we might correlate these types with prepotency, replacement, and fusion. Where characteristics do not blend, as in eye-color, it is evident that, while the offspring must receive from both

parents the material basis for the formation of the complete color of the eye, either the maternal or paternal material must be prepotent and exclude the development of the other; the logical inference is that the former actively replaces the latter; but it is not necessary that exclusion from the cell-chromatin should follow. Now, while some blends seem to support the theory of fusion, the sum total of facts of heredity are strongly against this as a universal principle, for many maternal and paternal structures are preserved in their absolute integrity for generations without the least indication of mixture.

b. Reduction of Hereditary Substance.—By the above "distribution" the chromatin is constantly increasing in quantity, because an equal amount passes into every cell of the body. The embryonic sperm and ovum cells receive their share, it follows that originally each has the chromatin complement of a complete cell; part of this must be gotten rid of, otherwise the oösperm will represent not one cell but two cells. It has long been known that the ovum is prepared or "matured" for the reception of the spermatozoon by the extrusion of two small "polar bodies," containing both chromatin and hyaline protoplasm, and separating off by karyokinetic division. From this it appears that before fertilization the original amount of chromatin is reduced in quantity. For twenty-five years speculation has been rife as to why the ovum should extrude a portion of its substance in two small cells. Why not in one cell? why not in a larger number? Thanks to the intense curiosity which these polar bodies have aroused, and to the great variety of explanations which have been offered for them, we have arrived to-day at a solution which links the higher animals with the lower, breaks down the supposed barrier between the sexes, and accords with the main external facts of heredity.

It seems best to disregard the order of discovery, and to state the facts in the most direct way. First, a few words as to the speculations upon the meaning of the polar bodies.

The early theories of the meaning of sexual congregation or fertilization[1] were naturally based upon the apparent significance of this process in the human species, in which the sexes are sharply distinguished from each other in their entire structure, and the reproductive cells are also widely differentiated in form, the ovum large and passive, the spermatozoon small and active. It was most natural to regard these elements as representing distinct physiological principles, corresponding to the essential sexual characteristics—in short, as male and female cells, the former vitalizing and rejuvenating the latter. Thus one of the earliest definite "polar-body" theories was that the embryonic ovum was hermaphrodite, and contained both male and female principles, and that it was necessary to get rid of the male substance before the spermatozoon could enter.

As Von Siebold and Leuckart had demonstrated that some ova reproduce parthenogenetically, that is, without fertilization by spermatozoa, Weismann turned to such forms for the solution of this problem, and was surprised to find that parthenogenetic ova only extrude one polar body; this led him to attach one meaning to the first polar body, and another meaning to the second, which he viewed as designed to reduce the hereditary substance in the ovum without regard to sex. Thus both this and the older theory conveyed alike the idea of *reduction*, but with an entirely different supposition as to the nature of the material reduced or eliminated.

The Modern Theory of Reduction.—Van Beneden's discovery that these bodies contained chromatin led gradually to the view that they were not fragments of the ova, but represented minute, morphologically complete, cells. Bütschli showed that they were given off independently of, and prior to, the contact of the spermatozoon, and, finding in the leeches that the first polar body subdivides to form two bodies, he considered them as formed by true cell division, and containing both nucleoplasm and chromatin. Giard independently reached a similar opinion, assigning an atavistic meaning to the polar cells. Whitman, in 1878, advanced the idea that they represented vestiges of the primitive mode of reproduction by fission, while Mark described them as "abortive ova."

At this point speculation subsided until it was revived by Weismann's attempt to connect these bodies with his theory of heredity,[19] already referred to. The whole history is clearly given in R. Hertwig's masterly memoir upon Ovo-and Spermatogenesis in the Nematodes.[20] Taking advantage of Boveri's discoveries in staining technique, and stimulated by Weismann's prediction that spermatozoa would also be found to extrude polar bodies,

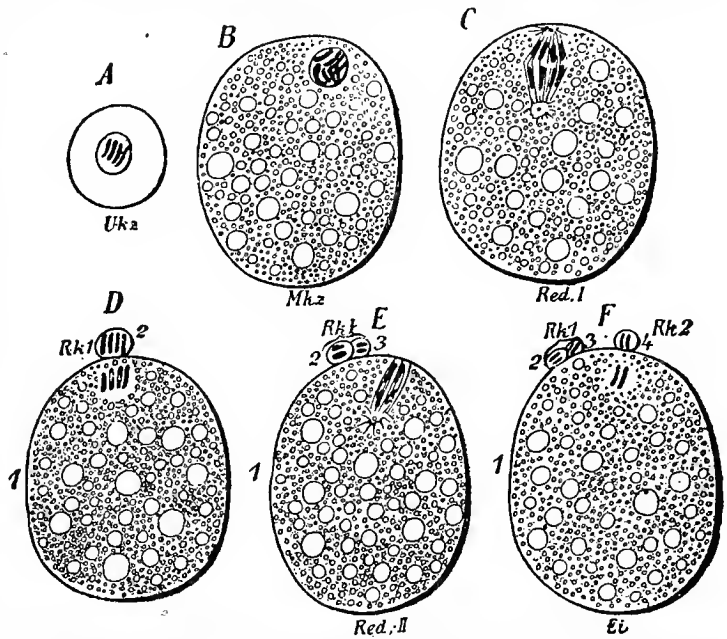

FIG. 245.—The Maturation of Ova, or Formation of Polar Bodies in Ascaris. (From Weismann, after Hertwig.) *A*, original germ-cell in embryonic germ-layer—4 chromatin rods; *B*, ovum mother-cell—8 rods; *C–D*, first polar body extruded; *E*, splitting of first polar body—ovum still contains 4 rods; *F*, second polar body extruded—ovum mature with 2 rods.

this author examined all stages in the peculiarly favorable germ-cells of the thread-worm of the horse (*Ascaris megalocephala*).

He made the surprising discovery that ova and spermatozoa are formed in a substantially similar manner by repeated divisions, the single difference being that the last products of division among the sperm-cells are effective spermatozoa, capable of development in fertilization, while the last products of division in the ovary are, first, the true ova, and second, the abortive ova (polar cells) incapable of development. In both ova and spermatozoa, when ready for union, the nucleus contains but one-half the chromatin which a typical nucleus contains; in the case of *A. megalocephala* (see Fig. 245) each of the germ-cells contains but two chromosomes, while the normal body-cells contain four. The manner in which this maturation of the germ-cells for conjugation is brought about is beautifully shown in these diagrams, taken from Weismann's essay, "Amphimixis." We observe that the number of chromosomes in the primary germ-cells is four (Figs. 245 and 246, *A*). Then are formed by subdivision the ovum and sperm "mother-cells," in which the chromatin substance is doubled, so

that we observe eight chromosomes. The mother-cells then divide and the chromatin is reduced to four rods ; a second division rapidly follows, whereby the chromatin is reduced to two rods, or half the original quantity. These last divisions take place by karyokinesis, but, as Hertwig points out, they differ from typical karyokinesis in the fact that the divisions follow so rapidly upon each other that the vesicular resting-period of the nucelus is omitted. Thus, he suggests, is prevented an over-accumulation of chromatin substance prior to the fusion of the ovum and sperm.

It is evident that the polar-cells are rudimentary ova, which do not possess the yolk-mass, etc., essential to development, and are divided off at a very late stage, sometimes after the egg has left the ovary, but are in other respects analogous to the spermatozoa. The reason why these polar-cells have not disappeared altogether in either plants or animals is that they originally possessed a deep physiological importance. As the first polar-cell subdivides and forms two, it follows that from both ovum and sperm mother-cells four daughter-cells are formed, each containing half the chromatin substance of a normal nucleus. In the ovary three of these daughter-cells abort and the fourth forms a true ovum ; in the sperm-gland, however, all four daughter-cells form spermatozoa.

We may thus consider the polar-cell problem as in all

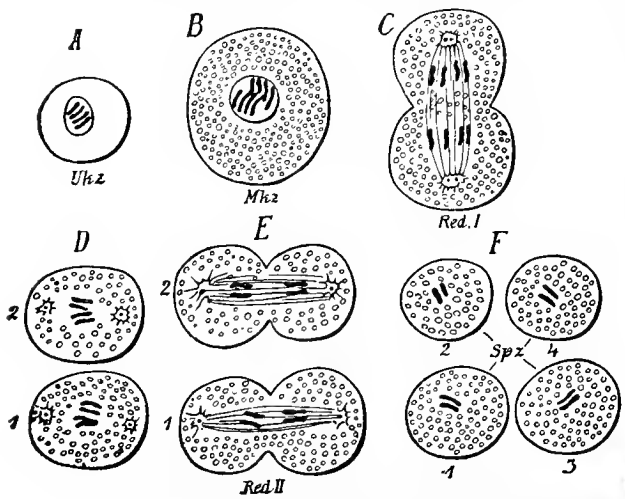

FIG. 246.—Spermatogenesis in Ascaris. (From Weismann, after Hertwig.) *A*, original germ-cell—4 chromatin rods ; *B*, sperm mother-cell—8 rods ; *C-D*, first daughter-cells, with 4 rods each ; *E-F*, formation of second daughter-cells, or mature spermatozoa, with 2 rods each.

probability settled ; the whole process is probably an inheritance or survival of a primitive condition in which all four ova, like all four spermatozoa, were fully functional.

The Relation Between the Reduction of the Chromatin Substance and Heredity.—We have just seen that the last stages in the preparation of the ova and spermatozoa for conjugation result in halving the number of rods in the original germ-cells. Now, as Hertwig and Weismann point out, one point is still left in doubt. Why is the chromatin substance doubled in the mother-cells so that two successive subdivisions are necessary to reduce it to half the original quantity ? Hertwig has not attempted to answer this question, as he prefers to wait for further research. Weismann, however, who is unfortunately cut off from research by failing eyesight, has offered a speculative solution to this problem which he trusts may guide future investigation.

This leads to a few words in regard to his conception of the relation of the chromatin to heredity. 1. His first premise is that in fertilization there is not a fusion of chromatin, but that a certain independence is preserved between the maternal and paternal elements, based upon the observed fact that the two pairs of rods do not fuse, but lie side by side, and upon the assumption that these pairs are kept distinct in each cell through all the subsequent stages of embryonic and adult development. If this is the case, the hereditary substance contributed by the father would remain separate from that contributed by the mother, throughout. 2. "Each of these pairs would be made up of the collective predispositions which are indispensable for the building up of an individual, but each possesses an individual character, for they are not entirely alike. I have called such units 'ancestral plasms,' and I conceive that they are contained in numbers in the chromatin of the mature germ-cells of living organisms, also that the older nuclear rods are made up of a certain number of these. . . . Obviously these units cannot become infinitely minute ; however small they may be they must always retain a certain size. This follows from the extremely complicated structure which we must without any doubt ascribe to them." These units are not, however, ultimate, they are in turn extremely complex, and are composed of countless biological units of the kind conceived of by Nägeli and others. 3. The reduction of the chromatin only acquires a meaning when taken in connection with the above supposition of distinct ancestral plasms, and has no meaning if we accept Hertwig's view that there is a complete fusion of maternal and paternal germ-plasm. This meaning is that reduction in the maturation of germ-cells is *sui generis*, it does not divide the ancestral plasms into two similar groups, but one daughter-cell receives one set of germ-plasms or hereditary predispositions, and another daughter-cell receives another ; reduction is thus differential. According to this view the four sperm and ovum daughter-cells would each contain a different set of ancestral plasms. 4. The fact that the chromatin substance is doubled in the sperm and ovum mother-cells, so that we observe double the number of rods characteristic of the species, is to be explained as an adaptation to the requirements of natural selection, for this doubling and subsequent double division render possible an infinite number of combinations (as many, in fact, as there are individuals) for Selection to operate upon.

This explanation of Weismann's is an example of his apotheosis of the theory of natural selection. Every process is made to suit this theory, which, as we have seen in the section on Speculative Heredity, is, in his opinion, the exclusive factor of evolution. But this very high degree of mingling and remingling of ancestral predispositions would be fatal to evolution, for after a combination favorable to survival had been established in one generation it would be broken up into a new combination, perhaps unfavorable to survival, in the next generation. His entire essay upon "Amphimixis," or the theory of mingling of reduced hereditary substance, marks a turning-point to decline in Weismann's influence as a biologist. His whole reasoning is now in a circle around the natural-selection theory.

C. *Union of Hereditary Substance—The Meaning of Conjugation.*—Weismann looks upon sexual reproduction as designed to mingle hereditary tendencies and to create individual differences whereby natural selection may form new species. It is evident that such combinations must be mainly fortuitous and productive of indefinite variations.

The fact, however, that variability and evolution by the accumulation of certain variations in successive generations is also observed in organisms which reproduce asexually, both among plants and animals, shows that we must look in another direction for the underlying cause or purpose of sexual reproduction. Weismann rightly combats the old idea of *vitalization* of the ovum by the spermatozoon, and it is perfectly evident from the researches of Maupas and Hertwig that the ovum may as accurately be said to vitalize the spermatozoon as the reverse. Conjugation is simply the approximation of two hereditary substances of distinct origin and their incorporation into a single cell destined to give rise to a new individual. The action and reaction of

these substances may be considered equal and mutual, so far as we now know.

The remarkably ingenious experiments of Hertwig and Boveri, above alluded to, strengthen this idea. Some years ago Weismann wrote: "If it were possible to introduce the female pronucleus of an egg into another egg of the same species, immediately after the transformation of the nucleus of the latter into the female pronucleus, it is very probable that the two nuclei would conjugate just as if a fertilizing sperm-nucleus had penetrated. If this were so, the direct proof that egg-nucleus and sperm-nucleus are identical would be furnished." Boveri succeeded in accomplishing a similar feat by shaking an ovum and thus depriving it of its nucleus and subsequently admitting *a spermatozoon which fertilized the denucleated ovum and produced a complete individual!*

Weismann goes further, and maintains that there is nothing in the nature of vitalization or "rejuvenescence" in conjugation—that, given proper environment, protoplasm is immortal and runs upon a course of undiminished activity. This we have seen is not the case in the infusoria, and, as recently remarked by Hartog, there is only one class of organisms which, according to our present knowledge, are completely agamous and immortal, namely, the group which includes the bacteria. It may in future appear that even in these minute organisms there is a cycle of development in which conjugation plays its part.

Maupas's experiments seem to establish the interpretation of the purpose of conjugation as well as of sex, the latter being a consequence of the former, namely, that after a long period of direct subdivision of hereditary material from a single individual, a limit is reached beyond which the forces of heredity are not reproduced in their original intensity unless combined with another set of similar forces of different origin. This combination restores the original intensity. It is objected to this that two sets of feeble forces cannot constitute one vigorous force, but this is met by the observed fact that such union does start a new life cycle, and is therefore rejuvenescent. We may regard this as the fundamental meaning of conjugation and the production of variations as entirely secondary.

6. Experimental Embryology.—Experimental embryology plays the rôle of experimental physiology and vivisection upon the ovum, spermatozoon, oösperm, and embryo. The idea is to discover normal laws and relations by setting up abnormal relations. Thus the Hertwig brothers for many years experimented upon the ovum during the conjugation period with drugs and extremes of temperature and found that when the regulating forces in the ovum are artificially suspended abnormal conjugation and development results. Following the gravity experiments of Pflüger, Roux has opened up a new branch of embryology in his "Entwickelungsmechanik," or the science of the combinations of vital energy which produce development by studying the influence of gravitation, light, heat, and magnetism upon the embryo.[21] Roux has also practised the extirpation method by removal of portions of the embryo. Verworn has also practised extirpation upon the infusoria,* or single-celled organisms. A third line of experiments has been introduced by Driesch and Wilson by shaking the embryo in the two- and four-cell stage, and thus producing out of a single oösperm from two to four complete individuals. Some of the results of these various methods may now be briefly summarized.

a. Relation of Nucleus to Cell.—After a long series of experiments, Verworn reaches the conclusion that the *nucleus* is not a dynamic or force centre, either automatic or regulating, but the nucleus combined with the extra nuclear protoplasm must be the seat of heredity. He compares the rôle of the nucleus with that of a cell organoid, like the chlorophyll of plant-cells, as not constantly present but as neeessary to activity. This conclusion coincides with the prevailing theory we have outlined as to the relations between the chromatin (within the nucleus) and centrosomes (without the nucleus), although Verworn, working upon living cells, naturally could not separate either of these elements, which are only brought out by staining.[22]

b. Abnormal Fertilization or Polyspermy.—In the normal state the entrance of a single spermatozoon produces a reaction in the ovum-wall preventing the entrance of other spermatozoa, but when the ovum is weakened by chloroform solution, also by morphine, cocaine, curare, and other poisons, two or more spermatozoa enter before the reaction appears; in fact the degree of polyspermy is directly proportional to the intensity of the chemical, thermic, or mechanical disturbance of the ovum. Nicotine and strychnine seem to increase the activity of the spermatozoa. *Double fertilization* or over-fertilization *has not in a single case resulted in the production of twins*, so that Fol's supposition is negatived, although other forms may behave differently. Fol supposed that single, double, or multiple births might be proportionate to the number of spermatozoa entering the ovum. The effect of over-fertilization is to produce a number of karyokinetic figures, or spindles (see Fig. 238, illustrating "typical cell division") within the oösperm instead of one; the normal cell division runs riot, and no complete individuals are produced. The cell-division may be arrested at any stage by thermic influences; thus two pronuclei, paternal and maternal, about to unite can be held apart in an oösperm, by lowering the temperature. Polyspermy also results from a lowered temperature. It is noteworthy that the conditions of bastard fertilization (fertilization by sperm of another variety of animal) and polyspermy are different; chloroform produces the latter, but not the former.

The latest researches upon polyspermy are those of Rückert. He has made the surprising observation that in some fishes the penetration of more than one spermatozoon into the ovum is a normal process. But a single sperm nucleus unites with the ovum nucleus to form the main tissues of the body, while the other sperm nuclei combine with certain elements in the ovum and form the parablast, an embryonic layer whose history has always been doubtful.

c. The Production of Twins and Double Monsters.—See Driesch in the embryos of starfish, Hertwig in the same form, and Wilson in the embryos of the lancelet (*Amphioxus*, the lowest animal in the vertebrate scale). Wilson's experiments are the latest. He produced, with perfect ease, embryos from one-half to one-eighth the natural size, and corresponding in number from two to eight, by shaking the early embryo in its various stages of division from two to eight cells. Thus just after the oösperm has divided into two cells, shaking produces two quite separate and independent twins of half the normal size. These embryos develop into free swimming larvæ, but do not live more than a day. Shaking in the four-celled stage produces embryos which live a much shorter time. In the eight-celled stages the embryos develop but die before invagination. If the embryonic cells are more or less *incompletely separated*, we find a series leading from scarcely bilobed forms to those in which two nearly perfect bodies are joined by only a narrow bridge of tissue.

Here we have a hypothetical key to the mode of formation, both of twins and of double monsters.[24]

d. Dynamics of Embryonic Development.—This line of research has not as yet been brought to a stage in which its bearings upon heredity are so obvious as in the above phenomena. The main conclusions from the researches of Pflüger, Born, Hertwig, and Roux are that development is due to forces within the oösperm, which are powerful and independent enough to readjust themselves, if artificially thrown out of their normal relations, to external physical forces, such as gravity, light, heat, magnetism, etc. Yet there are two sets of forces to be considered in development: first, the internal self-differentiating, second, those interacting with the external environment.

The self-differentiating forces are very powerful in the early stages, and the ability to produce a whole is not divided between single cells. As we have seen above that each of the four cells of a single embryo lancelet is

capable of producing a complete lancelet, so Roux finds that when a portion of an embryo is destroyed, say by thrusting in a hot needle, this wound is healed, the part removed is regenerated, and a complete, though sickly, individual is produced. To take another case, if the embryonic region destined to form the tail is split in two, a pair of complete tails are sometimes produced, not two half tails.

On the other hand, Roux finds in some cases that if the cells are injured in early stages and not detached, the remaining healthy cells will produce only the regions of the body which they were normally destined to produce. Thus the four-celled stages mark a division into the four quarters of the future body, the right and left head end and the right and left tail end; suppose the right head and tail ends are injured, then the left head and tail ends produce a perfect half embryo. In some cases a more or less complete individual is produced by post-generation. Similar experiments have been conducted by Chabry [25] and reviewed by Andrews, who concludes that each half cell in the two-celled stage of embryonic division has for the main part all that the other has, and if the other be killed, not a half larva but a whole larva, deficient in only a few organs, will be produced.

e. Cross Fertilization.—Interesting experiments have been made by Boveri upon the production of bastards, or fertilization between ova and spermatozoa of different varieties. This was done by depriving the ovum of a sea-urchin of its nucleus by shaking in a test-tube; from the denucleated ovum of one genus (*echinus*) and the spermatozoon of another (*sphærechinus*) a larva of middle form is produced. But when a fragment of an ovum is fertilized, and this is found possible, a larva is produced with the character of the sperm only. This appears to prove that the spermatozoon conveys the power of forming a complete individual. These few examples of the kind of progress which is now being made in experimental embryology are sufficient to prove that the phenomena of teratology are largely seated in the conditions under which the ovum and spermatozoon unite, that fertilization during periods of alcohol, morphia, or nicotine poisoning may produce in the offspring of man results altogether analogous to those which we observe in these lower organisms.

Conclusions.

Heredity.—Perhaps the most impressive result of this review of recent researches in heredity is the uniformity of life-processes throughout the whole scale of life from the infusoria to man. Such uniformity furnishes a powerful argument for the advocates of the study of biology as an introduction to the applied science of medicine. Much that is now entirely omitted from medical education, because it is considered too remote, is in reality at the very roots of the science. To understand the disorders of life we should first thoroughly understand the essential phenomena of normal life. Of course we shall never see life as it really is, because there is always something beyond our highest magnifying powers; but we come nearest to this invisible form of energy when, with such investigators as Van Beneden, Hertwig, Boveri, and Maupas, we strip the life-processes of all their accessories and view them in their simplest external form.

The problems of evolution are found to be inseparably connected with those of heredity. No theory is at all adequate which does not explain both classes of facts, and we have seen that the explanations of hereditary processes offered by those who believe in the transmission of acquired characters and those who do not, are directly exclusive of each other. We should gather from every quarter facts which bear upon the most important and central problem of the transmission of acquired characters. Medical practitioners enjoy exceptional opportunities of contributing evidence upon this mooted question. It must not be forgotten that while the inheritance of the changes observed during life caused by various habits is the simplest method of explaining the evolution of man, we know absolutely nothing of how such changes can be inherited through the germ-cells. We cannot at present construct even any form of working hypothesis for the process which

> "shapes our ends,
> Rough-hew them how we will."

The Germ-cells.—1. The material substance of hereditary transmission is the highly coloring protoplasm, or chromatin, in the nucleus of the germ-cells, probably connected with the activity of the centrosome containing a certain form of dynamic protoplasm, outside of the nucleus.

2. Before conjugation and fertilization the hereditary substance of both the male and female cells is reduced to one-half that found in a typical cell. The substance is, however, first doubled and then quartered, the meaning of which process is not understood.

3. There is a difference of opinion as to whether the paternal and maternal hereditary substances, during fertilization, are fused or lie side by side; also as to how the substance is distributed through the tissues, whether *en masse* or by qualitative distribution. The balance of evidence seems to favor the view that the chromatin of each cell contains, besides its special characters, some of the general characters of the entire organism.

4. No physiological connection between the germ-cells and body-cells is known, but the facts of heredity seem to render such a connection theoretically necessary. Several classes of facts connected with reproduction seem to support this theory.

5. The facts of heredity support the theory of a continuous hereditary substance in protoplasm, as the basis of repetition of type, but do not favor Weismann's hypothesis that the germ-cells alone contain this hereditary material.

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Henry Fairfield Osborn.

[1] This article is largely a revision of the Third Cartwright Lecture before the Alumni of the College of Physicians and Surgeons, with new material added.

[2] See Proc. Roy. Soc. Edin., 1888, p. 93.

[3] See Animals and Plants under Domestication, 1875, vol. ii., p. 349.

[4] Contemporary Review, vol. xxvii., pp. 80–95.

[5] The Law of Heredity, 1883.

[6] See Parthenogenesis, in his Anatomy of Vertebrates.

[7] Generelle Morphologie, vol. ii., p. 170.

[8] Zool. Anz., vol. ix., p. 166.

[9] Biological Memoirs, p. 432.

[10] Journal of Anatomy and Physiology, 1891, p. 433.

[11] Comptes-Rendus, March 13, 1882. These experiments have been confirmed by Obersteiner.

[12] See Huxley, Article Evolution, Enc. Britannica, p. 746.

[13] See Geddes and Thomson: The Evolution of Sex, 1891; also Düsing: Die Regulierung des Geschlechtsverhältnisses bei d. Vermehrung der Menschen, Tiere und Pflanzen, Jen. Zeit. f. Natur., Bd. 17, 1884.

[14] Sur la multiplication des Infusoires Ciliés, Archiv. de Zoologie expérimentale, Sér. 2, vol. vi., pp. 165–273; Le Rajeunissement Karyogamique chez les Ciliés, vol. vii., pp. 149–517. See also Hartog, Quart. Journ. Microscop. Science, December, 1891.

[15] See Marine Biological Laboratory Lectures, 1889. Boston: Ginn & Co.

[16] Hugo de Vriea: Intracellulare Pangenesis. Jena, 1889.

[17] Die Bedeutung der Zellkerne für die Vorgänge der Vererbung, Zeit. f. Wiss. Zool., 1885. And, Das Karyoplasma und die Vererbung, op. cit., 1886.

[18] See also the introduction of Weismann's last essays on Heredity (Macmillan & Co., 1892), especially the article "Amphimixis."

[19] On the Number of Polar Bodies and their Significance in Heredity. 1887.

[20] Ei und Samenbildung bei Nematoden, Archiv. f. Mikr. Anat., Bd. 26, 1890. This species is found in abundance in the intestines and fæcea of the horse.

[21] See a summary of this whole subject in American Naturalist, May and June 1892, "Experimental Embryology," by E. A. Andrews.

[22] Max Verworn: Die Physiologische Bedeutung des Zellkerns, Archiv für Physiologie, 1891, pp. 113–115.

[23] Untersuchungen zur Morphologie und Physiologie der Zelle, O. and R. Hertwig. Fischer, Jena, 1890.

[24] E. B. Wilson: On Multiple and Partial Development in Amphioxus, Anatomischer Anzeiger, 1892, p. 732.

[25] Contribution à l'Embryologie normale et tératologique des Ascidies simples, Journ. de l'Anatomie, 1887.

HERNIA. In Vol. VIII. of this work the writer discussed first the subject of strangulated hernia and its treatment, and then the accepted modern methods in attempting radical cure of hernia; a previous volume containing other methods than these more recent ones. Since the time when the article in Vol. VIII. was completed there have been devised in various parts of the world yet other herniał operations of interest. These and a few modifications of the thoughts which I formerly expressed render a further study of these subjects advisable.

Regarding strangulated hernia I have little to add. I endeavored in my previous article to point out, and wish here again to emphasize, the fact that the peril lies in delay and repeated and prolonged taxis, and not in the simple cutting operation to give relief. The patients who die do so not through any fault of the surgeon, but from the procrastination of the physician, who counsels waiting "just a little longer."

After a few hours have elapsed it is in most instances no longer a question between the surgeon and the physician, but between the surgeon and the undertaker.

I think it rather a common error in the profession to estimate the degree of the strangulation by the severity of the pain and tenderness. This rule is an unsafe guide.

I still think an hour sufficient time to devote to taxis and the various devices calculated to promote the success thereof.

Among these, one that I can recommend as sometimes of more value than application of ice, is spraying the swelling with ether. If no spray apparatus is at hand, pouring the ether on, a little at a time, and vigorously fanning, will also cause intense cold, and this acts favorably both by contracting the bulk of any gas within the strangulated loop of bowel and by relieving muscular spasm. The latter factor, considering the aponeurotic nature of the stronger constricting fibres—those of the external oblique muscle,—is not, at least commonly, of importance. Perhaps spasm of the internal oblique or transversalis muscles, at or near the deep ring, may occasionally be present and be relieved by the cold.

Poulticing and hot baths can hardly do good in any other way than this; and as they must necessarily increase the bulk of the gas, I now substitute the cold (by ether spray) instead.

It need hardly be said that aspiration of gas and of fluid fæces, through an aspirating-needle, might so readily be followed by septic infection in the track of the withdrawn needle as to make this plan a dangerous one.

Recent experience has inclined me to advise against the use of morphine in any cases of strangulation. Like the hot baths and poultices, morphine can only be of use by relieving a doubtful muscular spasm. And too often, by making the patient entirely comfortable, it seals his death-warrant. He cannot—in some instances—be made to realize that the unreduced bowel, now so free from pain and tenderness, is rapidly dying from obstructed circulation.

Indeed, the family doctor has not always, in such a case, the courage of his convictions, and either delays—where delay is a crime—or but half-heartedly advises a cutting operation; which suggestion the comfortable patient promptly rejects. He is no more enthusiastic for the knife than is his doctor; probably even less so.

In my previous article I described the case of an elderly lady in whom I found the strangulated gut dead, and removed thirteen inches, with immediate end-to-end reunion of the sound bowel. I then claimed that this was the largest amount ever successfully removed in America; though in a few instances in Europe more has been sacrificed with recovery—notably a case of Koeberle's, from whom 2.05 metres were excised. Since the publication of Vol. VIII., however, I have learned of an instance in which Dr. G. D. Beebe, of Chicago, removed four feet ten inches with success. Upon ascertaining this to be true, I published a statement of the facts in the New York *Medical Record* for December 5, 1891.

It is possible that in my previous article upon hernia I did not sufficiently emphasize the point regarding operation upon strangulation, that, with the rarest exceptions, it is advisable, should dead gut be found, to make an artificial anus and await a return of the patient's strength—delaying some weeks if need be—rather than to attempt a restoration of continuity, by any plan, at the time of operation for relief of strangulation. The patient is almost always in so weak a state—from postponed operation—that the *mere relief of the strangulation is all that is wise*, and the added time needed to perform either lateral anastomosis or end-to-end reunion may well turn the scale against him so that he will "die cured." On the other hand, after some weeks of vigorous alimentation, the patient will probably be so strong, in spite of the artificial anus, that the chances of recovery from the kelotomy will be much better than they would have been in the first instance.

It should clearly be understood, too, in a case of artificial anus, that, by whatsoever technique the restoration of the bowel-continuity is performed, it is never easy. No man can conscientiously attempt it who has not practised it a considerable number of times on the dog, or the human cadaver, or both. On the other hand, the general practitioner need not fear to operate for strangulation. If he is cleanly of person and patient and boils his instruments and dressings; if he makes an abundantly long cut, thereby seeing what he is about; if he always cuts until he sees the bowel, and freely relieves it where pinched; and if he treats it, when dead or doubtful, as described in the article in Vol. VIII.,—he is doing all that the most expert surgeon could do.

No one to-day advocates that relic of the dark ages, replacing the gut in the abdomen without opening the sac; for that means putting back a loop which may still be strangulated within the sac, or ruptured from the taxis, or ulcerated, dying, or dead. It is simply trusting to luck, and is bad surgery.

Neither can a conscientious man permanently replace a loop of doubtful vitality and sew up his wound. If it dies, what chance of recovery has his patient? The proper technique required under these circumstances I have already published in Vol. VIII.

Though I have just said that if the loop of intestine be dead, giving relief to strangulation and escape to fæces is commonly doing all that is wise at that time in an operative way, this remark does not apply to the much more common cases in which the bowel quickly begins to regain its normal color after cutting the constriction. Here we always, as a matter of course, devote from five to ten minutes to the necessary steps in attempting radical cure by one or another of the plans which I have either described or am about to detail. It would indeed be a pity to lose this opportunity to prevent, by good surgery, at one stroke, the possibility of another strangulation and the necessity for a truss thereafter.

Since my former article was published the technique of kelotomy for restoring continuity in a bowel badly torn, wounded, or dead, has been greatly discussed; and it cannot be said that to-day surgeons are united in opinion as to what method is best.

Were I again to meet a case such as the interesting one which I described in Vol. VIII., I should certainly not adopt the plan used then. I should to-day be able, by lateral anastomosis with plates cut from raw vegetable tissue (potato, for example), to complete the union in twenty minutes, or less in certain cases; and this saving of time would, of course, greatly improve the patient's prospects of recovery.

It is quite generally admitted, now, that statistics, so far as they can be trusted, favor lateral anastomosis as against any of the end-to-end plans, though sometimes a lack of room compels us to use one of the latter. The deadly mesenteric junction is where leakage so often occurs, following operation by the terminal methods; and from the very first the new opening is of necessity smaller than the normal, and still further to be reduced when the plastic exudate covering the line of union is changed, as finally it must be, into scar-tissue, and this undergoes the inevitable shrinkage.

The very small opening that exists during the days before sloughing carries it away with the fæces, is the objection, too, to the recently devised and most ingenious button of Dr. J. B. Murphy, which in cholecysto-enterostomy seems destined to be a brilliant success.

If *oblique* division of the bowel-ends be done, then, to be sure, the lumen is larger, but there is often a consequent bending or knuckle of the gut at that point, and the mesenteric danger remains. By any "stove-pipe" method, such as Jobert's or Robinson's, mistaking the proximal for the distal end would be fatal. And though Nothnagel's salt-test, as to direction of the peristaltic wave, seems an unsafe guide, we do not wish to start at the cæcum and handle perhaps ten or fifteen feet of bowel to make sure which end is proximal. Then, too, by any "stove-pipe" plan, if much is excised, we are met with the difficulty that the proximal end is distinctly the larger.

By lateral anastomosis, on the other hand, the operation is done at least as quickly, and it makes no difference thereby which end is proximal. The danger of leakage at the mesenteric junction with the bowel is removed; and an abundantly large incision—four inches or so, which is now always a point to be insisted upon,—permits a free canal, even if with time the new opening contracts one-half, which it will probably do. The blind ends, which theoretically might be expected to give trouble and accumulate fæces, practically do not do so, and quickly atrophy.

At the present date a majority of surgeons advocate lateral anastomosis; and, following the lead of the Germans, they have made what I believe to be a distinct backward step in laying aside all plates, rings, or other devices for aiding rapid work, and have returned to the older and certainly slower plan of suturing without such aids.

Since time is so tremendous a factor in success in bowel-work,—inasmuch as a difference of five or ten minutes with the peritoneum exposed may make all the difference between life and death,—I cannot too strongly oppose the present tendency to leisurely sewing. Speed, breathless speed, is, next to cleanliness and thoroughness, the keynote which cannot too often be sounded here.

In discussing the various mechanical means of rather recent device, I cannot but think that the best of these, for reasons purely logical, are plates with a narrow, four-inch long, opening cut from raw vegetable tissue; for instance, raw potato or turnip. These I devised and experimented with (trying also a number of other kinds of vegetable and fruit tissue) in the physiological laboratory of the College of Physicians and Surgeons, New York, during the whole winter of 1890–91, with the result that the last seventeen dogs subjected to kelotomy and the use of such plates recovered.

Upon the living human subject this material—raw vegetable tissue—has been submitted to the hardest test in Germany, where, in the summer of 1892, Dr. R. von Baracz, of Lemberg, and subsequently Dr. Richard Heigl, of Coblentz, each performed abdominal section for gastro-enterostomy, both patients recovering. Dr. Heigl, in his published comments, praises these plates (in these instances cut from raw Swedish turnip) as better than Senn's bone plates.

It is evident that if at any point the danger exists that such material might be digested and absorbed too soon, it would be in the stomach. Hence the value of these tests by the German surgeons named.

When soaked for an hour or two in warm or tepid water (not in carbolic solution, which softens it) these raw vegetable plates—I still prefer white potato—become as rigid almost as wood. This is probably due to swelling of the starch-granules; but is not accompanied by any marked change in shape of plates already cut out. After remaining for a few hours exposed to the digestive fluids of either stomach or bowel the plate begins to soften, while retaining its shape. At length it is completely digested and disappears, this occurring at a period of time varying according to what part of the alimentary canal it occupies. But always during the first ten or twelve hours at least—the time in which, most of all, we fear leakage at our anastomosis—it holds the peritoneal surfaces smoothly in contact.

In this length of time, or even half of it (if we have lightly scraped the surfaces to be apposed), we may be sure of firm agglutination. And after these hours of peril the softened plates yield to peristalsis, and quite easily cut free from their plate-sutures, taking themselves out of the way.

Contrast this with Senn's bone plates, which occasionally slide on each other and obstruct the opening, and require at least a week or so to be removed after they have ceased to be needed; which are tedious to prepare, expensive, and require multiple sizes for various contingencies; which are not to be gotten in an emergency; and which, finally, so far as the opening is concerned, are too small-sized. Whereas, on the contrary, these vegetable plates serve every purpose of Senn's, are more quickly softened and absorbed when no longer needed, may be carved in a minute, are always at hand, may be made, if desired, with a four-inch opening, and are devoid of cost.

The various catgut substitutes for plates, such as Abbe's and Davis's, are of comparatively little value, because, after a short time in the wet, warm fæces, they lose all rigidity, becoming absolutely limp. The same is true, in lesser degree, of Brokaw's segmented rubber rings filled with catgut strands. Moreover, the catgut devices swell greatly when put in any watery solution, such as semi-liquid fæces; and, as Senn alleges, have sometimes thus produced dangerous pressure at the point of ligation. The catgut rings of Abbe (described in my previous article) are no longer used by him. A number of patients have recovered under their employment, but union of peritoneal surfaces was largely due, I must think, to the row of sutures surrounding his rings wherever used.* The solid catgut (drum-snare) rings devised by Matas are not open to the same objections as the other members of that group, but they require to be boiled and otherwise specially prepared. Robinson's plates of fresh raw hide would seem to possess no advantages, and certain obvious disadvantages, when compared with the plates cut from raw potato.

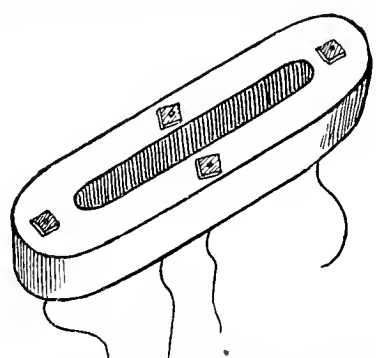


FIG. 247.—The Potato Plate Ready for Use. (Threads short and needles omitted; plate reduced about one-half in length.)

Regarding the question of safety (aside from the factor of speed) in bowel work by any method, two points are often neglected, and, as I believe, to the patient's peril.

The first is the *scraping of the peritoneum lightly*, wherever adhesion is desired. This can be done in a few seconds, and should not cause bleeding if properly performed, but simply congestion; and, because of this, a

* As a matter of fairness, I wish to state that in a few instances these rings, on being recovered forty-eight hours or so after an unfortunate demise, have been found *hard*. It is pure guess-work trying to account for such an oddity, but it would seem most likely that in these patients, the bowels being thoroughly emptied, at or before the time of operation, of their semi-liquid contents, the catgut rings were not given a free opportunity to absorb water and become soft.

more rapid and certain plastic exudate sealing the apposed peritoneal surfaces.

This matter seems to the writer hardly open to argument. Twenty cases in which rapid adhesion of *unscraped* peritoneal surfaces has occurred would prove nothing herein, when compared with one in which smooth and unscraped peritoneal surfaces did *not* become agglutinated after a prolonged contact. And such rare cases have been reported, although the surfaces were in contact many hours after being sutured.

A light scraping, as Senn first demonstrated, will render certain the formation of very firm adhesions within even three or four hours.

The second point which, it seems to the writer, is commonly neglected, although of the utmost value, is *always to give the patient, even before the anæsthetic, as large a dose of morphine by needle as is compatible with safety to his life.*

In the first place, by following this procedure, much less ether or chloroform will be needed than if no morphine be used, and the consequent liability to vomiting, with its attendant risk of tearing out or loosening sutures, etc., is hence largely avoided. Probably, too, morphine is of some little value as a prophylactic against shock from the severe operation about to be undergone. I quite agree with Dr. John B. Roberts,[1] who, in discussing operative shock, says: "The preliminary hypodermic injection of morphine and atropine, always given a quarter or a half-hour before commencing anæsthesia, probably lessens the shock, and without much doubt diminishes the tendency to vomiting after etherization has been discontinued."

In the second place, because of that morphine the bowel will be absolutely quiet, absolutely devoid of peristalsis, for hours afterward; and this is just what we need: *splinting* the intestine for a short time.

Peristalsis during these critical hours, before fibrin has sealed the spaces between our stitches, is fraught with such danger that to permit it is almost like inviting a possible leakage, by forcing out a drop, here or there, of liquid poison.

Should we refuse morphine, we cannot depend for safety upon the paralysis, however commonly present, of the loop recently subjected to operation. For, although this portion may be quiescent for some hours, yet the whole alimentary tube above will not be so! And semi-fluid fæces are being hurried along in surging currents, thrusting themselves forcibly against the newly placed barriers, whether of thread or plates.

Indeed, it is only because I also insist upon the use of morphine as stated that I think the use of plates absolutely safe without a complete row of stitches about them. During the hours while the plastic exudate from the lightly scraped peritoneum is sealing, more firmly than any sutures could seal, that wound, the intestine is as devoid of motion as if dead.

Let me here interpolate the remark that if the patient's general condition were excellent, and the abdominal cavity had not been very long opened (not otherwise), I should, as precaution upon precaution, sew once entirely around the plates a running Lembert, or some similar stitch, such as that elsewhere illustrated (see Fig. 248). And because of the smooth tension made possible by the plates, this sewing could be completed quite a little sooner, as well as more safely, than otherwise. In dealing with the lower half of the ileum, the danger of an occasional complete penetration with the needle is a very real one, save in expert hands—so very thin-walled is this part of the intestine.

To return to the question of a *morphine-splint:* the writer is not ignorant of the views upon peritonitis held by Lawson Tait and many other surgeons. The writer acknowledges the wisdom of its treatment, or better, prevention, by saline laxatives; but submits that here (as distinguished from ovarian or uterine surgery) exists an indication of the strongest kind for the use of morphine. And in the great majority of instances of this particular class of abdominal work, that indication outweighs, in his judgment, the arguments on the other side. Furthermore, it must be distinctly understood that the writer would not at all approve of continuing for an indefinite period to exhibit morphine, following bowel and stomach operations. When from ten to twelve hours have elapsed, then we can feel assured that firm agglutination has occurred between our lightly denuded peritoneal surfaces; an adhesion so firm as almost to tear elsewhere rather than yield at that spot. And now, the liability, or even the possibility, of leakage being practically past, we should, if there be some tendency, then or later, to abdominal distention, from this period *post operationem*, give hourly, small doses of saline laxatives, and perhaps also a glycerine enema. Under this line of treatment the effect of the morphine upon intestinal peristalsis is, within a few hours, overcome; and usually quite readily so.

And what, now, becomes of the five-inch plates of potato or turnip within the gut?

After twenty-four hours, or, if high in the intestinal canal, after perhaps even a somewhat lesser period of exposure to the heat and digestive fluids therein, the plates will readily yield to the waves of peristalsis, first permitting the freest passage of fæces through the four-inch lumen, and presently cutting out at the plate-stitches because of extreme softening; and they will be swept away. Their four stitches, if, as seems preferable, of catgut rather than silk, are soon after absorbed and also disappear.

Let me now describe in some detail a method of lateral

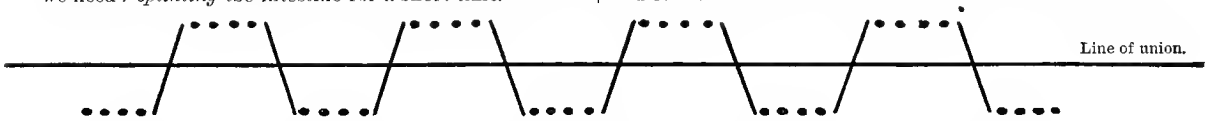


FIG. 248.

anastomosis with plates, as practised by me since the winter of 1890–91 (in entero-enterostomy only). In such operations—not very rarely needed, following, for instance, dead gut from a strangulated hernia, or resulting from tearing into the alimentary canal during separation of old adhesions in major gynecology—the technique about to be described possesses two advantages over any other, with plates or without them. These are: (1) Opportunity to test by the water-test the perfection of the line of suturing. (2) Entire avoidance of possible infection of the line of intended adhesion by repeated accidental dragging out, necessitating tucking back of the cut bowel-edges, which are none too thoroughly disinfected at the best.

Regarding the first point (the hydrostatic test), it is with surprise that I have noted how little it has received attention. If the operator means to depend solely upon suturing for securing union, one would suppose that from a half minute to a minute more spent in proving such stitches evenly and properly tight would be anything but wasted. Indeed in the bladder this is commonly done.

The error lies in closing the bowel-ends *first*, and *then* making the lateral anastomosis, with its surrounding lines of suturing (or plates). Such technique of course prevents the water-test. If instead, as suggested by me, these steps be *reversed*, then by running a stream of warm water into one gut-end, through the new lateral opening, and out of the other gut-end, how easy it is, in a moment, to notice a point of leakage and to correct it by an additional stitch! The tapes or clamps, always applied a few inches away, of course prevent the water from taking another path than that desired. And *then* the bowel-ends are to be inverted and closed, instead of this being made the first step of the operation.

And how much more pleasant, so to speak, for the

patient, to have a stream of leakage discovered at this time rather than subsequently upon the autopsy-table!

As to the second point in technique mentioned, let me quote from a recent article by Dr. Robert F. Weir:[1] In speaking of anastomosis he says:

"I had already called attention . . . to the tendency of the opposed intestinal incisions to slip out beyond the rings. This also occurs with Senn's plates, and, in fact, is common to all of these contrivances, so that special care in their use is demanded, and often the escaping portion requires to be tucked in between the plates more than once before the restraining outside sutures are finally inserted."

Had Dr. Weir used the method about to be described, he would not have had this complaint—and it is a just one—to make, regarding the usual methods either of suturing or of using plates. By the writer's plan, any and all sewing to be done about the new opening is completed *before* that opening is made, and for just the reason given.

Preparation of Plates.—These are cut one-third of an inch in thickness, and on an average five inches, or nearly, in length. Their width is not great, in order that they may slip easily into the bowel. At first I made them too wide. A very narrow slit is all that we need. The powerful circular muscles cause the cut bowel-edges in the slit to retract so that they do not touch each other, and the prompt infection of these edges by fæces prevents the likelihood of their adhering even if they did touch. The slit should be nearly or quite four inches in length. Of course this length is an added safety (immediate as well as remote), because the freer the passage of fæces when that begins, the less the strain on the integrity of the line of union.

Each plate is armed with four coarse catgut threads, not over nine inches long, to avoid tangling. The threads have a large knot, and before penetrating the plate we sew through a scrap of rubber cut from a drainage-tube, or, lacking this, a minute bit of cloth; this to avoid cutting through. If no running line of sutures about the plate is contemplated, it will be best to use *six* instead of four threads in each plate. Use a round, straight sewing-needle, the eye of which (to avoid accidental unthreading) should be a close fit for the catgut. The needles should all have their points buried in bits of potato, each about the size of a pea. If time permits, immerse the plates for a half hour in warm water, to make them more rigid and hard.

Method of Using the Plates.—Assume that the tapes or clamps are applied, and the bowel properly cleansed out by irrigation. Now:

(1*a*) Seize a needle with the needle-holder so that it shall be in the long axis of the holder. Begin with the one marked *A* in the accompanying diagram (Fig. 249). Pass the needle several inches (about seven, in operations upon the small intestine) into one of the open gut-ends, and when the place is reached at which, in the judgment of the operator, it should come through, detach the bit of potato from its point with the fingers, seizing it from without, and then pass the needle through and out. The little piece of potato will take care of itself, dropping to the bottom of the bowel; it is insignificant. The spot at which the end sutures, *A* and *D*, should escape, is one directly opposite the mesenteric attachment; that is, as far as possible from the mesentery. Now (after *A*) pass needles *B* and *C* in the same way. After each thread is passed, it should be held by an assistant tense against the wall of the gut on the side where it belongs, and the next needle should carefully run along the opposite wall; this to avoid tangled threads. Pull lightly on threads *A*, *B*, and *C*, while pushing the plate from behind, drawing it thereby into place within the intestine. Push rather than pull, to avoid oblique tension on the threads and possible cutting of the plate. Next pass *D*, and draw it also taut.

Go through the same steps with the other plate and the other gut-end. Always leave at least a full inch and a half between the plate-end and the gut end, in each instance.

(1*b*) The following alternate method of introducing the plate and its threads is, so far as the suggestion of the shorter needles is concerned, due to Dr. H. M. Hall, of Seattle, Washington. The plate is to be armed with four (or six) short, straight, round (so-called gynecological) needles, only one-half to two-thirds of an inch long. Their threads need not exceed four inches in length. (In other respects they are prepared as in the other plan.) These needles are inserted into the plate at their proper places, and their points made to penetrate just to the thickness of the plate, but no further. (These preparations are, of course, made before the operation begins.) The plate thus prepared is laid, needle-hilts downward, upon a thin, long strip of hard wood, as wide as the plates—a piece of cigar-box, for instance,—and both are inserted together a sufficient distance into the intestine, from its open end. By placing the four short plate-threads each on its own side of the wooden strip, tangling during the insertion is avoided. It is now the work

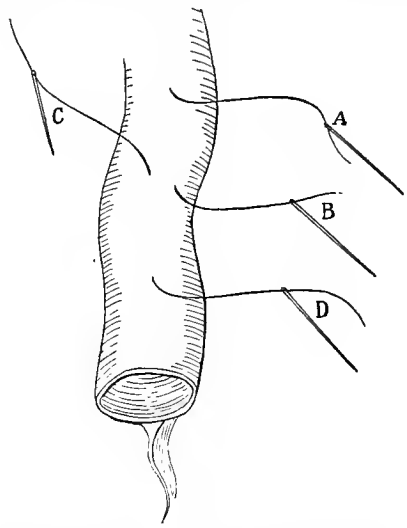


FIG. 249.—A plate in place and ready to tie to its fellow.

of but a moment to press upon the bowel overlying the plate, and thereby force the needles through at exactly the right places. Their points are seized by the needle-holder, and each is drawn through until its thread is tense.

By this technique, which I prefer to the other, both plates may be inserted and their threads tied in less than two minutes. The former technique would be necessary where only ordinary needles are procurable, *i.e.*, in emergency work.

(2) Wipe off the threads with a cloth wet in some antiseptic solution. Of course, this is not essential, but is a safeguard.

(3) Scrape lightly but thoroughly with a scalpel the surfaces to be coaptated; this also includes the ends to be inverted.

(4) Tie the four anchor (plate) threads each to its appropriate fellow, being careful to draw snugly but not to make extreme pressure. Tie first the threads on the lower (under) side of the seat of operation. Sloughing is of course possible if no care is used; though because of rapid softening of the plates, inside of twenty-four hours, it is less a danger even in careless hands than if bone-plates were used.

Experience proves that it is of little moment in which directions the open ends are pointed, before this ligation of the threads; that is, whether in opposite directions or not.

(5) Take one square Lembert stitch at the plate-edges, opposite to and concealing each of the four (or six) plate-stitches. This is precautionary. In the event of a drop of pus forming where a plate-stitch penetrates the gut (infection by capillarity), that pus, like any other fluid,

would move in the direction of least resistance, and, the softened plates not opposing, would be obliged, by this square stitch, to re-enter the intestines at the cut edge.

As an alternate choice—and perhaps preferably to such interrupted stitches—we may, as a matter of convenience, begin the entire operation by a straight, running line of suture five inches long, between the loops to be joined, and about one-fourth inch from their mesenteric border. This line may, if desired, be continued and carried completely around the plates, after these have been tied together. The stitches are rapidly inserted, being no more than three to the inch, and are preferably of the kind illustrated in Fig. 248. The surfaces are smoothly coaptated, and sloughing, from over-tension, is hardly possible; because the pressure from any stich of this continuous thread is not met by that of an opponent across the line of union.

Just as in suturing without plates, about the opening, great care should here be exercised lest the surgeon sew too deeply and penetrate into the bowel. As has been previously remarked, the smooth, though moderate, tension about the plate-edges permits very rapid and accurate sewing.

If the patient were in real and immediate jeopardy, I would advise not stopping for sutures at all; but, as the end of the bowel technique, to wrap

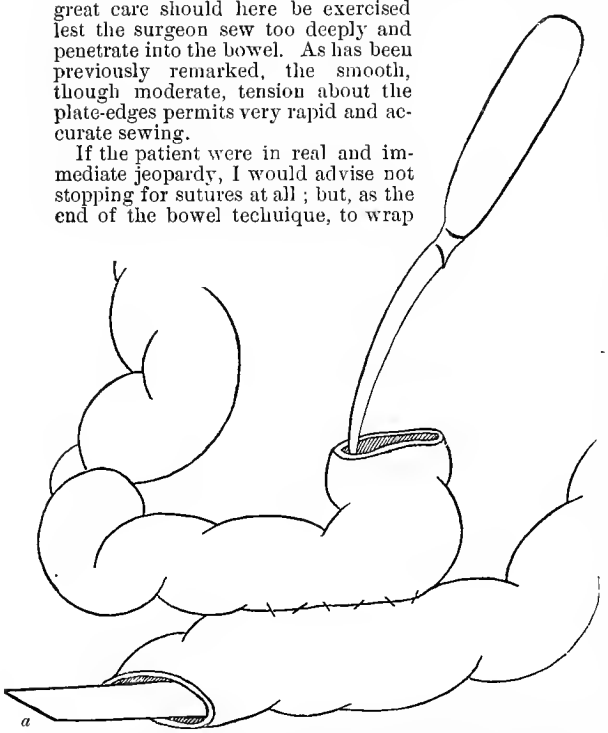


FIG. 250.—The suturing about the plates is completed; the anastomotic opening is being made; in short lines the row of sutures is indicated roughly; *a*, block of wood, to cut against. (When properly tightened, the sutures cannot easily be seen, of course.) Straight scissors, with one sharp point, should be substituted for the knife in this illustration.

around the plates at their line of union a long strip cut from the omental edge. A preliminary cobbler's ligature applied to the omentum will avoid loss of blood here. This, by actual time measurement, may be done in one minute. Such an omental strip is shown by Senn to be almost sure to live, though completely detached, for it becomes firmly adherent where it rests, and is a decided additional safeguard against possible leakage, with consequent infection.

(6) Run into one open gut-end a thin strip of wood as wide as the potato-plate (*a*, in Fig. 250). This is to cut against.

(7) Now we make our opening through the opposed and sealed gut-walls. I strongly advise for this purpose straight scissors, with, as usual, one blade sharp-pointed, instead of the bistoury indicated in the illustration (Fig. 250). If desired, by a little trouble, the bowel-end may be so held as to render the line of incision visible throughout its whole length; but this is hardly worth while, as with the scissors one can very easily feel, before cutting, the slit in the plate, and thus be exactly guided. We should make as long an anastomotic opening as the plates will allow. The strip of wood opposite, which has prevented cutting too deeply, should now be removed.

Should bleeding follow, of more than trivial degree, it could easily be controlled by forceps. As stated, the incision is open to inspection—from either end—with a little care. Also, the potato is elastic enough to permit, without harm, a temporary widening of the slit by any blunt means, for greater ease in seizing a vessel.

However, annoying bleeding is very unlikely to happen, both because the point at which the bowel is divided is that farthest from the mesentery, and, therefore, where the vessels are smallest; and, also, for the reason that the moderate pressure of the plates would tend to check it.

(8) Irrigate, under very gentle hydrostatic pressure, closing the outlet end with finger and thumb for a few moments. The line of suture, or union, should not leak, if contact is properly made.

(9) Invert and close the ends, each with one running line of suture, as in Fig. 248. The free end is seized with dressing-forceps and turned in until the plate is felt. The forceps holds it thus inverted while the stitches are placed. The long intussusceptum, far from being the danger that was once feared, proves a decided protection against leakage. A few needles, temporarily thrust through the intussusceptum transversely, prove of aid in preventing the rolling out of a part of the end during sewing.

(10) Take a stitch or two between the blind ends and the bowel, against which each should rest, first scraping lightly. This sewing prevents possible forcing of another loop into this angle, with resultant undue tension on the stitches at the plate-ends; an accident which led to leakage in one of my first experiments on dogs. It is also a safeguard against intussusception into the new opening, which has been observed by one worker in this field (Robinson). Of course, this point in technique is as applicable to lateral anastomosis without plates as to that with them.

Finally, of course, we remove the clamps or tapes from the bowel on either side of the region just subjected to surgical treatment.

For the sake of clearness, ten successive steps in performing the operation have been numbered and itemized; but it will be noted that half of these are not peculiar to this, or any other plate method, but are just as advisable when suturing alone, without such aids, is attempted.

I know of no briefer, no safer plan. It is my hope that the points herein discussed, and which the reader may not heretofore have put in practice, will be accorded an unbiased trial. They are the fruit of a number of years of work in this line; and the conclusions have not been drawn without time for consideration.

In discussing anew the subject of radical cure of rupture, the writer wishes to call attention to the appalling frequency of hernia, as marking the importance of the subject, and therefore demanding of every medical man his most earnest study.

The tables of Dr. Baxter show that not less than *three million* people in these United States are so afflicted; and the recent and thorough work of Dr. H. O. Marcy, in which these figures are quoted, does not deem them excessive.

Malgaigne estimated that in France one in every thirteen males, and one in every fifty-two females, are ruptured; including both sexes, one in every twenty.

Since my former article was published there has been a most striking change in the mental attitude of the surgical world—due to published statistics—upon the question *when to operate upon hernia which is not strangulated.*

It is not too radical a statement to say that, to-day, most surgeons advocate operation for radical cure *simply because a patient has a hernia.*

If this is true, it must be for the reason that surgeons not only think that radical cure is now regularly to be expected following operation for that purpose, and that

failures are indeed few; but also such advice must mean that, whereas once a patient herein jeopardized his life, now, from thorough asepsis, the operation has become practically free from all danger; as much so as amputating a finger, for instance.

The following figures will put the reader in position to judge for himself upon this matter:

Bassini has published 251 cases, with but 1 death, from pneumonia, when the wound had aseptically healed. Svennsen and Erdman, at the Sabbatsberg Hospital, 200 operations, no deaths. Lucas-Championnière had a single death among his 266 cases; cause not stated. Kocher, 119 operations, 1 death from pulmonary embolism on the fifteenth day after the operation, when the wound was completely healed. Macewen has lost 1 patient, from scarlet fever, out of his 98. Roswell Park, 85 cases, no deaths. Halsted, 83, no deaths.

It must ever be borne in mind, however, that such safety as this implies *absolute surgical cleanliness*, and this is no slight acquirement. This is a true cœliotomy, for by any and all modern methods of attempting radical cure of hernia the peritoneal cavity is opened in order to ascertain accurately whether the sac is empty or not. Let no man dare attempt it until he has made sure by lesser operations, in safer regions, that he can always command asepsis; that wounds of his own making shall regularly heal without suppuration.

Regarding the question of success in effecting radical cure, Bassini reports recurrences among but 5 patients in 251 cases of unincarcerated inguinal hernia; although—be it remembered—the period over which many of these cures extend is far too short to permit of our considering this report a final one.

In one of his recurrences Bassini had not removed the sac as usual. In another he trusted entirely to catgut sutures. In two others there was not strictly a recurrence, but simply an abnormal bulging at that part of the abdomen.

Kocher records 76 cases with but 2 recurrences; covering a period of from four and a half years down to less than a year (in a few cases).

Halsted has recently told me that from the time in 1889 when he began his present technique, until now, in 1893, he has had no recurrences among his 83 cases.

It would be a waste of time to multiply figures here. The methods which are now generally regarded as most reliable are of such recent introduction that the true results as to radical cures—those covering periods of not less than three, and better, five years as a test—are not yet obtainable save in a very limited number of cases.

However, it is extremely instructive to learn what *not* to do; and a study by Dr. W. T. Bull,* of a series of forty cases, inspected at periods varying from a few months to six years, is of great value herein; and his frankness in reporting undesirable methods, which he doubtless no longer uses, is a virtue all too rare.

He says: "Twenty of this number had been operated upon by excision and ligation of the sac; the remaining twenty had excision and ligation of the sac, together with suture of the pillars of the external abdominal ring. . . . By both methods, in all varieties, there were sixty per cent. of cures, and forty per cent. of failures."

In a second paper he states that only about half his wounds healed primarily; slow-healing drainage-openings being generally the cause of this. His drains were of rubber, usually. His catgut sutures were prepared by saturating them with Kocher's oil of juniper plan.

In this latter paper the importance, by any method, of obliterating the sac is emphasized. He states that *every* case operated upon by him after the method of Heaton—with injection of a solution of white-oak bark into the inguinal canal—has now relapsed!

Dr. Bull insists, as do Macewen and Lucas-Championnière, on the use of a truss "from the time the patient leaves his bed."

In this respect he differs from Bassini's customary practice, from McBurney, from Wölfler, and, in most cases, from Kocher. I cannot help feeling, however, that it is the part of wisdom to give the newly healed wall a light support for a few weeks by a truss (unless, indeed, the patient has been kept about six weeks in bed). If this were permanently to be worn, however, as a necessity, that would imply no true and radical cure, and should not properly be classed as such.

* Read before the New York State Medical Association, 1889.

In Vol. III. the reader will find discussed certain methods—mostly antiquated—of attempting radical cure. In my former article, in Vol. VIII., are yet other studies upon this subject, giving especially the plans advocated by Drs. Czerny, Banks, Nussbaum, Sewell, Riesel, Barker, Ball, Macewen, and McBurney. Since the final volume of the HANDBOOK appeared, various additional methods have attained prominence. These from their originality, or else their intrinsic value, deserve a permanent record, and will presently be discussed here.

It is noteworthy that two points in the technique of operation upon the inguinal canal have of late years received especial care.

The first of these has reference to strengthening the weak rear-wall of that canal, which, for an inch or so to the inner side of the deep abdominal ring, is composed of nothing more resisting than transversalis fascia and peritoneum. Obliteration of the sac, alone or combined with closing the external (superficial) abdominal ring by sutures, will still leave this a weak spot. And if once the bowel *begins* to re-enter the canal, inevitably the wedge principle will at length permit of a complete return of the hernia. Therefore it is that most surgeons to-day so carefully sew together the deep parts, hoping to prevent, by a tight, deep ring, and a strong, musculo-aponeurotic rear wall of the canal, the least admission of the thin end of the wedge.

The second of these points just referred to is the fact that an element of weakness in our operations is the presence of the spermatic cord running through the canal. If we could prevent this, then the canal could be solidly and completely closed against the invading bowel. In the middle ages, as Kocher has recently reminded us, surgeons used to castrate their patients, and remove the cord, as a simple means of solving this problem. Literally, that was cutting the Gordian knot with a vengeance! and led to a popular outcry against such surgery. Of late, certain operators have insisted upon the importance of this principle; and, without castrating, have nevertheless succeeded by various plans in permanently emptying the inguinal canal of the spermatic cord. Drs. Halsted, Fowler, Postempski, Wölfler, and Frank, are instances in point.

Among so confusingly long an array of methods the reader may wish to know which are at this time regarded by the profession with most favor.

I think I am safe in replying that to-day Bassini's method stands first in popularity among surgeons, and Macewen's second. Others are regarded as either more complicated, or as yielding a smaller percentage of true and permanent cures.

Bassini's Method.—This was first described by Dr. Eduard Bassini, of Padua, at the Congress of Italian Surgeons held in March, 1888. He reported at that time two hundred and sixteen cases. The following, which I have carefully compared with his own more recent article,* is taken very largely from Dr. S. E. Milliken's clear description.

Operation.—An incision is made, beginning at the spine of the pubis, and extending upward and outward. The upper extremity should be about two inches internal to the anterior superior spine of the ilium; everything is divided down to the aponeurosis of the external oblique. The latter is incised over a grooved director, passed into the external abdominal ring, superficial to the hernial sac and cord structures, and then running outward even a little beyond the deep ring. To expose this ring properly, the aponeurosis should be cut for about two or two and one-half inches. The upper flap is now freed from the

* Archiv. f. klinische Chir., Berlin, 1890, vol. xl.

underlying structures and reflected toward the median line until the conjoined tendon, composed of the internal oblique and transversalis muscles, is brought well into view. The lower flap or segment of the anterior wall of the inguinal canal is next dissected from its underlying fascia, until the shelving edge of Poupart's ligament is exposed. These flaps being held back by retractors, the next point of technique is to hook up with the index-finger the cord structures as they pass over the spine of the pubis, and lift them and the hernia out of their bed. This blunt dissection should be continued until you have reached the deep ring. The hernial sac, without reducing its contents, should now be isolated; this is best done by dividing the overlying structures on a grooved director until you have exposed the bluish-gray thickened membrane over a small area. This coat is raised with a small pair of rat-toothed forceps, that the hernial contents may not be injured when the opening is made. The entrance into the peritoneal pouch should be manifested by the escape of a small amount of serum, unless it be an incarcerated or strangulated hernia, when the fluid may be tinged with blood. The contents having been examined, all adhesions that may exist are tied off with fine catgut. Large masses of omentum should be ligatured, not necessarily at the most distal point, but

Fig. 251.—First Step.

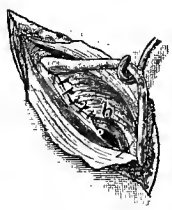


Fig. 252.—Second Step.

Fig. 253.—Third Step.

Bassini's Method of Operation for the Radical Cure of Hernia.

where the greatest constriction exists, and it is advisable to use the transfixion method. Occasionally it occurs that the obstacle to reduction is a fibrous constriction, situated within the deep ring. That is, however, easily detected at this stage of the operation, and can be divided without danger by incising upward. Returning to the treatment of the sac, it must be completely separated from the cord and other adherent tissues, to a point *well within the deep ring*, and a moderate amount of traction made uniformly at all points, which is best accomplished by a series of artery forceps held by an assistant. (The blunt dissection of the sac from the cord and other structures is best begun at its neck.)

Ligation of the sac with catgut is now done, also, by the transfixion method, having first twisted it at its neck. The sac is excised, leaving the pedicle about a fifth of an inch (one-half centimetre) in length, which immediately retracts into the abdominal cavity. If the hernia is very large, and thus the neck and opening of the sac are broad, Bassini applies, besides the ligature mentioned, a glover's suture, for security's sake. When a congenital hernia exists, the sac should be cut off one inch above the testis. The reforming of the tunica vaginalis is of no importance, and the prevention of hydrocele will thus be attained. This completes the first step of the operation (Fig. 251).

Second Step.—The upper and lower flaps, composed of the segments of the aponeurosis of the external oblique, being well retracted by sharp hooks, the cord structure held out of the operative field by a blunt hook or the finger of an assistant (if necessary we may lift the testicle out of the scrotum in doing this), the conjoined tendon of internal oblique and transversalis muscles, on the upper side, is now united to the shelving edge of Poupart's ligament by a series of interrupted chromicized catgut or kangaroo-tendon sutures. Bassini prefers silk sutures. The Macewen blunt-pointed needle accomplishes this admirably, but any curved needle will do. The needle, when passed through Poupart's ligament, must not include more than one-quarter of an inch of tissue from the edge. The relaxed posterior wall of the canal, composed of the transversalis fascia, should be included in the upper grasp of the needle, along with the conjoined tendon. From four to six sutures, inserted in this way, will be sufficient to unite firmly the musculo-tendinous structures, forming a new posterior wall for the canal. In this reconstruction care must be taken not to constrict the tissues of the cord. The first two sutures, close to the pubes, include also the border of the rectus muscle.

All of these stitches should be made to include a large amount, say an inch (two to three centimetres), of the internal oblique and transversalis muscles (Fig. 252).

Third Step.—The formation of the anterior wall of the canal is accomplished by suturing the recently divided external oblique aponeurosis, continuously, with fine catgut (Bassini uses silk), throughout its entire length (Fig. 253). This re-establishes the valve-like condition of the inguinal canal. Finally, the skin wound is closed with interrupted sutures after the insertion of a small glass drainage-tube, from two to two and one-half inches long (Bassini commonly does not use drainage) into the lower angle of the wound, and the following dressing is applied:

Iodoform powder (or what is preferable, fine crystals) should be spread along the line of suture and around the drainage-tube; on this a strip of Lister protective or rubber tissue, two inches wide and long enough to overlap one inch at the ends, a perforation being made for the drainage-tube; moist iodoform gauze, six layers thick and sufficiently long and broad to overlap the wound two inches on all sides, also perforated for the drainage-tube; next, a larger compress of moist sublimated gauze is placed over the upper part of the wound and held in position by a two-inch strip of surgeons' rubber adhesive plaster, extending almost entirely around the pelvis. An intervening layer of rubber tissue should be used to prevent infection of the wound from the plaster. Over the drainage-tube is placed sublimated gauze, very loosely distributed; next, cotton, and lastly it should be covered by rubber tissue, one foot square, which is perforated for the penis and held in position by a spica bandage. The advantages of having the above dressing are several: First, infection from without is prevented by the rubber tissue, which is most external, and by the small strip which is in immediate contact with the skin. By means of the adhesive plaster alone can perfect retention of the deeper dressing be accomplished. However, the most important point in this detailed dressing is the arrangement of the drainage-tube, which should be removed at the end of thirty-six or forty-eight hours by simply taking off the external dressing and not disturbing that which is in immediate contact with the wound. After the removal of the drain the point of exit should be well dusted with iodoform, covered with loose sublimated gauze, and a new protective dressing applied. Where animal sutures have been employed the wound should heal under one dressing, even in cases of strangulation. Perhaps two to three weeks in bed would be the average duration. Some have been allowed to get up as early as on the tenth day. No truss is advised.*

Method of Dr. William S. Halsted.[2]—This plan agrees in most essential respects with that of Bassini, but in addition so deals with the spermatic cord as to remove it—by a plan presently to be detailed—permanently from the inguinal canal, at the same time reducing its size. Consequently there is made—1, a new posterior wall to the now obliterated canal; 2, a tighter deep ring, the

* The writer, while preferring Bassini's technique in most respects, would suggest as a plan worth trying, the complete and permanent emptying of the inguinal canal by a method which he has not seen heretofore described. This consists in drawing the testicle, by its cord, out of the scrotum and then placing both cord and testis in the loose cellular tissue behind the inguinal canal, where they are to remain. Over them the conjoined tendon is sewn to Poupart's ligament as just described, etc. The advantages of having no canal and no inguinal rings is obvious, and true castration is avoided.

latter in a new situation; and 3, a much smaller spermatic cord.

Dr. Halsted published his method in the autumn of 1889, eight or nine months before that of Bassini appeared in print; although the latter surgeon, as heretofore stated, read a paper upon his method, in Italy, in 1888. Both began work upon a clear and definite new principle in hernia operations—Halsted upon two new principles—at about the same time. The priority is commonly, under such circumstances, given to the paper first appearing in print; and should therefore rest with Halsted.

The following is his description of this plan:

1. The incision begins at the superficial abdominal ring, and ends one inch or less (less than one inch in children) to the inner side of the anterior superior spine of the ilium, on an imaginary line connecting the anterior superior spines of the ilia. Throughout the entire length of the incision everything superficial to the peritoneum is cut through.

2. The vas deferens, with its vessels, is carefully isolated up to the outer termination of the incision, and held aside.

3. The sac is opened and dissected from the tissues which envelop it.

4. The abdominal cavity is closed by quilted sutures passed through the peritoneum at a level higher by one and a half to two inches, than that of the so-called neck of the sac.

5. The vas deferens and its vessels are transplanted to the upper, outer, angle of the wound. Before doing this, all the superfluous veins of the cord (all of them save one or two) are excised; thereby reducing the size of the cord, perhaps three-fourths. Consequently the new deep ring will be much smaller than otherwise—an evident advantage.

6. Interrupted, strong silk sutures, passed so as to include everything between the skin and the peritoneum, are used to close the deeper portion of the wound, which is sewed from the crest of the pubes to the upper, outer, angle of the incision. The cord now lies superficial to these sutures, and emerges through the abdominal muscles about one inch to the inner side of the anterior superior spine of the ilium.

7. The skin is united over the cord by interrupted stitches of very fine silk. These stitches do not perforate the skin, and when tied they become buried. They are taken from the under side of the skin, and made to include only its deep layers—the layers which are not occupied by sebaceous follicles; this to avoid possibility of suppuration by stitch-infection.

Dr. Halsted has for more than two years sewed most of his wounds in this way. The method was suggested to him by his experiments on dogs. He thinks that it is very difficult, and perhaps impossible, to disinfect the skin of a dog, and believes that pyogenic organisms may occasionally be present in the sebaceous follicles of the skin. At any rate, he had repeatedly observed pus in the suture-holes of the perforating skin-stitches, and could not with any certainty secure primary union of the skin-wounds of dogs until he had resorted to this subcutaneous method of sewing the skin.

Dr. Halsted states, in this connection, that whether or not it is possible or easy to disinfect absolutely the human skin, he had been much impressed with the fact that skin-sutures not infrequently suppurate, even in wounds sewed by the most careful surgeons in this country and abroad. He has thought it advisable, therefore, to test for a time the subcutaneous, buried skin suture.

8. One or two small, short, gauze plugs are used as wound drains.

The After-treatment.—The gauze plugs are removed at the first subsequent dressing — usually at about the seventh day. The patients are allowed to walk about on the twenty-first day.

A few cases have suppurated. These were laid wide open at once, and the stitches divided. Should the hernia return in these cases, it could not, of course, be counted against this method. In one instance of this nature, after the wound had been freely opened again, urine at length discharged for a time by this route; showing that one or more of the innermost stitches had pierced the bladder-wall—a most instructive case.

It will be observed that whereas Bassini uses three rows of sutures,—sewing the external oblique aponeurosis as a layer by itself,—Halsted has but two rows, including every structure between the peritoneum and skin in his first, or deep line of stitches.

The object of making the new deep ring further outward than before is in order that the vas deferens may pass through broad, raw surfaces, where the muscles are thick, and be thereby snugly embraced in its new situation.

Method of Dr. J. Lucas-Championnière.[3]—1. It is necessary to remove absolutely the sac by a ligature at the highest possible point, leaving not even the slightest infundibulum in the peritoneum opposite the deep ring. To accomplish this we must dissect up the peritoneum wall above the neck of the sac.

2. In the second place we should oppose to the return of the hernia a heavy, firm cicatrix, the result of the very free dissection to expose the peritoneum beyond the uttermost part of the neck of the sac. The whole length of the inguinal canal is, of course, split open in order to do this. The larger the operation—the more extensive the dissection,—the firmer this scar will be. These deep parts are sewn together by deep sutures. (No more exact statement than this is given as to *where* the stitches are placed.)

3. It is important, where omentum is present in the sac, to treat it boldly. In this respect the author claims that he has done what no surgeons have ever done before him. He pulls out of the abdomen, using "energetic effort," the omentum, when this has been a part of the hernial protrusion, and ties off and cuts away all he can. The consequence of this is to increase the empty space within the abdomen, and to remove from the inguinal region any remaining part of the omentum. In both respects this is desirable, and the omentum no longer plays its customary rôle in provoking a relapse.

"If I consider my method of radical cure superior to all others which I have studied, it is because I believe that other surgeons have not taken the care to obey all of these three fundamental rules. . . .

"The most interesting characteristic of the operations which have given the best results is the presence, subsequently to the operation, of a cord of cicatrix, voluminous and hard, extending from the scrotum up into the abdomen, along the region formerly occupied by the hernia. . . The cicatrices really powerful, truly solid, are those made not by a suppurative process but by primary intention."

In the sewing he uses buried sutures: not to make a reunion of the pillars, in the proper sense of that word, but to fuse together and solidify all the deep soft parts resulting from the free dissection. To do this, he uses stout catgut. Sometimes the same thread, after having been tied, is repassed and its ends are finally tied together after having been made to surround a fresh portion of the soft parts.

These sutures may be placed either in single or double tier, from one end of the wound to the other. The barrier is completed by suturing, over these deep parts, those more superficial, *i.e.*, the cellular tissues situated superficially to the muscular wall. This suture is always made with strong catgut, tying invariably three times, against slipping.

An interesting point in the technique is that in those cases in which the anterior aponeurotic wall of the canal seems quite lax, after removing the sac, the author *overlaps* the lips of the cut external oblique aponeurosis, sewing them with the deeper parts, together in this position, and thereby making the canal a tighter one.

Fig. 254 shows his method of tying off the sac. He insists, repeatedly, upon this chain-method. (To the writer of this review this device seems to possess no advantages over the more simple and easily applied "purse-string" or "tobacco-pouch" suture described by Gerster,

and mentioned by me in the article on hernia in Vol. VIII. Furthermore, by the latter plan, the stump of the sac is not entirely cut off from its blood-supply, which is certainly a point worth considering.)

"Among all known ways of operating for radical cure two only seem to me more interesting than the rest, viz., those of MacEven* and of Bassini. I do not much believe in the efficacy of the folding up of the sac, thereby constituting a kind of stopper of defence to the hernial region, as MacEven teaches. But, to accomplish his procedure, it is absolutely necessary to carry the dissection of the sac very high, even into the belly; and in this his procedure resembles mine. One is assured thereby that, at least, because of such high dissection, the sac will be completely abolished, and the cicatrix due to the fusion of the freshened surfaces will be both large and long.

"As for the procedure of Bassini, I do not attach much importance to the reconstruction of the inguinal canal which he thinks to make around the cord. But to

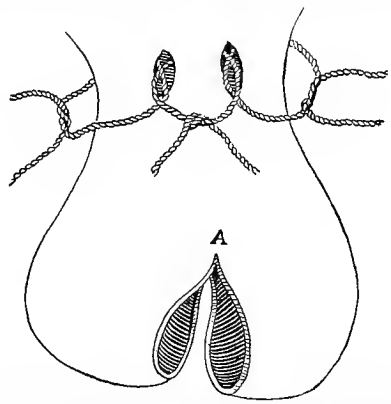


FIG. 254.—Method of Lucas-Championnière in Tying off the Hernial Sac. *A* represents the incision made for the purpose of ascertaining whether the sac is empty or not.

accomplish that end he opens freely that canal, in front and behind, and carries high his dissection of the serous sac. Necessarily, then, he will obtain a result analogous to that which I recommend—a free and thorough sac-removal and a very big cicatrix. That is the reason of his success."

Dr. Lucas-Championnière claims 266 operations upon hernia, of which 221 were in men. He states that he has had only one opportunity to operate a second time upon one of his own cases.

A propos of his radical teaching with reference to thorough excision of omentum forming a part of the hernia (quoted above), it is well to appreciate and guard against dangers due to defective technique in carrying out this procedure. Dr. W. T. Bull[4] has classified these under three heads, as follows:

1. Bleeding from inefficient ligature.
2. Damage to neighboring intestine, which may be included in a carelessly applied ligature. Such a nipping lasting only fifteen minutes before its discovery and correction, has in one published instance led to a slough, perforative ulceration, and death.
3. Inflammation and abscess of the omental stump: of course to be avoided by the strictest asepsis, and sterility of the ligature-material, of whatsoever kind selected.

As to the first of these three points, Lucas-Championnière advises, just as in dealing with the sac, his chain-ligature (see Fig. 254). Bull ligates in sections, no one of which is of as great volume as the finger. It is as well, as an additional safeguard, to tie any large vessels seen on the face of the omental stump. The latter, with but *small* masses embraced in the loops of ligature, may safely be cut much nearer to the point of constriction than otherwise; and thus less dead tissue would be left to decompose.

Method of Drs. Weir and Trendelenburg.—These surgeons, at nearly the same time, attempted radical cure by the device of opposing the return of the hernia (after tying off and cutting away the sac) by placing in the inguinal canal a plate of fresh bone. It would probably be a mistake to suppose that either surgeon regards the plan favorably to-day. Indeed, Dr. Weir quite recently spoke to me of it as having been merely tentative. He used it in two cases; in one the operation was a failure, the bone having shortly to be removed; in the other the result was unknown. Dr. Weir[5] used a piece cut from the scapula of a recently killed dog. A semicircular disk was cut out of this plate at its upper edge, to avoid pressure here upon the cord running over it. Several small holes were also punched in the plate, which was then disinfected, placed in the wound, and covered up.

I mention this method simply as standing for a principle—that of opposing to the return of the bowel some resisting solid mass filling, and yet foreign to, the inguinal canal. A very old method of attempting this is to plug the canal with the patient's testicle of that side, which has been forced up in place and held there by sutures outside, or by prolonged pressure, inducing adhesive exudation. Another of these devices was the introduction of a gelatine cylinder covered with isinglass (Belmas). The open treatment of the canal during the seventeenth and eighteenth centuries, permitting it to become filled by organic material—granulation tissue—of course comes under the same head, as does also the implantation therein of a skin-flap (Dzondi), or of the invaginated scrotum (Gerdy). This principle is not now approved by those best qualified by experience to decide, and certainly the percentage of recurrences observed after this mode of operating is not encouraging.

Method of Dr. Theodor Kocher.[6]—In describing this I have used, in the main, his own language. The skin and superficial fascia are divided over the inguinal canal, and laterally outward, in the direction of Poupart's ligament (Fig. 255). At the superficial ring the cord and sac are exposed. By lifting these toward the light the border of even a very thin hernial sac can be recognized. This is then carefully dissected and isolated from the structures of the cord until it can be strongly drawn down and its pedicle exposed. (Kocher does not mention it, but of course the sac is opened, for obvious reasons.)

The index-finger of the left hand is now introduced into the inguinal canal, and laterally from the deep inguinal ring a small opening is made through the aponeurosis of the external oblique muscle (again see Fig. 255). A slender pair of artery forceps is passed through this opening and through the lower muscular fibres of the internal oblique and transversalis muscles, following the left index-finger as it is withdrawn through the inguinal canal, and finally out of the superficial opening (Fig. 256). With the same instrument the isolated sac is grasped and drawn through the canal and through the narrow opening in its anterior wall, that is, in a lateral direction from its upper end.

The hernial sac now hangs through a narrow opening above Poupart's ligament (Fig. 257). It is drawn out as much as possible, and then, as Heliodorus did, and as Ball has recently advised, it is energetically twisted. The sac is, however, not removed nor ligated, but is strongly drawn down and laid over the outer surface of the aponeurosis of the external oblique muscle and against the superficial ring; in other words, running superficially to, and in the direction of, the inguinal canal.

By this tension on the sac, as is shown in Fig. 258, the anterior wall of the unopened inguinal canal, and especially the tense aponeurosis of the external oblique muscle, are pressed inward and backward into a gutter.

As the twisted sac lies tensely stretched in this manner, deep silken sutures should be applied, beginning at its upper and outer extremity. These are passed above the twisted sac, through the fibres of the aponeurosis of the external oblique muscle and the underlying muscle-fibres of the internal oblique and transversalis, through the

* There is no letter *w* in the French alphabet. This is Dr. Macewen's misfortune.

twisted hernial sac itself, and then including the ligament of Poupart beneath it. We must be careful not to sew into the external iliac vessels, and the finger-tip introduced deeply into the canal, and crowding back the spermatic cord, is our guide as to the deep structures embraced.

These sutures—five to seven or more—bring together also the pillars of the superficial ring, to which the lower end of the hernial sac is fastened. In case of a long sac, all that extends below the superficial ring is cut away.

The operation is more certain when the upper suture can be deeply applied laterally from the place of entrance of the spermatic cord into the abdominal wall.

In tying the sutures, begin with the highest first. The finger-tip, once more introduced within the canal, is our guide as to when the deep parts are brought properly together thereby. Finally the skin-wound is sutured.

No drainage is used as a rule, and, save in exceptional cases, no truss is advised afterwards. The patient—in those cases healing *per primam*—averaged only seven and a half days in bed. This was not Kocher's wish, however, but due to the limited hospital space. He says, "we agree with Macewen that it is right and desirable that after a radical operation the patient remain six weeks in bed, and not return to work until after eight weeks."

Method of Dr. Joseph D. Bryant.[1]—This consists in isolation of the sac—after exposing by incision the whole length of the canal and the deep ring—and then weaving the empty sac in and out, across and across the long axis of the canal, through four slits cut in the external oblique aponeurosis. Thereby the sac is made at once to oppose a return of the hernia, and also to aid in bringing more closely together the hernial parts.

The exact mode of weaving the sac is clearly shown in the accompanying illustrations, Figs. 255, 256, and 257.

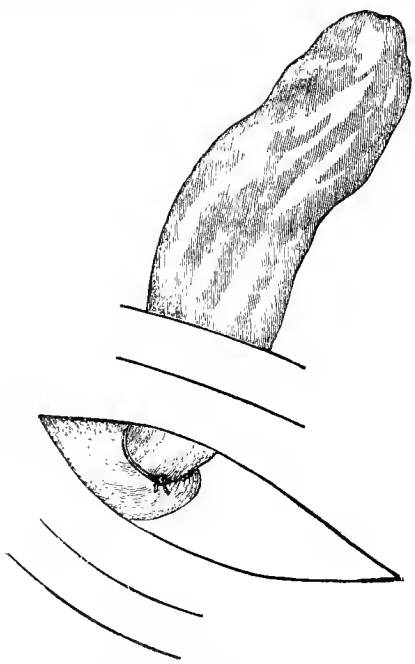


Fig. 255.—Sac going through Upper Slit of Inner Pillar.

A case of sloughing of the sac following its ligation has led Dr. Bryant to cease tying it in this technique. To this extent, therefore, Fig. 255 is now incorrect.

Finally the original slit in the external oblique aponeurosis is closed, and the superficial ring narrowed, with quilted catgut sutures, which are also to be carried through the sac beneath for added solidity; over all the skin is to be sutured.

Dr. Bryant remarks: "It is my opinion that this method cannot be applied indiscriminately, as can the open method, since it frequently happens that the sac is

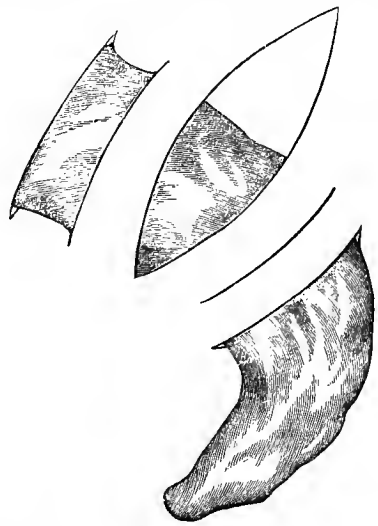


Fig. 256.—Sac going through Slits of Inner and Outer Pillars.

illy developed, or so much damaged by isolation that it will be unwise to hope for particular benefit from the weaving process, even if it be possible to employ it; and,

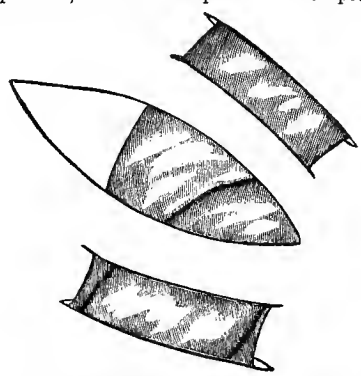


Fig. 257.—Sac passing through Outer Pillar and beneath Inner Pillars.

too, not infrequently, the external pillar of the ring may be found to be so narrow and attenuated as to render its slitting impracticable." Recently Dr. Bryant has not

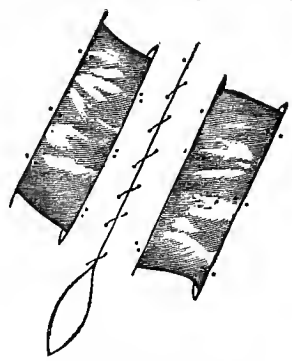


Fig. 258.—Quilted Tissues.

performed this operation so frequently as heretofore, and so informs me.

Method of Dr. George R. Fowler.—This surgeon makes

his incision, and treats the sac in the same manner as does Bassini. He then follows a plan of his own, to be described, which is a modification of the *method of Postempski*. In this latter plan the technique throughout is like Bassini's, save that Postempski permanently removes the spermatic cord from the inguinal canal, thereby being enabled to close the latter more completely. Postempski lifts out the cord as far as the deep ring, displacing it in a direction upward and toward the median line, and attaches it in its new position (just beneath the skin, and superficially to the external oblique aponeurosis) by loose loops of buried catgut suture.

Dr. Fowler's method (used for two years, now) differs from this, the Bassini-Postempski, in two respects, viz., as regards the character of his incision, and in respect to a peculiar method of suturing. He first slits the abdominal wall, "an inch or more," straight upward from the deep ring, and going as deeply as the peritoneum. Into this slit he lifts the cord, and holds it there, at the highest point possible, by "a loose loop of catgut suture placed at a proper distance above the internal ring." The integument and fascia are dissected up from the aponeurosis of the external oblique for a distance toward the median line sufficient to permit the placing of the spermatic cord in this, its new position, so far as its length will allow.

"Both ring and cord, as well as the inguinal canal being now cleared, the next step to be taken consists in a close approximation of the margins of the gap left. In order to accomplish this in the most perfect manner all drainage of the wound must be dispensed with, and it goes without saying, in these days, that the most rigid aseptic precautions have been adopted, in order to make this entirely safe. If antiseptic fluids have been used these should be washed away with sterilized salt-solution, or a solution of the blood-salts in normal proportions. In this way any fluid remaining approaches in character normal connective-tissue fluid, and no irritation is produced by its presence.

"The wound is now ready for suturing. In order to secure proper layer-to-layer approximation of the divided and separated structures it was formerly the custom to secure these by means of buried catgut sutures. I have abandoned this method ever since employing the Bassini-Postempski procedure, and have substituted for it a method devised by myself, and which I have heretofore described as the "crossed suture." The material employed is *crin de Florence*, or silkworm-gut. Firm and evenly rounded strands of this are selected. In using it the strand is threaded at both ends upon large and full-curved Hagedorn needles. In order to avoid troublesome and annoying unthreading of the needles during the manipulation, I secure these to the thread by passing the end of the latter through the eye of the needle a second time from the same direction as that from which it was first passed. By this means a firm loop or "bight" holds the strand securely to the needle, Fig. 259 (*Annals of Surgery*, May, 1892).

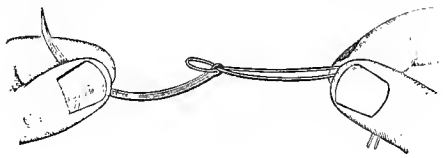


FIG. 259.

"The strand being thus secured to the needles the latter are passed from behind forward, one through each edge of the divided lowermost layer. The latter consists essentially, in the case of an ordinary indirect inguinal hernia, of the muscular structures and conjoined tendon upon the inner margin, and Poupart's ligament upon the outer. At the points where the transversalis fascia presents itself as the floor of the canal, a fold of the latter is included in the loop. Care should be taken in this part of the manipulation not to wound the external iliac vessels. The needles, after emerging (the loop being drawn taut) each from its respective side, are reversed as regards position; that which passed through Poupart's ligament being now carried to the inner side and passed through the skin, again from behind forward, while that which included the inner margin of the lowermost layer, or muscular structures and conjoined tendon, is passed through the skin at the outer margin in the same manner. The thread is therefore crossed on a level with the plane which represents the space between the two layers. Upon drawing upon the ends of the threads the loop which includes the muscular structures and conjoined tendon upon the inner, a fold of transversalis fascia in the floor, and Poupart's ligament upon the outer side, of the wound, is tightened, and perfect approxima-

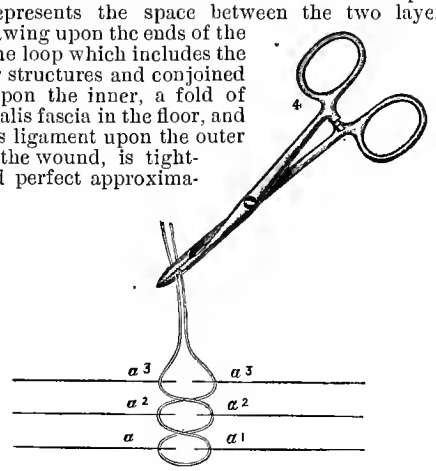


FIG. 260.

tion of these structures results. By tying the suture over the skin the incision is completely closed. Fig. 260 (*Annals of Surgery*, May, 1892) shows the "crossed suture," in this case crossed a second time.

"The sutures are placed about three-eighths of an inch apart and a sufficient number are employed to close completely the wound, no drainage being employed. All the sutures are placed in position before any are tied. In accomplishing the latter it is well to begin from above and as each is drawn taut a finger is carried to the bottom of the wound in order to assure one's self that each is fulfilling its purpose. A strip of protective and the usual dressing complete the procedure.

"The sutures are left in place for at least three weeks; I have left them in for five weeks with no ill effects. They are removed as an ordinary suture by simply cutting the thread upon one side of the knot and making traction upon the other. No difficulty is found in withdrawing the silkworm-gut, the latter readily following the figure-of-eight track which it forms.

"I never permit a patient thus operated upon even to sit up in bed for the first six weeks following the operation. This, at the present time, I consider an important adjunct to the operation, although further experience may shorten this time somewhat in selected cases. In persons in whom, from long truss wearing or other causes, there is a loss of resiliency of the wall of the abdomen, it is well to prolong the stay in bed for a fortnight longer, and to employ, in addition, massage and electricity, following the healing of the wound.

"The advantages claimed for this method of operation relate, *first*, to the plan of placing the cord in such a position as to render it next to impossible for a knuckle of intestine to follow it in its course. Under all circumstances in which a recurrence is favored or produced, the duration of the force is from within forward and downward. When the cord is made to assume a course upward and then inward before making its descent in the direction of the scrotum, nothing short of the patient standing on his head will favor the entrance of a portion of intestine alongside of the cord, and permit it to follow its course. It may be said that the weight of the testicle will tend to straighten the cord finally; this is true to a certain extent, but the manner of placing the sutures here described will prevent this, for the reason that the cord

is held away from the line of incision by being retained entirely outside of these, independently of the chromicized catgut loops which fasten the cord in its new position. *Second*, the crossed suture secures, in the approximatiou of the edges of the divided layers separately, all the advantages of the buried catgut suture ; being removable at will it presents none of the disadvantages arising from the uncertainty as to the length of time which the latter may be depended upon to hold securely. In addition to this, the crossed suture firmly grasps and securely holds the several layers, not only edge to edge, but surface to surface. The result of this is a firm and solid wall, extending from the parietal peritoneum to and including the skin-surface. *Third*, prolonged maintenance of the dorsal decubitus insures stability and firmness of this wall, and at the same time, aided by massage and faradization, it restores the relaxed and thinned abdominal wall to some approximation to the normal condition."

Dr. Fowler has used this method up to date in thirty-three cases ; and has had but one recurrence—a patient with femoral hernia, in whom suppuration and extensive sloughing occurred. The author advises against the use of a truss after the operation.

Method of Dr. George A. Baxter.[8]—This consists in an incision exposing the whole length of the inguinal canal to the deep ring, followed by a second cut going directly upward from this ring through the entire abdominal wall and exposing the bowels for a distance—varying as to number of inches in different cases—"sufficiently far to enable the sac to be engaged in it without being too much folded upon itself."

The sac, after a very thorough dissection to the highest possible point, is tied at a level which would be "within the canal" if the sac were still lying there. Then the sac is turned vertically upward from the deep ring and pressed deeply into the upper wound. Any excess at the free end of the sac is cut away.

Two lines of sutures are next inserted. The deepest pass first through the skin and directly into the peritoneal cavity, then out through the sac in its new position, then into the belly again, and so out of the skin on the opposite side of the wound. About four or five of these stitches are inserted transversely, going from the highest point down to the deep ring. Next, a more superficial row, about as numerous, and covering the same extent of wound ; but these only pass from the skin to the peritoneum, and run *over* the sac, and embrace the musculo-aponeurotic coverings of the abdomen and the skin.

The author points out the danger of ventral relapse from allowing, while suturing, the muscles to retract, as they will to different degrees, and of passing the needles without first remedying this. One should seize the muscle-edges and draw them flush and even with the skin, and, while holding the wall thus, pass the needles.

Next one or two "curved or crucial sutures are passed at the internal opening of the canal from below upward, dipping over the cord (which is placed to the outer side of the incision, and still in the canal) but entering and passing through the tissues after the manner adopted in the majority of operations for ruptured perineum—traversing them, in other words." Now tie all the sutures passed.

Finally, "the hernial canal and scrotal opening are closed with deep suturing." (As to this, no more definite statement is made, nor is the kind of suture-material named.) No drainage is to be used unless we find the sac or its contents diseased.

The author calls attention to the "necessity for careful removal of all fat from the neighborhood of the internal opening, and the freshening of the edges of the tissue at this point for better union."

Dr. Baxter claims among its advantages that this plan "deflects all expulsive efforts from the ring and canal to the abdominal parietes, thereby lessening greatly the liability to a recurrence in the old channel ; and, by doing so, leaves the ring and canal in a perfectly quiescent state during the whole progress of healing."

This operative procedure is so recent as to have no list of cases to show as yet. Dr. Baxter gives illustrations of methods and results in one difficult case.

Method of Dr. A. Wölfler.[9]—This, the most complicated of possible methods for radical cure, has, I think, for this

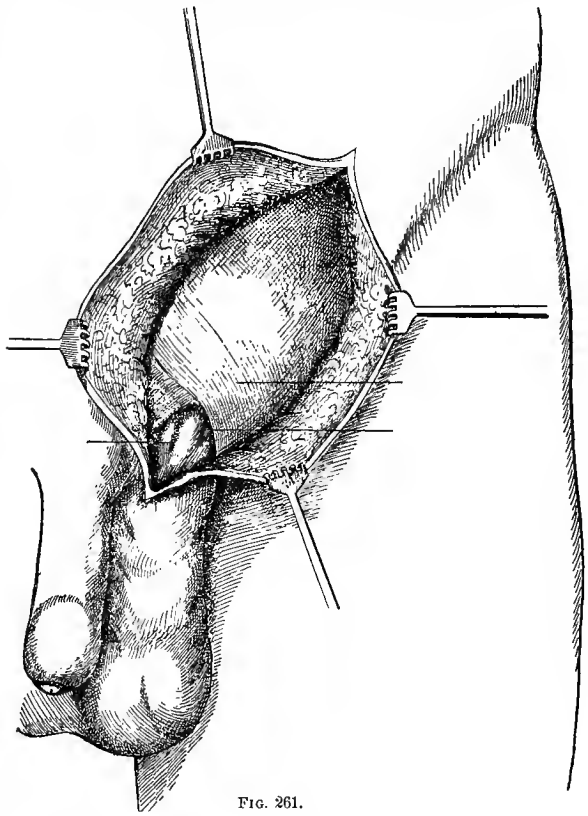


Fig. 261.

reason been but little tried by others than Wölfler himself. It is, however, so ingenious in several respects as certainly to be deserving of accurate description. Most of the steps he has used for four years past. These are :

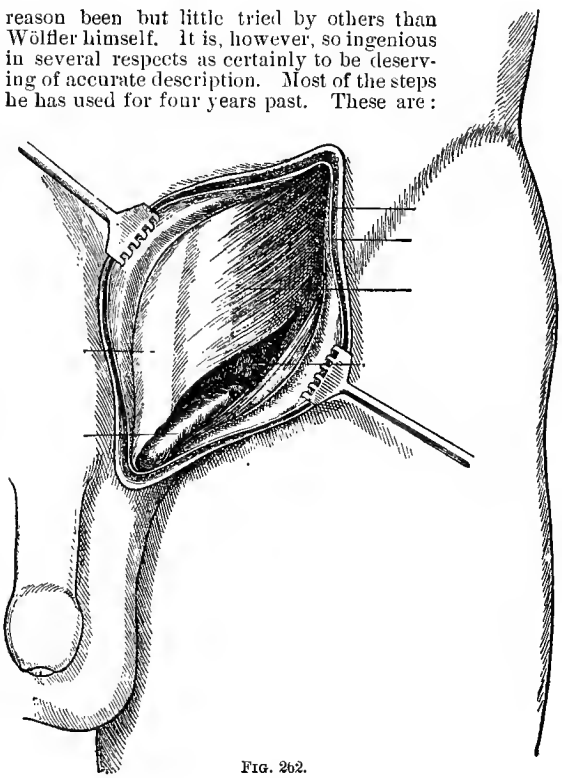


Fig. 262.

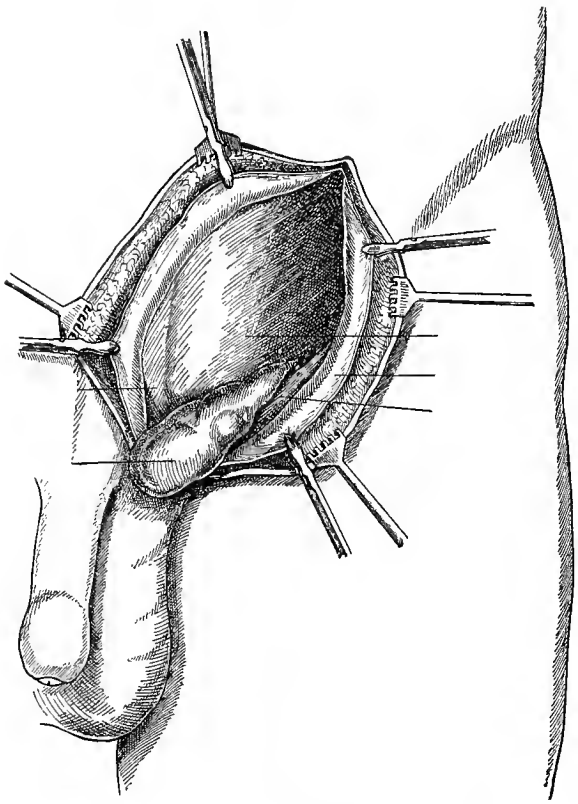


FIG. 263.

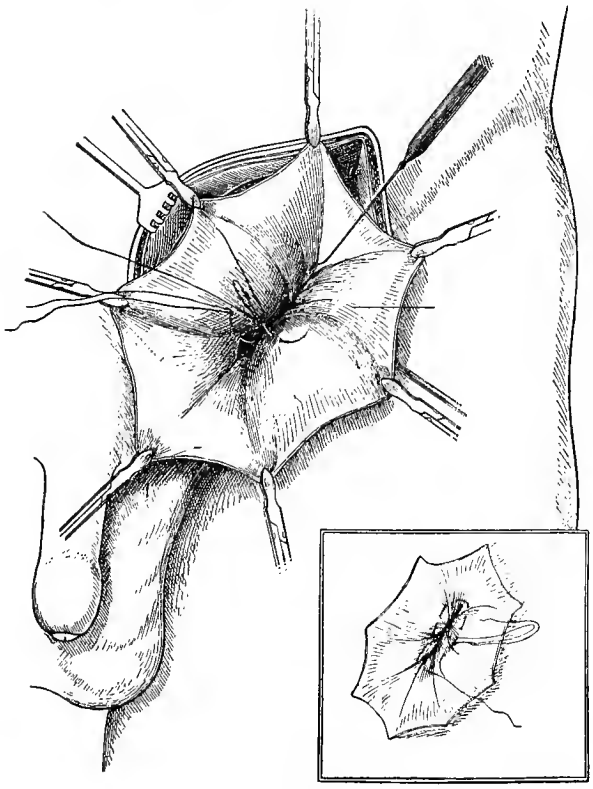


FIG. 264.

1. Denudation of the superficial ring, and of the anterior-wall of the canal—the aponeuroses of the external oblique muscle (Fig. 261).

2. Splitting the external oblique aponeurosis, thereby exposing the cord, sac, and the deep ring (Fig. 262).

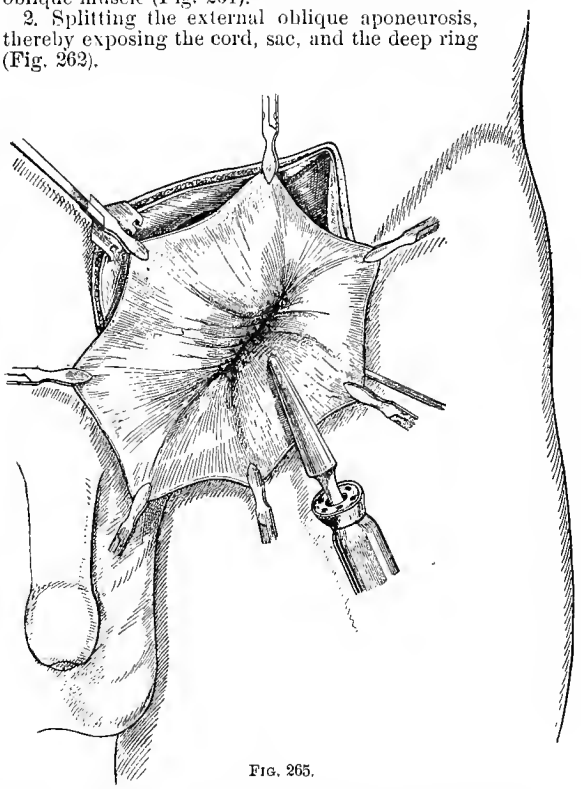


FIG. 265.

3. Isolation of the blind (distal) end of the sac (Fig. 263); and opening this freely by aid of several pairs of forceps (Fig. 264).

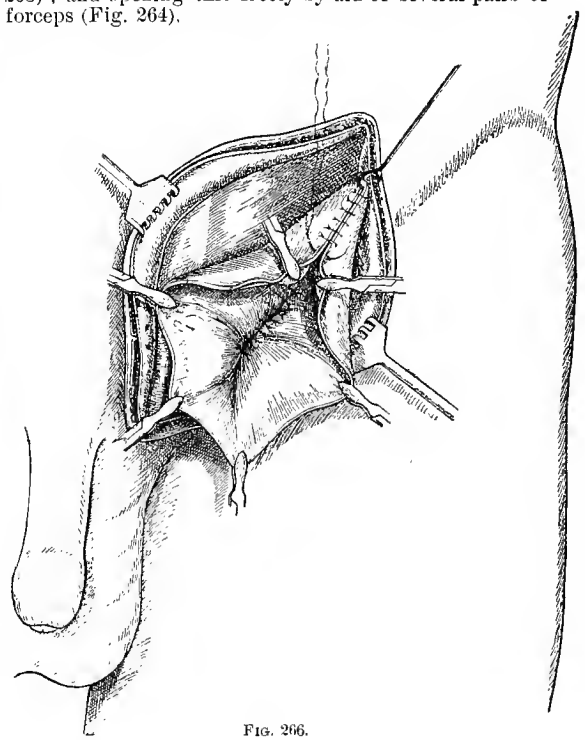


FIG. 266.

4. Closure of the neck of the sac by suturing (silk), by either of two methods (Fig. 264).

5. Then scorching of its interior by actual cautery (Fig. 265).

6. Final closure, by suture, of distal portion of

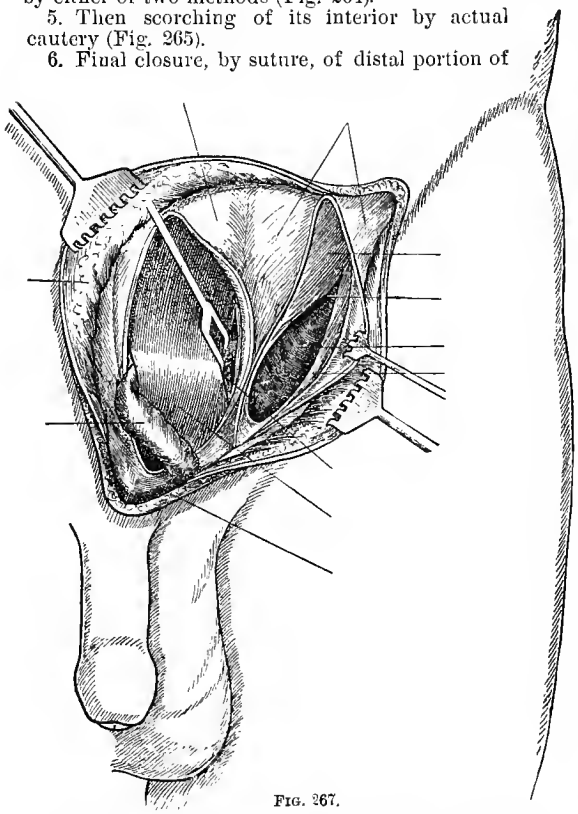


Fig. 267.

sac, Fig. 266, leaving it still in inguinal canal. In case the sac is easily peeled up, it may, instead

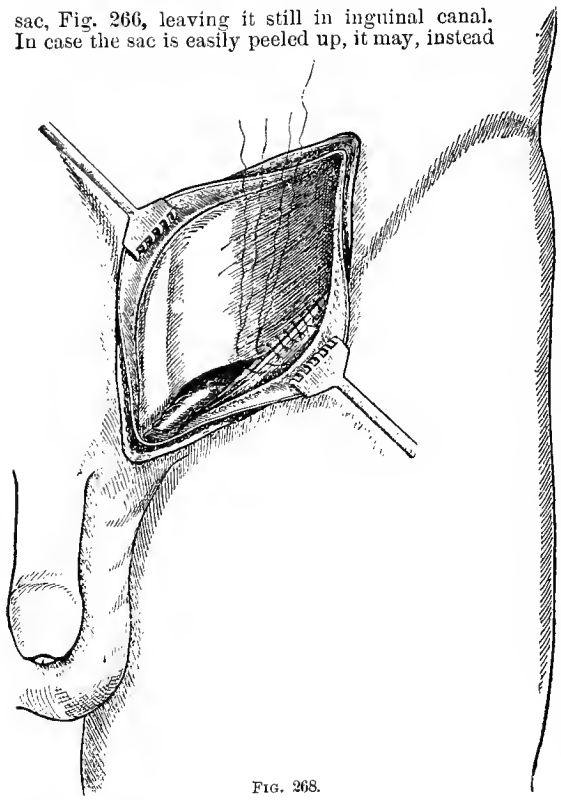


Fig. 268.

of step 5, be cut away near its first-named line of sutures after the cauterization.

7. The cord must now be displaced from the deep ring and brought as far inward as is possible.

8. Temporary castration, by pulling the testicle, attached to its cord, out of the scrotum, then tucking it through an opening behind the sheath of the rectus muscle of its own side, then out through a slit between the two recti, and so back again home (Fig. 267). This device has only as yet been used four times, and but recently. The inguinal canal is now, of course, empty, save for the scorched and doubly sutured sac.

9. Narrowing of the canal and deep ring by sewing snugly over the sac in them first the transversalis mus-

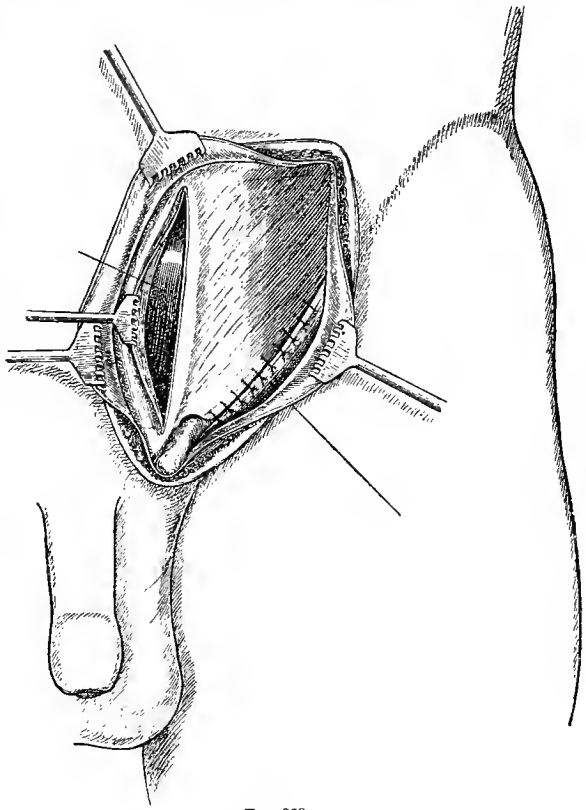


Fig. 269.

cle, and next the internal oblique, each to the deeper, shelving portion of Poupart's ligament (Fig. 268).

10. Opening sheath of rectus muscle (Fig. 269).

11. Displacement outward of this muscle until it is sewn, like the previous muscles, to Poupart's ligament (Fig. 270); or else to the under surface of the aponeurosis of the external oblique, on the outer side of the cleft in the latter. In addition, the cut sheath of the rectus, or its anterior portion at least, is so sutured.

12. Closure of the split external oblique aponeurosis, and obliteration of the superficial ring, by suturing, even down to the pubic bone (Fig. 271).

13. Suture of the integument, over a small drainage-tube.*

In making the superficial incision this should run, not parallel with Poupart's ligament, as the cut (Fig. 261) would indicate, but rather more nearly in a vertical direction. The same is true of the direction in which the external oblique aponeurosis is slit. Consequently there is a much broader aponeurotic surface than merely Pou-

* In Figs. 268, 269, 270, and 271 it is evident that the cord is wrongly drawn, and should have been made to appear running in its new position, from between the two recti muscles, downward and outward to the scrotum.

part's ligament to which to sew the two deeper muscles. Also, the rectus does not have to be dragged so far outward for suture (as shown in Fig. 270) as otherwise would be the case.

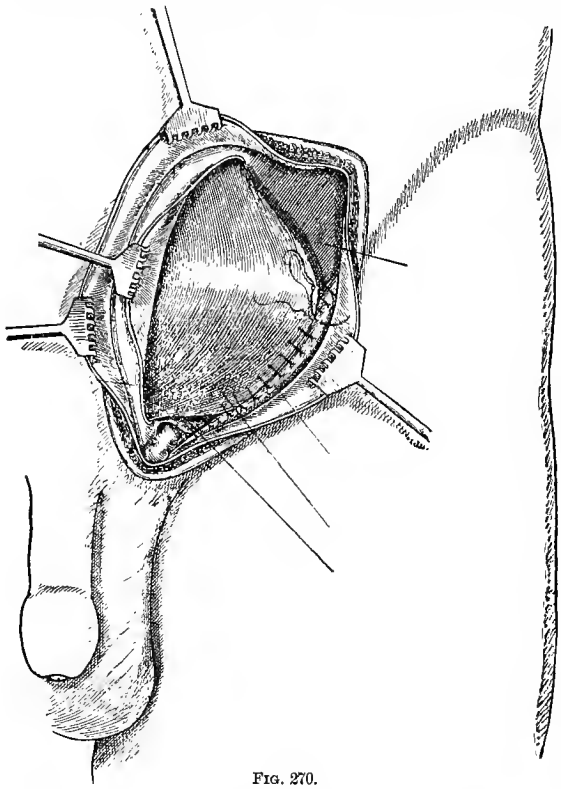


FIG. 270.

As to the further treatment of the cauterized and stitched sac, the author states that he commonly crowds it as much as possible against the deep ring, and then sews the muscles over it as stated. "When (exceptionally) this cannot be done, the sac is drawn, before this suturing, toward the scrotum ; and any excess in length is divided opposite the superficial ring by either cautery or knife."

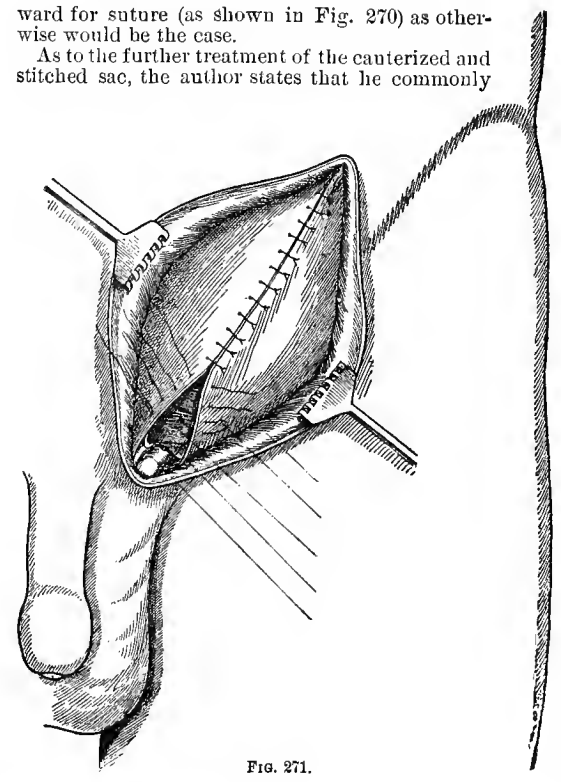


FIG. 271.

Regarding the temporary castration, Wölfler advises inserting a thread through the scrotum at the location of the divided gubernaculum, for the purpose of readily finding it again, so as to replace, by a stitch, the testis in its exact former relation to the gubernaculum.

It will be observed that Wölfler indulges, as a rule, in eight distinct lines of suturing : 1, The neck of the sac ; 2, after cautery, the more distal portion thereof ; 3, the transversalis muscle ; 4, the internal oblique ; 5, the rectus ; 6, its cut sheath, or the anterior part of it ; 7, the external oblique aponeurosis ; 8, the skin.

In his introductory remarks it is pleasing to notice that he disapproves of Macewen's method, among others, because it is so complicated, so lacking in simplicity !

Method of Dr. Frank.[10]—This surgeon has recently reported two cases in which, after removing the sac as usual, he has carried out a new idea, in endeavoring permanently to empty the canal of the spermatic cord, so that the canal may be obliterated by suturing. This is done by dragging the cord inward until it escapes opposite the superficial ring, when it is tucked down into a neatly fitting gutter of sufficient depth, chiselled from the horizontal ramus of the pubes. The superficial ring, like the rest of the hernial region, is now entirely to be closed by sutures.

Turning now from inguinal to femoral hernia, the writer presents, in closing this study, three recent methods devised for attempting radical cure of hernia escaping below Poupart's ligament, through the femoral ring. It is commonly agreed that, by whatever plan attempted, femoral hernia is somewhat less frequently the subject of relapse than is inguinal. Dr. Marcy has stated in his new work upon hernia, *à propos* of this, that Drs. Macewen and McBurney have recently written him saying that they do not know of a single recurrence in their own operated cases. The widely differing plans, nevertheless, preferred by these two gentlemen may be ascertained by reading the description, in Vol. VIII., of their respective inguinal operations.

Dr. George R. Fowler's method in femoral hernia consists (after the isolation, high ligation, and cutting away of the sac) in the application of his "crossed suture," before mentioned in this article (see Fig. 260). Poupart's ligament is forcibly retracted upward, when the internal opening of the crural canal is brought into view. The first loop of each suture will include, according to its location, either Poupart's ligament or the lower border of the aponeurosis of the external oblique muscle, the vagina vasorum, the pectineus muscle and fascia covering it, and, perhaps, Gimbernat's ligament. The usual care must be exercised, while sewing, not to wound the vessels. The needles are now reversed, the suture crossed, and the margins of the iliac and pubic portions of the fascia lata included in the second loop. The needles are again reversed, the suture again crossed, and the superficial fascia and integument grasped in the last or outer loop, this last being completed by tying the suture upon the outer surface of the skin.

Dr. Salzer[11] first removes the sac and then closes the external orifice by a flap formed from the fascia covering the pectineus muscle turned upward and sutured to the middle third of Poupart's ligament. In this manner the *septum crurale* is replaced by a tough, resistant layer of fibrous tissue. The thickness of the pectineal fascia varies, but it is most likely to be strong enough in old persons and in those who have worn a truss for femoral hernia for a long time.

I think it preferable to oppose to the advance of the bowel a thicker, firmer mass than that made by Salzer's layer of pectineal fascia alone, and have preferred, as a slight but not unimportant modification of his method, to dissect up quite a deep and free flap of pectineus muscle and not alone of its fascial covering, suturing this

to the freshened and well-exposed broad under surface of Poupart's ligament, and thereby solidly filling the space between the femoral vein and the free edge of Gimbernat's ligament. Outside this musculo-fascial flap I also unite the freshened iliac and pubic portions of fascia lata, if need be making a long vertical incision through this membrane, an inch or more to one or other side, to permit easy apposition of the edges, without tension on the sutures; and finally I close the skin-wound; all stitches being preferably of freshly boiled silk.

Dr. Kocher describes as follows the method preferred by him: "In femoral hernia, also, it is necessary completely to isolate the hernial sac serosa, to draw it strongly down, and to tie it as high as possible. With the short and broad pedicle this ligation is not always so easy as it is in the inguinal hernia. Then cut away the excess. Still more difficult is the suturing of the canal. Nothing is to be gained by sewing the remains of the processus falciformis which forms the anterior crural ring, to Poupart's ligament; but here also the deep parts of the femoral canal must be brought together. This is best attained (as we can say after watching the courses which our cases have followed), by passing the sutures through the transverse portion of the pectineal fascia (which, under the name of "ligament of Cooper," covers the pectineus muscle at its insertion into the pubes, and which can plainly be seen on the lower side of the neck of the hernial sac), and drawing it up and firmly suturing it to Poupart's ligament. This causes broadening of the ligament of Gimbernat which covers the inner angle of the femoral ring, and usually gives a sufficiently good closure of the hernial opening."

Dr. Kocher has sometimes also employed the following method in the treatment of the sac: This, having been completely isolated and twisted as strongly as possible, is drawn through a small opening made above Poupart's ligament, and in the manner above described is included in the sutures which are passed through the pectineal fascia and Poupart's ligament for the purpose of closing the femoral ring. *Robert H. M. Dawbarn.*

1 Amer. Journ. Med. Sciences, 1892, p. 258.
2 New York Medical Record, April 9, 1892
3 Johns Hopkins Hospital Bulletin, vol. i., No. 1.
4 Cure Radicale des Hernies. Paris, 1892.
5 Annals of Surgery, March, 1893.
6 Medical News, Philadelphia, February 15, 1890.
7 Annals of Surgery, December, 1892.
8 New York Medical Record, November 9, 1889.
9 Annals of Surgery, March, 1893.
10 Billroth: Jubilee Volume. Stuttgart, 1892.
11 Wiener klin. Wochenschrift, 21 Juli, 1892.
12 Centralbl. f. Chir., August 20, 1892.

HISTOLOGICAL FORMULÆ, ETC., RECENT.

That histology is a progressive science is evidenced by the many new and modificatory formulæ constantly appearing; that it is becoming more and more an exact science is shown by the quality and accuracy of the results. Methods are the *sine qua non* and their importance cannot be too greatly emphasized.

Fixation of Tissues.—Fixing, as ordinarily understood, implies the killing as well as a slight degree of hardening of the tissue. Its more precise aim is to cause as nearly as possible, by means of certain reagents, the same relative position, size, and structure of the elements after death as before. This may be more or less successfully accomplished either by the use of an agent that acts instantaneously or one that acts gradually. Rapid fixation perhaps gives the most satisfactory results. It is of course essential that the structures should be alive at the time of fixation, so that pathological or post-mortem changes may be avoided. Plenty of the "fixer" should be used. Fifty to one hundred times the volume of the specimen is a good proportion. It should be changed whenever it becomes turbid. After once being used it is to be thrown away. No universal fixer has as yet been found. With so many varying conditions and peculiarities of structure, experiment alone can decide just which formula is best for any particular case.

According to Kultschitzky[1] the following important rules must be borne in mind in the fixation of tissues: Use those reagents which do not form tissue-like precipitates with protoplasm. This requirement is met by *chromic salts, sulphate of copper, sublimate* and some other salts. Preparations from chromic salts when transferred to alcohol *should be kept in absolute darkness* (Virchow) until the fixing agent is removed so far as possible. Chromic acid transforms protoplasm into tissue-like forms and should be avoided unless its application can be controlled. Fixing fluids should contain an organic acid (*e.g.*, acetic) which changes nuclein into an insoluble state. The acid should be used in a diluted form, as nuclein is said to be soluble in strong acids, or even in weak acids if their action is too long continued. A small quantity of alcohol is also desirable. Strong alcohol dehydrates too rapidly and induces changes in the protoplasm. With the foregoing as a basis, he recommends the following solution: Mix excess of finely powdered bichromate of potash and sulphate of copper in fifty per cent. alcohol and allow the solution to stand in complete darkness for twenty-four hours. A greenish-yellow fluid is the result and this before using should be acidulated with acetic acid (five or six drops to one hundred cubic centimetres). The object to be fixed is placed in this fluid from twelve to twenty-four hours, according to its size and the degree of hardness required, the whole transaction being carried on in the dark to avoid the precipitation of the salts. The specimen is then placed in strong alcohol from twelve to twenty-four hours, after which it may be sectioned in any of the usual ways. The usual reagents for preservation after fixation, alcohol, chromic acid and its salts, are rejected on account of the tissue-changes induced by them; ether, xylol, toluol, or any substance which does not act upon albuminous matter, is recommended.

Osmic acid in the form of vapor or in solution, corrosive sublimate, Flemming's, Kleinenberg's, Perenyi's, Merkel's, and other mixtures have stood the test of time and are too well known to need more than the briefest mention. Tissues fixed in osmic and chromic acids do not readily take the carmine stains. Osmic acid is easily reduced in the presence of organic matter. This is a more important factor than light.

To retard this reduction Lee[2] recommends that the osmium should be kept in the form of a two per cent. solution of osmic acid in a one per cent. aqueous chromic acid solution. This solution serves for fixation with osmium vapors and for the making up of Flemming's solution. All dust should be carefully excluded.

Rabl's Fluid:[3]

One-third per cent. chromic acid	200 c.c.
Concentrated formic acid	4 or 5 drops.

The mixture must be prepared fresh whenever needed. After twelve to twenty-four hours' fixation the tissue is washed with water and the hardening completed in alcohol. It is one of the very best reagents for karyokinesis.

Permanganate of Potash.[3]—This reagent, in a saturated solution, is said to kill even more rapidly than two per cent. osmic acid. It preserves the forms of cells very well and has been found useful in the study of isolated and contractile cells, *e.g.*, spermatozoa.

Carnoy's Fixing Fluid or Acetic Alcohol.[4]—First formula:

Glacial acetic acid	1 part.
Absolute alcohol	3 parts.

The second is:

Glacial acetic acid	1 part.
Absolute alcohol	6 parts.
Chloroform	3 parts.

The chloroform is said to render the action of the fluid more rapid. Acetic alcohol is one of the most rapid and penetrating "fixers" known. It preserves nuclei well, but must not act too long, and admits of most any way of staining. It is applicable to tissues in general and should be washed out with alcohol.

Davidoff's Solution:[5]

Saturated solution of corrosive sublimate,	3 parts.
Glacial acetic acid	1 part.

This has been found very useful for ova, which may

remain in it from half an hour to an hour, then washed for a few minutes in water and carried up through the successive alcohols. This mixture also works very satisfactorily with other tissues and for the rapid killing of many animals.

Another solution, almost as good, consists of:

Saturated solution of picric acid	3 parts
Glacial acetic acid	1 part

The structures are to remain in it for three or four hours and then brought into seventy per cent. alcohol.

Kolossow's Solution.[14]—A 0.5 per cent. solution of osmium in two or three per cent. of nitrate or acetate of uranium is recommended as having very great penetrating power.

Gage's Picric Alcohol:

Distilled water	500 c.c.
Ninety-five per cent. alcohol	500 c.c.
Dry picric acid	2 gms.

It amounts to a one-fifth per cent. solution of picric acid in fifty per cent. alcohol. The tissues are fixed in this solution from one to three days, then washed in sixty-seven per cent. alcohol for two to three days and kept for at least one day in eighty-two per cent. alcohol. They may remain in the latter indefinitely. If small pieces of tissue are used the time for each step may be abridged; if large, the time should be lengthened. This "fixer" is of quite general application and admits of any of the usual methods of staining.

Picric acid should *always be washed out with alcohol* (Lee).

This reagent is said to transform albuminates into an insoluble state. After the removal of the acid the tissue can be colored with any stain. It is recommended for chitinous structures on account of its penetrability. It has also some decalcifying power.

Zinc Chloride.—Broca,[6] in 1879, recommended a ten per cent. alcoholic solution of this salt for the preservation of gross preparations of the brain. Grandmaison (*Comptes rend. hebdom Soc. de Biol.*, I., 1889) has considered "De l'emploi des solutions de chlorure de zinc pour la fixation des éléments anatomiques." This reagent has given excellent results on brain-tissue for histological purposes in the following solution:

Ninety-five per cent. alcohol	100 c.c.
Zinc chloride	5 gms.

Its action is rapid and even. After two to three days' immersion the tissue is placed in ninety-five per cent. alcohol until thoroughly hardened and dehydrated, when it may be imbedded and cut in any of the usual ways. It stains very readily in hematoxylin or carmine.

Lemon-juice,[7] fresh and filtered, has been warmly recommended by Van Gehuchten as a fixative for nuclei. Fix for five minutes, wash well with water, and stain with methyl green.

Alcohol.—Two grades are sometimes employed. Dilute alcohol is often useful, in that it is strong enough to exert some coagulating power, but has sufficient water to render its dehydrating action feeble and innocuous. Absolute alcohol kills quickly and the tissues are not allowed to become deformed. Alcohol, however, is chiefly useful as a "fixer" in connection with some salt dissolved in it, as corrosive sublimate, picric acid, etc.

Pyridin.[8]—A coal-tar product, possessing the peculiar property of being miscible with either oils or water, and coagulating albuminates with a neutral reaction. Hardening is effected in an incubator in about eight days; with small specimens less time is required. The tissues are at once hardened, dehydrated, and cleared, and can be easily sectioned and stained. The anilin dyes dissolve very readily in pyridin. The sections may be mounted in balsam, or after four days' hardening transferred to water, in which case they take up hematoxylin and picrocarmine very well. The reagent gives the best results with nervous tissue. It has also been found useful in the study of bacteria. The odor is very penetrating and rather disagreeable.

Heat.—Heat is very efficacious in killing suddenly and coagulating albuminous substances. "It has the great advantage of allowing of good staining subsequently and of hindering less than any other method the application of chemical tests to the tissues."[9] Heat is not applicable to all organs or organisms, nor is it always easy to determine the exact degree of temperature suitable for each structure; 80° to 90° C. will generally be amply sufficient, and very frequently it will suffice not to go beyond 60° C. A few seconds' exposure is generally enough. When the protoplasm is supposed to be coagulated throughout the structures are brought into thirty to seventy per cent. alcohol, if water is employed as the heating agent. The efficacy of the ordinary fixing mixtures is largely increased by heating them.

Small objects (Protozoa, etc.) may be brought into a little water in a watch-glass or on a slide, and heated over the flame of an alcohol lamp. For larger objects the water or other liquid may be heated beforehand and the animals thrown into it. For the fixing of eggs (amphibian and others) heat has given most excellent results.

Decalcification.—Bones or calcified tissue contain a considerable amount of inorganic substance, represented chiefly by the phosphate and carbonate of lime. These salts are soluble in various acids, and when once removed the organic constituents are left behind, leaving the bone flexible, elastic, and more or less translucent, and, with proper imbedding, admitting of easy sectioning. To obtain the most satisfactory results the bone must be thoroughly fixed and hardened like any other tissue, before being put into the decalcifier. Reagents which are said to harden and decalcify at the same time are of doubtful utility for fresh specimens.

A general but important rule to bear in mind is to employ the acid in a very weak solution, in order to make as little change as possible in the soft tissue it leaves behind. When the lime is chiefly in the form of a carbonate, as in the skeleton of *Echinoderms*, the acid must be added very gradually. The specimen should be immersed in water in a glass vessel, and the acid added drop by drop until the appearance of air-bubbles shows that it is taking effect, the remainder of the acid being added as required. When the lime is mostly in the form of a phosphate, as in the bones and teeth, the acid may be used in a stronger solution.

The most widely used reagent for this purpose is nitric acid. It exerts a great gelatinizing power even in weak solutions, thus tending to deteriorate the soft structure if acting alone or in aqueous solution. It has been found that the gelatinizing or softening action might be greatly hindered by the use of an alum solution (Gage). Care must be taken not to allow the objects to remain too long in the decalcifying fluid, or decomposition will ensue.

Gage's Methods.[18]—The fresh bone, tooth, or calcified cartilage, is fixed and hardened by any of the approved methods, as for soft tissues. Picric alcohol has been found very satisfactory. The tissue is then ready for the following decalcifying mixture:

Sixty-seven per cent. alcohol (95 per cent. alcohol, 2 parts; water, 1 part)	100 c.c.
Strong nitric acid	3 c.c.

Other things being equal, the smaller the volume of the bone the more rapidly will it decalcify. The fluid should be changed after twenty-four to forty-eight hours. If the specimen is large it may be necessary to change the fluid two or three times. A stay of from ten to fifteen days does not seem to injure the soft structures. If there is no gritty feeling upon the introduction of a needle, the decalcification is complete. Upon removal from the decalcifier, the tissue is rinsed a minute or so in water, then placed in sixty-seven per cent alcohol one to two days, then in eighty-two per cent. until ready to section.

Small animals, *e.g.*, salamanders, treated by this method give most excellent results for skull, brain, etc.

Second Method.—After fixing, the tissue is put into the following mixture: A saturated aqueous solution of alum is diluted with an equal volume of water, and to each 100 c.c. of this half-saturated alum solution add

5 c.c. of strong nitric acid. The mixture is changed every two or three days until the decalcification is complete. It is somewhat more rapid than the first decalcifier. After decalcification the tissue is thoroughly washed in water and carried through the alcohols as before.

For teeth this is perhaps the better decalcifier. Both mixtures preserve the soft structures, marrow-cells, ciliated epithelium, etc.

In the first the alcohol, and in the second the alum, serves as a restrainer, preventing the gelatinizing and destructive action of the nitric acid.

Thoma's Method.—Bones or other calcified tissue, either fresh or hardened, are placed in alcohol 95° Tralles until completely saturated, and then transferred to a solution consisting of:

Alcohol (95° Tralles)	5 parts.
C. P. nitric acid	1 part.

in which they are left several days, being frequently shaken. The fluid should be renewed and shaken until the tissue is completely decalcified. The fluid acts quickly, the calcic nitrate formed being quite soluble in weak alcohol. This may be proven by adding to the above solution a surplus of precipitated carbonate of lime; upon evaporating 100 c.c. of the filtrate there will be found 8.67 grms. of calcic nitrate. Large pieces of tissue may be decalcified in two to three weeks. They are then washed in alcohol and put into a vessel containing a surplus of precipitated carbonate of lime in alcohol 95° Tralles. This mixture is also shaken up and renewed, until every trace of the acid is removed from the tissue, which takes usually from eight to fourteen days. The specimens should be left in the solution even a short time after litmus-paper shows no acid reaction. Most of the deposit of the carbonate of lime can be removed from the specimen with a spray of alcohol; the small particles left do not interfere. The deposit may be avoided by wrapping the specimen in filter-paper, but it takes longer to remove the acid. Or a dialyzer with a diaphragm of filter-paper may be used. Large pieces of dense tissue are rapidly decalcified and the acid completely removed, no swelling of any account occurs, and the soft structures undergo little or no change.

Hydrochloric Acid.—This acid also has an extensive use, but it has the disadvantage of causing considerable swelling. To obviate this to a greater or less extent it may be used in combination with chromic acid or alcohol. Or a three per cent. solution may have added to it ten to fifteen per cent. of common salt. Or (Waldeyer) to one thousand parts of a one-tenth per cent. solution of palladium chloride may be added ten parts of hydrochloric acid.

Lactic Acid.[9]—This is said to work well in ten per cent. or stronger solution, being more rapid than picric acid, and as applicable for embryonic and small bones as for older calcified tissue.

Phosphoric Acid.[9]—This has also been recommended in ten to fifteen per cent. solutions. The tissue must be immersed for a long time. Unless absolutely pure acid is used the tissue does not stain well. Considerable precaution must also be taken in the handling of it.

Chromic Acid.—This reagent is used for decalcifying, generally beginning with a weak (one-tenth per cent. solution) and passing to the strong (one per cent.). Bone should remain in it from two to three weeks.

Haug's Phloroglucin Method.[9]—One of the most rapid of the decalcifying agents. It preserves the structures perfectly, except blood, which it modifies considerably. The method was introduced by Andeer, who used the phloroglucin in combination with hydrochloric acid, but with variable results. The substitution of nitric acid removed this difficulty. The solution is prepared by warming 1 gm. of phloroglucin in 10 c.c. of C. P. nitric acid. This must be done slowly and carefully. Soon a dark ruby-colored solution is obtained; to this is added 50 c.c. of distilled water. If a larger quantity of the fluid is desired, 10 c.c. of the acid are added to every 50 c.c. of water, until the volume has reached 300 c.c., which is the limit of the protective influence of the phloroglucin.

In this solution the pieces of well-fixed and well-washed material are placed. Fœtal or young bones, as well as those of the lower vertebrates, are decalcified in half an hour. Older and harder bones require but a few hours.

A twenty per cent. solution generally suffices, although thirty-five per cent. may be found useful for teeth. If rapidity is not so essential, the following may be used:

Phloroglucin	1 part.
Nitric acid	5 parts.
Alcohol, ninety-five per cent.	70 parts.
Distilled water	30 parts.

After decalcification the bones are washed in running water for about two days. The sections stain well and do not fade.

Desilicification.—Objects should be first hardened in alcohol, then placed in alcohol in a vessel made of lead, gutta percha, or glass coated with paraffine. Hydrofluoric acid is then added drop by drop, care being taken to avoid its poisonous fumes. Contact of the acid with the skin causes wounds difficult to heal. Small sponges and other similar siliceous objects, by remaining a few hours or a day in the above solution, are wholly deprived of their silica, while the tissues do not suffer.

Staining.—The chief function of a stain is to differentiate certain tissue-elements, or, as in a successful gold chloride impregnation of nerve-endings, a whole tissue or group of tissue-elements. The former Lee[2] designates as cytological selection, the latter as histological selection. The precise action or combination of stains is as yet very obscure. Living tissue has no affinity for ordinary stains. Certain special reagents which do color living tissues, temporarily at least, will be noted later. A living cell is never at rest, and only after it has become considerably weakened will it permit the stain to act. The coloring of the nucleus is a sign of death. If the cell recovers, the cytoplasm will ultimately throw off the stain.

Furthermore, according to M. Flesch,[10] a favorable stain, *e.g.*, cyanin, produces a much different result in a "fixed" preparation than in a living one. The parts affected in the dead preparation can never be similarly affected when alive.

Some stains are successful only after previous treatment of the tissue with easily reducible combinations. By control experiments it is seen that the staining extends only as far as the metallic precipitate. The original constituents of the tissue are not stained, but the chemical products, probably the metal albuminates resulting from the treatment with hardening agents. There is reason for believing that the parts which, when living, are more highly endowed physiologically, take on a deeper color. The methods of fixing and hardening count very much, therefore, toward the successful action of a stain, and must be taken into careful consideration when making a selection. Tissues fixed in chromic acid or its compounds do not take the carmines well, while hematoxylin acts very readily on such tissues.

Lee[2] considers two methods of bringing about selective staining, the *direct* and *indirect*. With the former the operation must be watched and stopped at just the right stage, when the desired elements are sufficiently colored, otherwise the stain acts on the other parts and a diffuse color is the result. With the *indirect* (by far the more common) the tissues are over-stained and the superfluous color afterward removed by some reagent (usually acidulated alcohol).

Stains may be used in aqueous or alcoholic solutions. Each is useful in its own way. With the former there is danger of maceration if the tissue is delicate and left too long in the fluid. With some tissues the swelling induced by the water may be an advantage, and results not attainable by any other method are produced. Alcoholic stains possess the property of preserving the structures while the coloring is going on. Considerable time is saved by not being compelled to carry the specimen through as many grades of alcohol, and the danger of tearing delicate parts by osmosis is likewise prevented.

Structures may be stained after having been imbedded

and cut, *i.e.*, in the form of sections, either before or after fastening to the slide, or they may be stained in bulk before being imbedded. Here again there are certain advantages peculiar to each method. A more even distribution of color is perhaps insured with aqueous or weak alcoholic stains.

According to Whitman,[11] the more important qualifications of a dye for staining *in toto* are the following: (1) It should *penetrate* readily, so that its action on the deeper and more superficial parts may be as equable as possible. (2) Its action at full strength should be *intense*, capable of imparting any desired depth of color. (3) It should give a *differential* rather than a *diffuse* staining; *i.e.*, it should act with unequal degrees of intensity on the different elements of the cell, thus contributing to sharpness of definition. (4) Its *preservative* qualities should be sufficiently pronounced to enable it to act any required length of time without causing maceration. (5) The color imparted should be *permanent*. The differential character of the stain may be strengthened by washing a few minutes in slightly acidulated alcohol. A rather broad generalization, then, would be that aqueous solutions are more adaptable for sections or for very small and easily penetrable organisms, while for staining in bulk alcoholic solutions are to be preferred. Too strong an alcoholic solution of stain will cause diffuseness of color. The percentage employed may be as high as seventy per cent.

Any system of classification of stains must be extremely artificial and inadequate. Stains themselves may be derived from *organic* or *inorganic* sources. As to their use, they might be grouped according to their action on *fresh* or *hardened* tissue. A more common and perhaps better division would be their affinity, either chemical or cohesive, for only certain parts of the tissue, *i.e.*, *selectivity*; or for the general and indiscriminate coloration of the whole tissue: *diffuseness*.

The following table may serve as a convenient index:

Diffuse or general stains.	Eosin, picric acid, and other aniline colors.				
Differential or selective stains.	Nuclear.		Metallic.	Intra vitam.	
	Fresh tissues, color temporary.	Hardened tissues, color more or less permanent.	Silver nitrate, palladium chloride.	Methyl blue, cyanin.	
	Methyl green, aceto-carmine.	Hematoxylin, carmines.			
	Some aniline colors.				

Hematoxylin.—This, except for permanency, is perhaps the best all-around stain for animal and vegetable tissues. It stains alcoholic, osmic, and chromic acid preparations very readily, but with the latter care should be taken that all of the acid is extracted, or fading will soon ensue. Hematoxylin is the active principle in the extract of logwood. As it is not very readily or easily extracted, it had better be obtained from the market already prepared. None of the solutions of hematoxylin are perfectly stable, only one or two are fairly so (Lee).

Over-staining may be corrected by the use of weak acids. The tissue should be re-neutralized with ammonia to prevent fading. This is quite likely to occur even with the greatest care.

Hematoxylin solutions are not ready for use immediately after being made up. They must first "ripen," according to the mixture, for a few hours, or days, or months. The ripening process, according to P. Mayer,[12] is due, not necessarily to light, but to the air, which causes the oxidation of the hematoxylin. From the products of oxidation, or from treatment with alkalies, there may be obtained the active coloring principle, hematein, or ammonia-hematein, which in trade is known as hemateinum crystallisatum. It is a brown-red powder and soluble in either distilled water or alcohol. The solution should remain clear upon the addition of acetic acid.

The hematein may be prepared as follows: Dissolve 1 gm. of hematoxylin with the aid of heat in 20 c.c. of distilled water, filter, add 1 c.c. of caustic ammonia (specific gravity 0.875), and put the purple fluid into a dish large enough to allow the liquid to cover the bottom to the depth of ½ c.c. Protect from dust and allow to evaporate. The amount of dry ammonia-hematein is about equivalent to the hematoxylin first used.

Mayer's Hemalum:

(*a*)	Hematein or ammonia-hematein	1 gm.
	Ninety per cent. alcohol	50 c.c.
	Dissolve by the aid of heat.	
(*b*)	Alum	50 gms.
	Distilled water	1 litre.

Mix the two solutions, cool, and filter. A crystal of thymol may be added to prevent moulds. Quite large pieces become intensely stained in twenty-four hours, and the stain apparently gives as good results as Böhmer's solution. For most purposes it is better to dilute with water or a weak alum solution. For a good nuclear stain wash out with a one per cent. alum solution.

An acid hemalum may be obtained by adding to the above solution (*a* and *b*) a two per cent. solution of glacial acetic acid. This is said to give a more precise color than the ordinary hemalum. Remove the acid by simply washing with water.

On account of certain defects found in Kleinenberg's mixture (alcoholic), Mayer recommends the following solution:

Hemacalcium:

Hematein or ammonia-hematein	1 gm.
Aluminium chloride	1 gm.

These should be rubbed together in a mortar very thoroughly.

Glacial acetic acid	10 c.c.
Seventy per cent. alcohol	600 c.c.
Calcium chloride	50 gms.

Mix the alcohol and acetic acid and add the hematein aluminium chloride. When dissolved add the calcium chloride. The fluid is red-violet in color. If the objects are stained too red, treat with two per cent. aluminium chloride dissolved in alcohol, or in a one-half per cent. to one per cent. solution of acetate of sodium or potassium in absolute alcohol.

For some purposes it is well to mix the hemacalcium with one-third of its volume of glycerine (*e.g.*, entoderm or tentacles of hydroids). It is said that the permanency of the fluid is good, but clearing with bergamot or clove oil causes an early fading. Certain oxidation or reduction changes are likely to occur in time and injure the preparations.

Delafield's Hematoxylin.—A well-known and exceedingly useful stain. It will keep for years. See Vol. III., p. 676.

Ehrlich's Acid Hematoxylin:

Water	100 c.c.
Absolute alcohol	100 c.c.
Glycerin	100 c.c.
Glacial acetic acid	10 c.c.
Hematoxylin	2 gms.
Alum in excess.	

This mixture should ripen until it assumes a dark-red color. It will keep for years in a well-stoppered bottle. Sections stain in a few minutes. The stain is suitable for coloring *in toto*, as over-staining does not occur. To get a blue stain, wash out with common drinking-water which is slightly alkaline. It is said that the addition of acetic acid prevents the alum from splitting up into free sulphuric acid, and a basic, lake-forming compound of alumina, as generally occurs in the ordinary (alum) hematoxylin solutions.

Haug's Hematoxylin:[b]

Dissolve hematoxylin	1 gm.
In absolute alcohol	10 c.c.
This is added to an aqueous solution of alum acetate (Liquor aluminis acetici)	200 c.c.

A good nuclear stain and useful in most methods for the nerves. It is quite durable but, like the other hematoxylins, it must be well ripened before use. It is more useful for section than bulk staining. The fluid has at

first a deep violet-black appearance, but after some weeks' ripening it assumes a brown-black color, much like Ehrlich's acid hematoxylin. After treatment for over-staining with acid alcohol, the sections are washed out in water till they become blue.

Gage's Hematoxylin :[78]

Distilled water	200.0 c.c.
Potash or ammonia alum	7.5 gms.
Chloral hydrate	4.0 "
Hematoxylin crystals	0.1 gm.

Place the water and alum in an agate or porcelain vessel and boil for five minutes or more. This is to destroy any germs in the water or alum. Let the solution cool and add sufficient freshly-boiled distilled water to replace what has evaporated from the original 200 c.c. Add the chloral hydrate and dissolve the hematoxylin crystals in 10 c.c. of ninety-five per cent. alcohol, and add to the mixture. Let it "ripen" for a week. If the stain is too concentrated, it may be diluted with freshly-distilled water, or with the mixture of water, alum, and chloral. If the stain is not sufficiently concentrated, add more hematoxylin. With the above sections are usually sufficiently stained in from one to five minutes. It has not been tested for bulk staining. "The boiling is to destroy any living ferments present in the water or alum, and the chloral hydrate is to prevent the development of germs which accidentally reach the solution after it is made."

Benda's Hematoxylin[13] for karyokinetic figures. — Treat the sections with a concentrated solution of cupric acetate for twenty-four hours, in a brood oven. Wash out thoroughly. Stain in a one per cent. aqueous solution of hematoxylin till the sections are black. Extract the superfluous color in hydrochloric acid, 1 to 500, until the sections are yellow. Neutralize the acid in a saturated solution of cupric acetate. Wash. Dehydrate and mount.

Cuccati's Alcoholic Hematoxylin :[14]

Iodide of potassium (C.P.)	25 gms.
Distilled water	25 c.c.
Dissolve and pour into absolute alcohol.	75 c.c.

Keep in a tightly-stoppered bottle and shake repeatedly.

Rub together in a mortar,

Crystallized hematoxylin	75 ctgms.
Alum (C.P.) (Neutral Potash)	6 gms.

Add of the above iodine solution 3 c.c., keeping the mixture well stirred, and gradually add the rest of the iodine solution. Keep in a well-stoppered bottle and leave from ten to fifteen days. Then shake well and after an hour or two filter, and preserve the filtrate very carefully to prevent evaporation and deposit of alum or iodide crystals. This fluid is said to stain only the chromatic part of the nuclei, the color being most deeply fixed in the karyokinetic figures. As over-staining does not occur, the sections may be left in the mixture almost indefinitely, and it is therefore also suitable for bulk staining. It is stated that with proper care the solution never goes bad.

Another Alcoholic Hematoxylin[15]—Make the three following saturated solutions: First, calcic chloride in seventy per cent. alcohol; second, powdered alum in the same percentage of alcohol; and third, hematoxylin in absolute alcohol. Mix one part of the calcic chloride solution with eight parts of the alum solution, and add the hematoxylin drop by drop until a deep purple color is obtained. The color becomes richer by time. If tissues have been hardened in any chromic or acid medium, they should be put into a five per cent. solution of sodium bicarbonate before staining; all trace of acid must be removed.

Iodized Hematoxylin[16] (Sanfelice):

(1) Hematoxylin	0.7 gm.
Absolute alcohol	20.0 gms.
(2) Alum	0.20 gm.
Distilled water	60.00 gms.

After dissolving, solution (1) is poured drop by drop into solution (2). The fluid is then exposed to the light from three to four days. Ten to fifteen drops of the tincture of iodine are added and the fluid, well shaken up, is allowed to stand for some days. Tissues stain in this mixture in from twelve to twenty-four hours. They are then transferred to ninety per cent. alcohol acidulated with acetic acid, in which they remain for the same length of time. Sanfelice believes that this gives the same stain as Böhmer's hematoxylin with tissues previously treated with tincture of iodine; it thoroughly penetrates pieces to be stained *in toto*. Owing to its antiseptic qualities, it keeps longer than most hematoxylins.

COCHINEAL. — Cochineal for some purposes is unrivalled. In aqueous solution it gives a greater richness of differentiation perhaps than alum carmine. In an alcoholic solution it gives a *direct* nuclear stain (Lee).

Partsch's Alum Cochineal.[17]—An old formula; its great utility for histological purposes is a sufficient justification for calling attention to it. Powdered cochineal is boiled for some time in a five per cent. solution of alum, the decoction is filtered, and a little salicylic acid added to prevent mould. Paul Mayer thinks that in some ways it is better than the well-known but later formula of Czokor.

Mayer's New Cochineal Formula :[18]

Cochineal	5.0 gms.
Calcium chloride	5.0 gms.
Aluminium chloride	0.5 gm.
Nitric acid (sp. gr. 1.20)	8.0 drops.
Fifty per cent. alcohol	100.0 c.c.

Pulverize the cochineal, and mix with the calcium and aluminium chlorides in a mortar. Add the acid and alcohol, and heat to boiling. Let the mixture stand a number of days, shaking frequently, and finally filter. The objects must be treated with fifty per cent. alcohol before and after entering the stain.

CARMINE.—Carmine is a most excellent nuclear stain, and pre-eminently adapted for staining *in toto*. The stain should have a slight alkaline reaction; the presence of too much alkali is injurious, rendering the solution unstable; the want of it, on the other hand, deprives the stain of very much of its differentiating effect. Fix the stain by treating with acetic or formic acid before dehydrating and mounting the sections. In botanical preparations, carmine stains most vegetable albuminoids, while starch and cellulose take it up slightly, or not at all.

To obtain the best results with carmine, especially ammonia carmine, on preparations hardened in bichromate, the tissue must be stained before going into alcohol.[2]

Carmine is not readily soluble, even in water, without the aid of some other agent, *e.g.*, ammonia or borax. Carminic acid, the basis of the coloring matter of cochineal and carmine, is readily soluble in either water or alcohol.*

Paul Mayer[18] found, after some experiments, that if carminic acid, or, better yet, ammonia carminate, be treated with acetate of alum, all the acid is precipitated as alum carminate. This substance has the peculiar property of being soluble in either acids or solutions of acid salts (*e.g.*, alum) or in alkalies, or in solutions of alkaline salts (*e.g.*, borax). Water or very weak alcohol must be used for the solvent. An alum solution stains nuclei in the same way as does alum carmine. The borax solution, though weaker, but with other things being equal, gives a redder color. The differentiation is very clear even when washed with water only.

Mayer's Carmalum.

Carminic acid	1 gm.
Alum	10 gms.
Distilled water	200 c.c.

Heat the mixture and filter. The filtrate will remain clear if an antiseptic is added. The solution is of a light red color, shading toward violet. It is said to have good penetrating powers even in osmium preparations, and it is claimed that it is better than alum carmine for staining *in toto*.

Simply washing out with water is likely to leave the

* For the various methods of preparing carminic acid, see the paper by George Dimmock, published in the American Naturalist, vol. xviii., p. 324, 1884.

plasma slightly colored; if this is not desirable use a weak alum solution, or in more stubborn cases weak alcohol. If a less amount of alum is used in the solution, a deposit will form after a time.

As an equivalent for Grenacher's alum carmine, Mayer suggests a one-tenth per cent. solution of carminic acid in a three to five per cent. solution of alum; this may readily be made in the following proportions:

Water	1,000 c.c.
Alum	30 to 50 gms.
Carminic acid	1 gm.

Dissolve without heat. This is a weaker and cheaper solution than Grenacher's, and gives a redder tone to the tissue. The absence of heat is an advantage. Like the alum carmine it requires an antiseptic—a crystal of thymol.

Mayer's Paracarmine:

Carminic acid	1 gm.
Aluminium chloride	½ gm.
Calcium chloride	4 gms.
Seventy per cent. alcohol	100 c.c.

May be dissolved cold or warm. Let it precipitate, and filter. The solution is of a clear red color. Washing out with acid is said to be unnecessary either for sections or masses. If found desirable to wash out for surface views, use a weak solution of aluminium chloride in alcohol, or alcohol with about five per cent. acetic acid. The objects do not become so fiery red after treatment with acid alcohol as with borax carmine. The time limit of staining depends upon the objects. This is claimed to be preferable to borax carmine, because it is in a stronger alcoholic solution, therefore a better preservative and not alkaline.

The carmine formulæ of Mayer have not yet been sufficiently tested to warrant a statement as to whether they are superior, or perhaps inferior, to some of the older formulæ for carmine stains, or if, indeed, they are as valuable to the carmines in general as his hematein method is to the hematoxylins.

An Alcoholic Acid Carmine:

Carmine	4 gms.
Hydrochloric acid	2 c.c.
Seventy per cent. alcohol	100 c.c.

Boil over a water-bath until dissolved, cool and filter. A good stain for general purposes. It is rapid in its action and differentiates well, and should be washed out with seventy per cent. alcohol.

Strasburger's Borax Carmine: [15]

Borax	4 gms.
Distilled water	56 c.c.
Dissolve and add carmine	1 gm.

One volume of this solution is diluted with two volumes of absolute alcohol, and filtered. The nuclei stain with great clearness.

Haug's Alum-Borax-Carmine: [9]

Carmine	1 gm.
Borax	1 gm.
Ammonia-alum	2 gms.

Pulverize and add

Liquor aluminis acetatis	100 c.c.

Boil the solution for half an hour or more. Decant and filter after twenty-four hours. It is good for use in a few weeks. Said to stain sharper and clearer than alum carmine and to be more permanent, also useful for bulk-staining. Wash out in water.

Haug's Ammonia-Lithium-Carmine:

Carmine	1 gm.
Ammonium chloride	2 gms.
Pulverize and boil in water	100 c.c.

After cooling add drop by drop,

Liquor ammonii caustici	15 to 20 c.c.
Pure lithium carbonate	0.3 to 0.5 (gm.?)

The stain should be filtered. It colors intensely immediately after its preparation. The solution is very permanent, and is especially recommended for preparations hard to stain. It gives a gorgeous strawberry-red color, and stains sections in from one to three minutes. Differentiate the over-stained sections in hydrochloric acid alcohol, then put immediately into absolute (picric) alcohol.

Delage's Osmic Carmine.[19]—Take a strong solution of carmine in ammoniacal water and evaporate it on a water-bath, until the appearance of red clouds on the surface indicates that the excess of ammonia has disappeared. After cooling, add an equal volume of osmic acid (one per cent.) and filter under a bell-jar. A very dark fluid is thus obtained which has the staining properties of carmine, and the fixative properties of osmic acid. At the end of some days this reagent loses its odor and becomes darker. The fixative qualities have disappeared. It is best, therefore, to mix the acid and carmine solution at the time of using. This mixture is said to bring out more minute anatomical features than gold chloride.

Anilins.—Anilin [20] ($C_6H_5NH_2$) is a colorless oil boiling at 183° C., partly soluble in water (1 to 31), and acts as a strong base, forming well-crystallized salts with acids. The anilin oils of commerce are a mixture of anilin with ortho- and para-toluidin (Benedict). When mixtures of anilin and toluidin are heated together with certain oxidizing agents—such as arsenic, chloride of tin, mercuric chloride, etc.—among the various substances formed are two compounds named rosanilin and pararosanilin. The dyestuffs under the anilin colors are derivatives of these. Benedict divides them into three groups: *basic*, *acid*, and *neutral coloring matters*. In dyeing the *basic* are always used in the form of their salts *i.e.*, of their compounds with mineral or organic acids. They all contain nitrogen atoms, and it is to the presence of these that they owe their basic properties. The *acid* contain hydrogen atoms, which can easily be replaced by metals. They possess the property of combining with bases to form salts with the simultaneous evolution of water. The *neutral* are not numerous, the only example given by Benedict is artificial indigo obtained from propiolic acid.

The anilins are derived from coal-tar, and must be of the proper quality to be of any use in histology. Many are inconstant, and not to be depended upon for permanent results. Some are soluble in water, others in alcohol only, and one must be largely guided in his selection of a dye by the method in which the tissue has been treated. It is believed that the dyes are best fixed with benzole, and that by the use of this fluid there is a greater probability of the colors remaining permanent in Canada balsam. These dyes, as a rule, are not adapted to bulk staining. Very few of them give a precise nuclear stain by the *direct method*. Two of them, methyl green and Bismarck brown, are pre-eminently nuclear stains. Some of the others may be made so with fresh tissues by combining them with acetic acid.

The majority give a diffuse color, which in some few cases may result in a most precise and useful stain, by the *indirect* method—decolorizing.

Lee classifies these dyes according to their use for *direct* or *indirect* staining—the latter is also known as the "Flemming" method. With the *indirect* method it is necessary to get as *strong a solution as possible*, and the sections must be *very thoroughly* stained. Up to a certain point, the more the tissues are stained, the better do they resist the washing-out process, which is an advantage. Washing out is generally done with (ninety-five per cent.) alcohol, but it is well to *just rinse* the sections in water before bringing them into the alcohol. Clove oil will *extract more color* from the tissues, and it is therefore better to use some clearing medium, such as cedar oil, bergamot oil, xylol, etc., which does not attack the stain.

Victoria Blue.—The specimens fixed in "Flemming's mixture" for some hours are stained in a saturated aqueous solution of the dye. Wash in pure alcohol, clear in cedar or bergamot oil. It is a brilliant and useful nuclear stain. Chromatin and nuclei are colored blue. The cytoplasm is colorless if well washed out; if not, green or greenish blue. The "spongioplasm" is very finely brought out by this method. The reagent has a special affinity for elastic fibres. For this Lustgarten recommends an alcoholic solution diluted with from two to four parts of water. It is believed that fixation in some

chromic mixture is a necessary condition. Stain for a long time.

Safranin.—This is one of the most important of the anilin dyes, on account of its various degrees of electivity for nuclei and other constituent elements of different tissues, and for its superior permanence in balsam. It is exceedingly necessary to have a *good safranin*. With no other stains are there, perhaps, so many grades. It is, therefore, quite essential to procure the dye from some reliable source. Grübler (Leipzig, Germany) supplies only such as have been found by experiment with tissues to furnish the desired stain. Münder (Göttingen) also furnishes reliable dyes.

Babes's Solution:

Water	100 parts.
Anilin oil	2 parts.
Safranin to excess.	

The mixture should be warmed to from 60° to 80° C. and filtered through a wet filter. This solution will keep for a month or two.

Zwaardemaker's Solution.—This is obtained by making a mixture of about equal parts of alcoholic safranin solution and anilin water (anilin water is simply a saturated solution of anilin oil—pure anilin—in water); shake up the two and filter.

Cyanin (*Quinolein Blue, Chinolinblau*).—Cyanin should be dissolved in ninety per cent. alcohol and the solution diluted with an equal volume of water. (The dye must be dissolved in the alcohol, it will not dissolve in the dilute solution.) This stain colors fatty matters an intense blue. As it has powerful staining qualities, it should be used in very weak solutions. It is said that if tissues be stained slowly in very dilute aqueous solution of cyanin they may be mounted in balsam and a fairly precise and nuclear stain may be obtained. This dye is also useful for staining Infusoria, which under certain conditions it stains during life.

Congo Red [22] (*Congoroth*).—An "acid" dye, the aqueous solution, however, having a neutral or alkaline reaction. It becomes blue in the presence of the least trace of a free acid. (A test for the acidity of tissues.) It is a diffuse stain, but seems to be used chiefly in staining axis-cylinders.

Benzopurpurin.—Weak aqueous solutions should be used for staining, which is effected in a few minutes, then wash out with alcohol. Zschokke [22] says that *Benzopurpurin B.*, is the very best contrast stain to hematoxylin known to him, because it is not apparently affected by alcohol, or the usual clearing agents.

Deltapurpurin.—This is of a more purple red, having properties similar to those of Benzopurpurin, and may be used in the same way.

Benzoazurin.[23]—This dye is used in dilute aqueous solutions. The sections are over-stained and decolorized with one-half to one per cent. hydrochloric acid alcohol. If a nuclear stain is desired, the sections should be withdrawn when the celloidin has become bleached. If the tissue-elements are also to be stained, they should be taken from the acid alcohol a little earlier. A beautiful blue nuclear stain is obtained, which is quite as distinct and sharp as that given by hematoxylin or carmine. Two points are made for this dye: (1) that it stains very readily old alcoholic preparations; (2) that preparations containing picric acid are little or not at all affected.

Eosin (*Erythrosin, Primrose soluble, Pyrosin B., Rose B. à l'eau*).—Eosin is obtained by the action of bromine upon fluorescine, and is chiefly used as a contrast stain to hematoxylin. Lee suggests that a solution of eosin in anilin water might give results very different from those obtained from the ordinary solutions. Most preparations of eosin are soluble in both alcohol and water; some, however, are soluble only in alcohol.

Picric Acid.—This is very useful for secondary or ground staining in connection with hematoxylin and various carmine solutions. It has considerable power of washing out anilins, and great care must be used in this connection.

For Fresh Tissues.—*Methyl Green* (*Methylanilin Green, Vert Lumière, Lichtgrün, Grünpulver, Vert en Cristaux*).—A most excellent nuclear dye. It should be used in the form of a strong aqueous solution containing a little acetic acid (about one per cent.). The solutions *must* always be acid. Wash with water (may be slightly acidulated) and mount in some acid aqueous medium containing a little of the methyl green in solution. In the nucleus it stains nothing but the chromosomes or nuclein element, leaving the nucleoli, caryoplasm, and achromatic filaments untouched. Outside of the nucleus it stains some kinds of cytoplasm and some kinds of formed material, especially glandular secretions. Extranuclear structures are in general stained in some tone of blue-violet. Staining is instantaneous, over-staining never occurs. The solution is very penetrating, killing cells instantly without swelling or other change of form, and preserving their forms for at least some hours, so that it may be considered a delicate fixative. It is a most useful reagent in amyloid degeneration. "Undoubtedly methyl green is one of the most valuable stains yet known."

Schneider's Aceto-carmine.[24]—An old formula, but most admirably adapted for fresh tissues. To boiling forty-five per cent. acetic acid, add as much carmine as will dissolve. (Forty-five per cent. holds the greatest amount of carmine.) It may be used in a weak solution—diluted to one per cent.—or strong. The latter fixes and stains at the same time, and is very penetrating, a quality which renders it of much use where common reagents would often fail. The stain is a pure nuclear one.

Bismarck Brown (*Manchester Brown, Phenylin Brown, Vesuvin, La Phénicienne*).—The dye is not easily soluble in water. It may be boiled, and filtered after a day or two, or acetic acid added (the acid destroys the permanency of the stain), or alcoholic solutions may be used. A convenient form is the following:[25]

Bismarck brown	2 parts.
Alcohol	15 parts.
Distilled water	85 parts.

The solution gives a light oak tint and forms a pleasing contrast to safranin or hematoxylin. The mixture must be filtered often. The dye never over-stains and is rapid in its action. It is a fairly pure nuclear stain, and will work well either with fresh tissues or with such as have been hardened in chromic acid. It also possesses the property of staining cellular elements during life, but must be pure and neutral. For general purposes the addition of carbolic acid has been recommended.

Trinkler's Vegetable Stain.[26]—The stain is obtained by extracting the chlorophyll from the leaves of *Syringa vulgaris* by means of alcohol. After twenty-four hours the filtered extract is evaporated to dryness and the residue dissolved in water. The solution is of a dark-green color tinged with brown.

Double Staining.—*Genevan Reagent.*[27]—Under this name is recommended a double-staining reagent found useful in the differentiation of vegetable tissues. It consists of a slightly alcoholic and ammoniacal solution of Congo red (two per cent.) and chrysoidin (one-fifth per cent). The section is first decolorized by *eau de javelle* and then immersed in this reagent for a few seconds, when a beautiful double or triple staining is obtained.

New Method of Double Staining [28] (Pianese).—There is first prepared a saturated solution of nigrosin in a saturated solution of picric acid in alcohol (Martinotti's solution). Two parts of this solution and one part of anilin water are next mixed and allowed to evaporate in the open air. The crystals deposited from this are dissolved in absolute alcohol. From the latter solution are obtained cubical crystals of an olive-green color, soluble in water, alcohol, or ether. With these crystals is made a two per cent. solution in alcohol for tissues, in water for micro-organisms.

The sections are first stained with Beale's carmine or Orth's lithium carmine, and having been treated with acidulated alcohol are washed and dehydrated. They are now immersed from two to ten minutes in the alcoholic solution of picro-nigrosin, until they assume a brown hue. They are next decolorized in an alcoholic solution of oxalic acid, dehydrated, cleared, and mounted.

The nuclei are stained red ; the plasma, a dark yellow ; connective tissue, a pale green ; elastic fibres, violet, and cartilage yellow. If it is desirable to stain micro-organisms at the same time as the tissues, the sections are, after having been stained with carmine, decolorized by Gram's method, or by the Koch-Ehrlich method for tubercle bacilli, and then are immersed for five minutes in the aqueous solution of picro-nigrosin, and the process continued as above.

Kossinski's Safranin and Indigo Carmine.[29]—Stain the sections from ten to twenty minutes in a saturated aqueous solution of indigo-carmine, wash with water and with alcohol and stain with safranin (0.5 per cent. in dilute alcohol), dehydrate, and mount.

"Metallic" Stains.—The discussion of this group of stains will be limited to those applicable *par excellence* to the nervous system, and will be treated of under the head of staining nervous tissue, in conjunction with certain other stains.

"Intra Vitam" Stains.—A very few dyes possess the peculiar property of staining the cells of living tissue without any very evident impairment of their powers. They are cyanin, methyl blue, Bismarck brown, Congo red, and under certain conditions dahlia and gentian violet, and some others whose action is as yet insufficiently known.*

The dyes must be used in an extremely weak neutral or alkaline solution, Congo being an apparent exception in that it is among the "acid" anilins and may be used in quite strong solution. Of all these methyl blue has received the greatest amount of attention on account of its special affinity for the peripheral nerve-endings. This dye will also be treated of under stains for nervous tissue.

Staining Nervous Tissue.—*Impregnation.*—Ramón y Cajal's[30] modification of Golgi's short silver nitrate method. Small pieces of the brain or myel are fixed in the following solution :

Potassium bichromate	3 parts.
Osmic acid, one per cent.....	25 parts.
Distilled water.....	100 parts.

Use plenty of the solution and change at least twice during the first day, keeping in the dark. Embryonic or adult tissue may be used, the former giving perhaps the best results ; since the fibres are as yet deprived of their myeline, the silver is more readily deposited in them. It should be left in the solution from twenty-four to forty-eight hours. Older tissue should remain two or three days. The hardening process is of very great importance : if it is insufficient the silver later will form a granulous precipitate ; if the hardening be too great, the precipitate will not occur at all.

After hardening, the tissue is washed in 0.25 per cent. solution of silver nitrate for fifteen minutes. It is then brought into a 0.75 per cent. solution of silver nitrate, to which has been added a little formic acid in order to favor the reduction of the silver. For the best results some care must be used as to the amount of the acid used. Van Gehuchten recommends one drop to each 100 c.c. of the fluid.

The tissue may be left in this silver solution from thirty-six to forty-eight hours. A longer stay does not ruin it.

If the hardening is of the proper degree, the silver nitrate will be deposited with extraordinary fineness in the nerve protoplasm as silver bichromate. The process thus far should have been carried on in the dark.

Kölliker recommends placing in forty per cent. alcohol before cutting free-hand, or better dehydrate in one hundred per cent. alcohol for one hour, then in celloidin one hour, and after an hour or two of hardening cut in the microtome. Put sections in creasote for a quarter of an hour, then in turpentine, and mount in xylol balsam without cover-glass. It is desirable that the imbedding process should be as short as possible. Van Gehuchten[31] transfers the specimens from the silver bath directly to strong alcohol, where they are left from fifteen to twenty minutes, then about a quarter of an hour in absolute alcohol. They are left about the same length of time in a solution of celloidin, then fastened to a holder and put into seventy per cent. alcohol to harden.

According to this process, sections can be cut in about an hour from the time the specimen has left the silver solution.

On account of the difficulty of obtaining successful silver precipitates in the sympathetic nervous system by the ordinary method, Ramón has suggested that double or even triple impregnations be made by re-immersing the tissue in the osmium-bichromate mixture, after it has passed through the silver baths. The reaction is said to be much more constant.

If a cover-glass be placed upon the balsam while it is yet soft, the sections soon become blurred or decolorized, the supposed reason being the irregular drying of the balsam causing a diffusion stream that carries off the silver precipitate. Greppin[32] uses hydrobromic acid to prevent this. As recommended by Ramón y Cajal, it is well to put the slides after mounting in an oven heated to about 40° C., so that the balsam may dry as rapidly as possible. Huber[33] employs a cover-glass after the following manipulation : The sections are mounted in turpentine balsam. The slide is held over a flame and gradually heated to avoid the formation of air-bubbles and to drive off the turpentine vapor, until the balsam is so thick that when cooled it becomes hard immediately. On the hot balsam a heated cover-glass is now lightly dropped and the preparation is said to remain durable.

Martinotti[34] has recommended the addition of five per cent. glycerine to the silver solution as favoring the reaction with the ganglionic cells and their nervous prolongations, and for obtaining preparations of extreme *délicatesse*. To prevent surface precipitates, he uses a pap of blotting-paper prepared in distilled water.

The silver method[35] colors deep black the nerve-cells with their protoplasmic processes and all non-medullated nerve-fibres, the neuroglia cells and their extensions a reddish-brown, while the vessels assume more of a reddish cast. At times certain lymph-spaces and a few medullated nerve-fibres are also colored. It is not yet settled whether the coloration depends upon an impregnation of the cell-bodies with the silver salt, or if it is simply an incrustation. Golgi, Ramón y Cajal, and Kölliker hold to the first idea ; it is only certain that with the non-medullated fibres it is an impregnation. The order in which the parts color most readily is as follows : the nerve-fibres, the protoplasmic processes, the nerve-cell bodies, the neuroglia cells, and the blood-vessels.

Golgi's Sublimate Method.[36]—An old but useful method. Very briefly, it consists of hardening the nervous tissue for fifteen or twenty days in potassium bichromate, and then passing it directly over to 0.25 or 0.50 per cent. solution of mercuric chloride. This is renewed as often as it becomes yellow, and the tissue should remain in the mercuric solution at least ten days. A longer stay will probably improve the results. The sections should be cut on a freezing microtome, and afterward thoroughly washed in water to avoid the formation of a black precipitate. They are best preserved by mounting in glycerin. The method is useful in demonstrating the nerve-cells with their processes, also the nuclei, and sometimes the blood-vessels.

The sublimate seems to be more limited than the silver nitrate method, as the more favorable results are obtained only from the cerebral cortex.

Signor Tal[37] modifies the above method by after-treatment with sodium sulphide. The mercury is changed into sulphide and the preparations become blackened ; the tissue that has not undergone the influence of this reaction is stained with a solution of Magdala red. The silver method is also said to be improved by this after-treatment with the sulphide.

Magini[38] recommends the substitution of zinc chloride in 0.5 to 1 per cent. solution for the sublimate. Sections are washed quickly in alcohol, imperfectly cleared with creasote, and mounted in damar.

The process is said to demonstrate better than Golgi's

* For a fuller discussion of this question, see Martinotti's paper, Zeit. f. Wiss. Mik., v., 305 (1888).

the finer structure of ganglion cells and their processes.

Cox's Sublimate Impregnation.[39]—The hardening and impregnating fluids are combined and allowed to act together for two or three months.

The mixture is as follows:

Five per cent. potassium bichromate.. 20 parts.
Five per cent. mercuric chloride..... 20 parts.
Five per cent. potassium chromate.... 16 parts.
Distilled water.....30 to 40 parts.

The reaction of the fluid should be as slightly acid as possible. The preparations are not permanent under a cover-glass in Canada balsam or damar, on account of the acidity of the medium or some other unknown cause. The sections must be cut in a freezing microtome. They are placed for an hour or two in a five per cent. solution of sodium carbonate, washed in water, placed for a short time in absolute alcohol, then in some oil, and finally covered with some rapidly drying resin [sandarac ?].

If they must be covered with a glass, the resinous layer should be allowed to dry and then covered with castor-oil. Then the cover-glass is put on and squeezed down so as to squeeze out the superfluous oil, or by using styrax, or a mixture of gum arabic and water, etc., the preparations may be kept intact under a cover-glass.

Obregia's Gold Modification of Golgi's Methods.[40]—The sections are transferred from absolute alcohol to the following solution:

Gold chloride, one per cent.....8 to 10 drops.
Absolute alcohol..... 10 c.c.

This should be made half an hour previous to use and exposed to diffuse light. When the sections are put into it, the containing vessel should be placed in the dark. In from fifteen to thirty seconds or longer the silver is gradually replaced by the gold, or the mercury changed into gold amalgam. The sections are quickly washed, first in fifty per cent. alcohol, then in distilled water, and finally in a ten per cent. solution of hyposulphite of soda for ten or fifteen minutes, and then washed in distilled water thoroughly. Too long an immersion bleaches so that the finer fibres disappear. The sections, after the proper degree of toning, may be stained as desired (Weigert's, alum carmine, etc.), and mounted in Canada balsam with cover.

Paladino's Palladium Chloride Method.[41]—Small pieces, 5 mm. thick, of the neuraxis, previously hardened in bichromate or sublimate, are left for two or three days in a one-tenth per cent. solution of palladium chloride, a trace of hydrochloric acid being added to insure the complete solution of the salt. The pieces are then transferred to a four per cent. solution of potassium iodide and left for an hour or two, then dehydrated and imbedded in paraffine. The paraffine is removed by xylol and the sections mounted in balsam. The reaction is favored by keeping in a dark place. The method is also applicable to the peripheral nervous system, and demonstrates the axis-cylinders particularly well.

Monti's Copper Method.[42]—Small pieces of nervous tissue are hardened in two to three per cent. bichromate or Müller's fluid, until they become quite firm. They are then immersed in a mixture of equal parts of a solution of copper sulphate and Müller's fluid. The reaction takes place after twenty-four hours. The stained elements appear of a blackish-yellow color in transmitted light, and of a reddish color in direct light. The reaction has been obtained in the small nerve-cells of the cortex and of the cerebral ganglia, in the small nerve-cells of the molecular layer of the cerebellum, and in the cells of the olfactory bulb, and in the fibres and neuroglia cells.

Berkley's Osmium-Copper-Hematoxylin Stain.[43]—A rapid Weigert method. Small pieces of the cerebrum, cerebellum, or myel, not more then 2.5 mm. thick, are fixed in Flemming's solution from twenty-four to thirty hours, in a temperature of 25° C., and then without washing transferred directly to absolute alcohol, which is changed twice during the following twenty-four hours, then placed from twelve to twenty-four hours in celloidin.

The knife must be well moistened with alcohol, and the sections must be very thin. They are washed in water and then brought into a saturated solution of copper acetate, and allowed to stand overnight in a small covered vessel; or, if it is desirable to expedite matters, the vessel containing the sections may be put on a water-bath and heated to a temperature of 35° to 40° C. for twenty-five to thirty minutes, and the copper solution allowed to cool.

The sections are washed again in water for a very short time, and finally carried into a hematoxylin solution which is prepared as follows: 50 c.c. of distilled water are boiled thoroughly for a few minutes in a flask and 2 c.c. of a saturated solution of lithium carbonate added; allow the boiling to continue a minute longer, and then add 1.5 to 2 c.c. of a ten per cent. solution of hematoxylin in absolute alcohol. The flask is then shaken and corked, and placed aside to cool. It is better to prepare small quantities of the solution as needed, since it deteriorates somewhat. The solution can be used at once, but it is better to allow it to stand for a day. After staining, the sections are thoroughly washed and put into Weigert's differentiating fluid of borax and potassium ferrocyanide, which may be diluted one-third with water. This decolorizing is an important part of the process. It is necessary that the fluid should penetrate the tissue quickly and that its action be not too long continued, otherwise a number of the finest medullated fibres will become decolorized. Usually one to three minutes are sufficient for the purpose. After decolorizing, wash the sections two or three times in water, then in alcohol, bergamot oil, and mount in xylol balsam. Sections prepared according to the above method should be of a blackish-brown color; the differentiation between white and gray substance is as clearly seen as with Weigert's method. Under the microscope the medullated fibres should appear blue-black-brown, the glia-substance yellow, and the nerve-cells colorless; or in case the chrome salts have not been completely reduced, some or all cells with their processes appear of a brownish-black color.

Ziehen's Method.[44]—The pieces of nervous tissue are to be placed for five weeks in a mixture of equal parts of one per cent. chloride of gold and one per cent. corrosive sublimate. The pieces are then sectioned in dilute lugol (one-quarter per cent.) solution. The medullated or non-medullated fibres, the nerve-cells, and the neuroglia cells are colored blue. In the ganglion cells the nucleus and nucleolus are clearly differentiated.

Benda's Picric Acid Method.[79]—Small pieces of nervous tissue are placed for two or three days or longer in a saturated aqueous solution of picric acid, washed in water, and the hardening continued in alcohol. Paraffine is preferred for imbedding, celloidin not giving good results. The sections are made as thin as possible and placed for some hours in a concentrated solution of iron sulphate (mordant); after careful and repeated washings they are transferred to a one per cent. aqueous solution of hematoxylin until they become of a deep-black color (about ten minutes). They are then bleached for about five minutes in chromic acid (1 to 2,000), washed well in water, dehydrated, and mounted in balsam. It is stated that not only are the fibres but the intimate structure of the ganglion cells made evident.

Upson's Gold Method for Axis-Cylinders and Nerve-Cells.[45]—Pieces of the neuraxis are hardened in the dark for four to six months in potassium bichromate, beginning with one per cent. and increasing to two and one-half per cent. Wash in water and complete the hardening by putting into fifty per cent. alcohol for the first two or three days, ending with ninety-five per cent. until the pieces are of a greenish color. Sections may be made with or without imbedding, but must be thoroughly dehydrated before proceeding. First method: Place the section for one or two hours in a one per cent. gold chloride solution to which two per cent. hydrochloric acid has been added. Wash in distilled water, transfer on platinum or paper lifter to the following solution:

Ten per cent. solution potash..... 5 c.c.
Ferricyanide of potassium..... a trace.

Wash in this for half a minute, then thoroughly in distilled water, and transfer to the following:

Acid. sulfurosum	5 c.c.
Tinct. iodi (three per cent.)	10 to 15 drops.
Mix and add liq. ferri chloridi	1 drop.

Let the section remain in this until it assumes a rose color. It is then washed thoroughly in distilled water, dehydrated in absolute alcohol, oil of cloves, and balsam.

Second Method: The section is immersed for two hours in the following solution:

One per cent. chloride of gold	5 c.c.
Ammonium vanadicum (sat. sol.)	10 drops.
Acid. hydrochlor.	3 drops.

After washing in distilled water it is immersed from thirty to sixty seconds in the following:

Ten per cent. caustic potash	5 c.c.
Ammonium vanadicum	a trace.
Ten per cent. permanganate of potash	10 drops.

The section is again washed and put in the following fluid:

Tin solution	15 drops.
Distilled water	3 c.c.
Iron solution	3 to 5 drops.
Acid. sulfurosum	3 c.c.

The tin solution is obtained by adding chloride of tin to three per cent. tincture of iodine, until the color becomes white or yellowish. The iron solution is a saturated solution of ferrum phosphoricum in distilled water. When the section has become red it is treated as in the first method. It is said that the results are splendid.

Marchi's Solution:[46]

Müller's fluid	2 parts.
One per cent. osmic acid	1 part.

Of great value in pathology in staining nerve-fibres in the earlier stages of degeneration, before sclerosis sets in (especially a few days after the establishment of a lesion). The degenerated medullated fibres are stained black while the rest remains almost uncolored. It is better to put thin pieces of the brain or myel into a large quantity of the solution (after previous hardening for ten days in Müller's fluid), and to leave them in it for a week or more; sections can also be stained by immersing in the above solution for a few hours. The further process is, as usual, mounting in Canada balsam.

Weigert's Method without Decolorizing.—The tissue is hardened in Müller's fluid and treated in the usual way with eighty-five per cent. alcohol, and then an equal length of time in absolute alcohol; then it is transferred to celloidin and finally imbedded. An important part of the process is the coppering. The imbedded pieces are allowed to remain for twenty-four hours in a mixture of equal parts of a seven per cent. to ten per cent. solution of sodium tartrate and a cold saturated solution of copper acetate, which is kept at an equable temperature of 38° to 40° C. They are then transferred to a mixture of equal parts distilled water and saturated solution of copper acetate for twenty-four hours, also in the incubator. The pieces may then remain in eighty per cent. alcohol until cut. The sections must be very thin to produce a sharp differentiation.

The staining fluid is composed of one part of the ordinary alcoholic hematoxylin solution (one to ten), as used for the old method, and nine parts of an aqueous solution of lithium carbonate. This mixture should be prepared as needed. The sections remain in the stain from four to twelve hours. They are then thoroughly washed in distilled water, dehydrated in ninety per cent. alcohol and cleared, first in anilin-xylol (two to one), and afterward in clear xylol, and mounted in xylol balsam. Care must be taken to employ the best balsam, otherwise the color will gradually fade from the specimens. If it is desirable to have the ground-work particularly light, the preparations can be washed in a very weak solution of acetic acid (⅛ per cent. to ½ per cent.), but a longer stay in distilled water usually suffices. The advantages claimed for this method are, that it dispenses with the tedious process of differentiation, and brings out more distinctly than the old method the finest medullated fibres, and the distinction between these fibres and the cells and other components of the tissue is more plainly marked.

It is said that Weigert's ordinary method can also be usefully applied to lymphatic glands and skin.

Hill's Modification of Weigert's Method.[15]—The object of the method is to render the nerve-cells and non-medullated fibres susceptible to the stain by previous treatment with carmine alum, or simply an alum solution. For good results the following process must be rigidly carried out: (1) Pieces of brain or myel are placed in a two per cent. to a two and one-half per cent. solution of potassium bichromate for six weeks. (2) The bichromate is washed out with an abundance of thirty per cent. alcohol, changed daily until no further color comes from the tissue. (3) The hardening of the tissue is completed in strong alcohol. (4) Pieces of convenient size are placed in water to remove the alcohol, and then for two days in a solution of carmine alum, prepared as follows: Place in a shallow dish carmine, potash alum, and distilled water. Boil for three hours, restoring the water to its original level from time to time as it evaporates. Both carmine and alum should be *in excess*. When cold the solution is decanted and filtered. (5) The tissue is then cut and the sections placed for twenty-four hours in a half-saturated solution of copper acetate. (6) The sections are then placed in the hematoxylin for eight hours at a temperature of about 40° C. (7) Decolorize to exactly the right degree in Weigert's bleaching solution diluted with an equal volume of water. It is safe to assume that the matrix of the tissue and the celloidin are decolorized at the same time.

Vasale's Modification of Weigert's Method.[9]—Three solutions are required: (1) Hematoxylin, one gm., dissolved in one hundred gms. of water by the aid of heat. (2) A saturated filtered solution of neutral acetate of copper.

(3) Borax	2 gms.
Ferricyanide of potassium	2.5 gms.
Water	300 gms.

The sections are removed from alcohol to solution (1) for three to five minutes, then for same length of time in solution (2), whereon they become black. They are washed quickly in water, and transferred to solution (3), wherein the ganglion cells, the neuroglia and degenerated parts are quickly decolorized, the medullated fibres remaining of a dark-violet color. Finally, the sections are washed thoroughly in water, dehydrated in absolute alcohol, cleared in carbol-xylol (three parts xylol to one part carbolic acid) and mounted in balsam. Alum or picro-carmine or Pal's method are recommended if a contrast stain is desired.

Mallory's Phospho-molybdic Acid Hematoxylin:[48]

Ten per cent. solution of phospho-molybdic acid	1 part.
Hematoxylin crystals	1 part.
Water	100 parts.
Chloral hydrate	6 to 10 parts.

Let the solution ripen for a week exposed to the sunlight. Filter before using; it can be used repeatedly. The sections stain in from ten minutes to an hour. Wash out in forty per cent. to fifty per cent. alcohol, changing two or three times. The celloidin becomes perfectly colorless. Then dehydrate and mount as usual. The best results are perhaps obtained by staining rather deeply for about thirty minutes and washing out thoroughly for thirty minutes or an hour. The ganglion cells and their processes, axis-cylinders, and neuroglia (seen especially well around the central canal of the myel) are all sharply stained of a deep blue color. If the specimens are left too long in the alcohol they lose their sharpness and clearness of detail. The staining fluid must be kept free from alcohol. The chloral hydrate retards deterioration. If the solution does not stain deeply enough, add a little more hematoxylin (Fig. 272).

Kultschitzky's Hematoxylin.[7]—Simpler than Weigert's. Pieces of brain or cord are hardened in Müller's or Erlicki's fluid and imbedded in celloidin. The sections are then placed in the following solution:

Hematoxylin (dissolved in a little alcohol)	1 gm.
Sat. aqueous sol. of boracic acid	20 c.c.
Distilled water	20 c.c.

A little acetic acid is added before using (two or three drops to a watchglassful). The sections should stain some few hours. The medullated nerve-fibres are stained blue, the rest of the tissue yellow or yellowish-red. If the sections are then placed for twenty-four hours in a saturated aqueous solution of carbonate of sodium or lithium, the nerve-fibres become dark blue, while all the rest becomes almost uncolored. Then pass through alcohol and mount in balsam.

A still more simple hematoxylin solution which is said to give the same result is :

Two per cent. acetic acid	100 c.c.
Hematoxylin (dissolved in a little alcohol)	1 gm.

Schmaus's Stains for the Axis-Cylinder in Sections of the Spinal Cord.[49]—Gierke's method is modified as follows : After previous hardening of the tissue in Müller's fluid, the sections are stained in the following solution :

Carminate of soda	1.0 gm.
Nitrate of uranium	0.5 gm.
Water	100.0 c.c.

The solution is heated for half an hour and filtered when cold. The sections are left in the fluid for fifteen to twenty minutes, and then washed in water. The axis-cylinders take the stain well, leaving the celloidin unaffected.

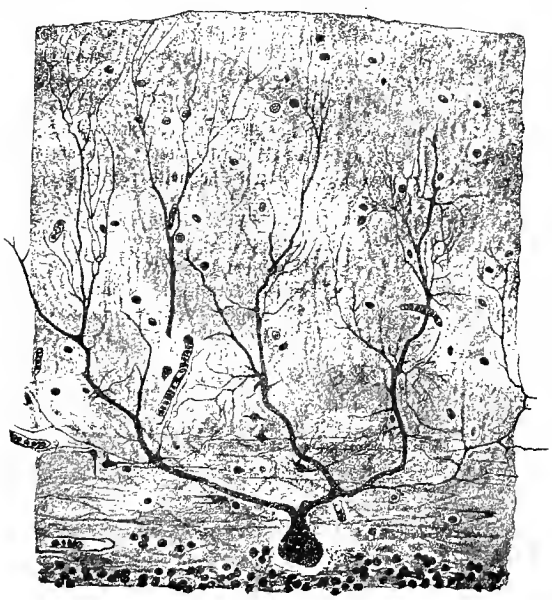


FIG. 272.—Purkinje's Cell.

Another method is to stain the axis-cylinders with English blue-black. The solution consists of one-quarter per cent. blue-black in fifty per cent. alcohol, with a little picric acid added. After an immersion of one hour the sections are washed and mounted.

Sig. C. Negro[50] has recommended a stain for the demonstration of the motor nerve-endings in striated muscle. It is practically Delafield's hematoxylin with some of the proportions slightly changed. The preparations are teased out on a slide, stained, washed, and mounted in a mixture of equal parts of glycerin and water.

Apáthy's method[29] for differentiating nervous and connective tissues consists of staining with Heidenhain's hematoxylin, and after-staining with very weak alum hematoxylin.

Methyl Blue.—Since the introduction of methyl blue as a staining agent for *living* tissue by Ehrlich[51] in 1885, with its special affinity for the peripheral nervous system, and the sensory fibres in particular, many new and important contributions have been given to science. It was at first believed that only the axis-cylinders of the sensory fibres took the stain. Arnstein[52] found in 1887 that the motor nerves and other elements stain as well, but later. The stain has already cleared up many doubtful points, and promises a solution to the nerve-ending problem. Useful as is Golgi's method in this connection, the methyl blue is in some ways superior to it. The stain seems to be more favorably adapted to the lower forms (cold-blooded). Mammals and birds soon die after the injection, and a true *intra vitam* reaction is not easily obtained.

The living tissue soon throws off the color unless some restraining agent is used. Iodine, picro-carmine, corrosive sublimate or picrate of ammonia may be used for this purpose. Various methods are employed with greater or less success. That of Professor S. Mayer[29] is among the recent ones, and probably as successful as any. The process consists essentially of two parts : first, the staining of the tissue, and second, the fixation of the stain. The staining solution is made by dissolving one gm. of the methyl blue in 300 to 400 c.c. of a one-half per cent. salt solution. The "fixing" solution is composed of a cold saturated solution of picrate of ammonia diluted with an equal volume of pure glycerin. The staining fluid is injected into a blood-vessel of the animal, or pieces of the fresh tissue are soaked in the fluid, or the animal itself immersed in the solution without immediate danger to life. The amount injected varies with the size of the animal. Six to eight cubic centimetres[47] are generally sufficient for a frog, the coloring usually taking place in from one to three hours. Small pieces of the object are immersed in the picro-glycerin, and are at once ready for examination. If suitable for a permanent preparation, the cover can be fastened down with a mass composed of equal parts of wax and resin. The picro-glycerin changes the color, all shades of red, brown, and black being seen in the axis-cylinders and the non-medullated terminal nerve-expansions. This is compensated for by the clearing up of the preparation and the permanency of the stain. The method is simple and rapid. Small pieces, as fresh as possible, are placed for about ten minutes in the methyl blue solution; they are then well washed in a one-half per cent. solution of salt and examined at once in the picro-glycerin ; the operation being complete in about thirty minutes.

Professor A. S. Dogiel[9] has found that the addition of osmic acid to the picrate of ammonia solution is attended with several advantages, in that it hardens the tissue just a little and stains the medullary sheath of nerves black. The solution is made by adding 1 or 2 c.c. of a one per cent. osmic acid solution to 100 c.c. of a saturated aqueous solution of ammonium picrate. The stain is fixed by immersing the preparation in this mixture from eighteen to twenty-four hours. It is then transferred to glycerin diluted with an equal volume of water, in which the color of the nerves will keep for a long time. If it is desirable to render the object firmer for sectioning, a stronger solution may be used as follows :

Picrate of ammonia (sat. sol.)	25 to 30 c.c.
One per cent. osmic acid	1 to 2 c.c.

The specimen remains in this for twenty-four hours, after which it may be imbedded in elder pith, liver, etc., and sectioned.

Parker's Method of Imbedding Methyl Blue Preparations in Paraffine.[53]—A concentrated aqueous solution of corrosive sublimate was found to be the best fixative for the stain. The object was left in this for about ten minutes. It was then dehydrated for fifteen minutes in solution (A) made as follows :

Methylal	5 c.c.
Corrosive sublimate	1 gm.

The next step is to remove the sublimate and replace gradually the methylal by xylol. To accomplish this the object is put for ten minutes into the following solution (B) :

Methylal	1 vol.
Solution A	1 vol.
Xylol	2 vols.

It is then transferred to an abundance of xylol for four or five days, and then it may be mounted as a transparent specimen in xylol balsam, or imbedded in paraffine

and cut in the usual manner. The sections should be fixed to the slide with Schällibaum's collodion. Mayer's albumen discharges the color. It is said that after an interval of a month the finer details of the specimen are likely to fade.

Blood. *Biondi's Method.*—The aim has been to find a method which would preserve the morphological elements intact by means of good *fixation, preservation, imbedding, and mounting*, or to treat blood as a solid tissue. The process is equally useful in the study of other fluid tissues, and has been successfully applied to the study of the maturation of the spermatozoa, and, as suggested by the originator, may doubtless be used to advantage in the study of the Infusoria. The material used for imbedding is *agar*, the columnar form (*Säulen Agar*) is considered the best. Long and explicit directions are given for the preparation of it, which may be consulted in Biondi's paper in the *Archiv für Mikroskopische Anatomie*, vol. xxxi., p. 103 (1887), or in an abstract of the paper published in the *American Naturalist*, vol. xxii., p. 379 (1888). The essential points are to get a very clear preparation and to keep it *sterile* until used.

By the aid of a pipette blood is taken from the heart of a frog, and two drops of it allowed to fall into 5 c.c. of two per cent. osmic acid. Shake immediately in order to scatter the corpuscles; after standing a few minutes the corpuscles will sink to the bottom of the vial, the deeper layer being formed mainly of the red ones, since their specific gravity is greater. They are left in the acid from one to twenty-four hours. When fixed, four to five drops of the mixture are dropped into the melted agar. By rotating the tube the corpuscles are distributed through the agar, the whole mass is poured into a paper box (as in paraffin) and allowed to stiffen. It is put into eighty-five per cent. alcohol for hardening, where it remains from three to six days, until it becomes hard enough to section, when it may be enclosed in elder pith and cut; or if finer sections are desired, the block of agar is transferred from the eighty-five per cent. alcohol to oil of bergamot for twenty-four hours, then direct to soft paraffine kept at a temperature of 45° C. After one or two hours the process may be completed in the usual way. The paraffin saturates the block, and the sections may be freed from the paraffin by the usual solvents and then stained. Almost any stain is suitable. Methyl green, methyl blue, fuchsin, and safranin, are mentioned as giving very reliable results. The agar itself does not stain, except with the most intense anilins (*e.g.*, gentian violet), but may be most easily decolorized with alcohol or any other bleaching fluid. The sections may be cleared in the ordinary clearing reagents except xylol, which causes the sections to curl. Mount in balsam or damar.

Auerbach's Method for Amphibian Red Blood Corpuscles.[54]—It is claimed that the corpuscles are invested with a colorless membrane. By allowing a drop of blood, carefully protected from loss of fluid, to stand for some hours, the substance of the corpuscle after a time recedes from the membrane, and the addition of a little physiological salt solution causes the membrane to swell up like a bladder. Hardening in a saturated picric acid solution and subsequent washing with water is said to demonstrate this still better. If such a preparation be stained with eosin and anilin blue, the membrane takes on the blue stain, and the adjacent layer the red. The membrane can be made to swell up and burst, allowing the contents to escape, leaving the empty sac behind, by treating with 0.1 per cent. to 0.25 per cent. solution of sublimate, one per cent. solution of boracic acid, one per cent. sodium chloride, or two per cent. to ten per cent. chromate of ammonia. Two parts are noted in the cell-body, a cortical and a medullary substance. The cortical portion in unstained sublimate preparations appears of a structureless homogeneous substance, colored reddish-yellow by the hæmoglobin. It is said to contain all the hæmoglobin of the corpuscle. This cortical or hæmoglobin layer also has a peculiar contractility, which causes a wrinkling of the surface.

In picric acid preparations, the cortex shows a very beautiful network, an unnatural condition due to the formation of vacuoles.

The medullary substance is colorless. In sublimate preparations dark granules appear scattered about. In picric preparations it appears clear like a large hole. In the nucleus are imbedded several nucleoli. In *Rana* from eight to sixteen are found, in the Urodeles still more, and in *Triton tæniatus* as many as forty. In the Urodeles their diameter is from 1.2 to 2 μ. As a rule, they are not connected with each other, so they do not form the junction-points of a network. In the adult animal these nucleoli usually stain blue; hence they are termed cyanophilous. In the larval condition a few of them will stain red (erythrophilous); while at a still earlier stage, there is but a single large nucleolus composed of both substances.

Gage's Method of Demonstrating Fibrin Filaments.[55]—A drop of fresh blood is placed on a cover-glass or slide, arranged as in B or C, Fig. 273. The preparations are then put into the moist chamber A to prevent drying. After ten to thirty minutes a drop of water is drawn around the edge of the cover, which is then raised, the fibrin generally adhering to it. The specimen is thoroughly washed in normal salt solution or water, and stained for three or four minutes in an aqueous solution of hematoxylin, followed by eosin for one minute. Wash and set the preparation on edge to dry spontaneously. When dry it is put over a shallow cell of some good cement. Thorough dryness is very necessary.

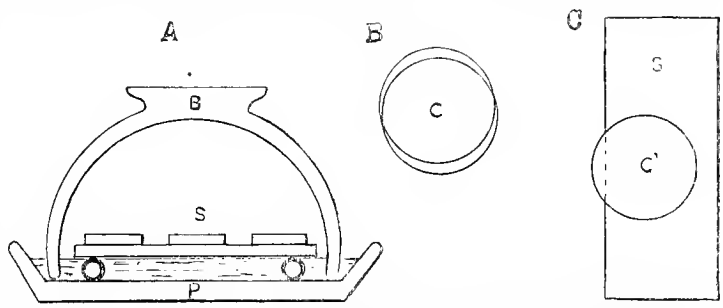


Fig. 273.—Fibrin Apparatus. *A*, Simple Moist Chamber; B, bowl serving as bell-jar; P, plate containing water; S, slides holding the preparations. They rest upon a bench made by cementing short pieces of large glass tubing to a strip of glass of the desired length and width.
B, Cover-glasses, made Eccentric (C) for more Convenient Manipulation.
C, Slide (S) with Projecting Cover-glass (C), so arranged in order to prevent the folding of the fibrin when the cover-glass is raised.

The network is much coarser in mammalian blood or lymph than in that of a cold-blooded animal, *e.g.*, frog or necturus. With the latter it is necessary to work with the greatest rapidity, as coagulation occurs much more quickly than in mammals.

Watase's Method for Differentiating Sexual Cells.—The following modification is adopted by Watase from Auerbach. The sexual cells, either in the testes, ovary, or in the hermaphroditic gland, where both male and female cells often exist side by side, are killed in Auerbach's fluid, or simply in a saturated aqueous solution of corrosive sublimate, and cut in paraffin in the ordinary way. Use Mayer's albumen, or better still, dilute alcohol or distilled water for fixing the sections to the slide, as the latter bias the tissue least for staining. Make a standard solution (A) of anilin water by dissolving anilin oil in water. Add enough alcohol to make a twenty per cent. solution.

For a blue stain (B) take:

Cyanin B. B.	1 gm.
Standard solution (A)	100 c.c.

For a red stain (C):

Chromotrop R. R.	1 gm.
Standard solution (A)	100 c.c.

A more powerful red stain (D) is as follows :

Erythrosin..... 1 gm.
Standard solution (A)..... 100 c.c.

For contrast staining it is immaterial which solution, (B) or (C), is used first.

If solution (D) is employed it should be used before the blue. The sections stain very quickly. Wash in fifty per cent. alcohol and proceed as usual. The anilin colors above mentioned may be used either in alcoholic or in aqueous solution without the anilin oil.

The nucleus of the ovum takes on a red color, while that of the spermatozoon becomes blue, indicating that the nuclear substance of the female cell is *erythrophilous* (Auerbach) ; that of the male, *cyanophilous* (Auerbach).

Different stages in the development of the spermatozoon, as in mammals, are indicated by different tones of color. At the beginning (spermatogonium stage) the color is *violet*, probably due to a mixture of the blue and red ; at the next stage (spermatocyte) the color is decidedly *green*, with one or two erythrophilous nucleoli ; another stage (spermatide) is *greenish-blue*, and the final (spermatozoon) is a *deep blue*. Sexual differentiation has been successfully demonstrated by Auerbach, Balbiani, and Ryder, but with different methods. Dr. Watase has succeeded in differentiating the sexual cells in the following animals : asterias, unio, limax, loligo, necturus, diemyctylus, rana, bufo, tortoise, fowl, mouse, rabbit, cat, dog, and man. He has also very recently obtained successful results in the sexual cells of Tunicates, by the use of the Biondi-Erlich triple mixture (aqueous solution).

The Permanent Preservation of Caustic Potash and Nitric Acid Preparations.—It was found that thirty per cent. to fifty per cent. aqueous solutions of caustic potash act with great rapidity upon intercellular substance, but quite slowly on cellular elements. Weak solutions dissolve all the elements quite rapidly. The action of the strong solutions can be checked at any time by means of a sixty per cent. solution of potassium acetate, or by the addition of enough glacial acetic acid to neutralize the caustic potash and form acetate of potash.

Perfectly fresh tissue should be used, but should not exceed half a cubic centimetre in size, and fifteen to twenty times as much potash should be taken. When the elements separate readily, the caustic potash is poured off and replaced by an abundant supply of a sixty per cent. solution of acetate of potash, to which one per cent. glacial acetic acid may be added. The isolated elements can be mounted in acetate of potash, glycerin, or glycerin-jelly. If staining is desirable the tissue, after removal from the acetate of potash, is washed thoroughly in water. It can then be colored with hematoxylin or alum carmine.

Nitric acid is used in a twenty per cent. aqueous solution ; the length of treatment varies with the temperature ; ordinarily one to three days are required. If heat be judiciously applied it may be completed in a few minutes. The acid is thoroughly washed out with water. Put the tissue into the following solution :

Saturated aqueous solution of alum ... 100 c.c.
Chloral hydrate..... 2 gms.

The nuclei are then stainable in aqueous hematoxylin. After the usual processes the preparations are mounted in glycerin jelly or balsam.

Imbedding Methods.—The *raison d'être* of imbedding is to fill up the interstices as well as the tissues themselves, with a more or less firm material, in order that the specimen may be cut without being torn or distorted. This is the end aimed at by all infiltration methods. Practically, there are two methods now in vogue : paraffin and collodion (celloidin). Each has many ardent adherents, and each in some way possesses advantages over the other. Paraffin requires heat ; sections of very large objects are likely to split, and are necessarily rather thick. With small objects much thinner sections can be cut than with collodion ; the adhering of the sections to each other in the form of ribbons is very convenient for serial work. With collodion heat is unnecessary. It is a cleaner and perhaps shorter method than with paraffin, but except for large objects, the sections under the most favorable conditions are thicker than by the paraffin method.

A safe rule to follow is to use paraffin for small objects, collodion for large, or where very thin sections are not so essential. These methods are so extensively employed that any detailed description is obviously out of place here, and what follows will be strictly limited to some of the various modifications that have been suggested within the last few years.

Lee withdraws his preference, except for small and easily penetrable objects, from chloroform as a clearing and infiltrating medium for specimens before going into paraffin. He finds it deficient in penetrating power for large objects, and somewhat tedious to remove before putting the specimen into pure paraffin. Cedar-wood oil is found preferable, as it penetrates rapidly ; preserves delicate structures ; mixes readily with paraffin, and does not make tissues brittle though they may be kept weeks or months in it.

Przewoski's Method.[57]—As a safer, more economical, and more easily applied method than absolute alcohol, this writer recommends that the object be transferred from ordinary alcohol to anilin oil, and left there for at least twenty-four hours. It is then wiped, and the anilin oil removed by soaking in chloroform for twenty-four hours. It is then immersed in chloroform paraffin (forty per cent.), and the next day in melted paraffin, which must be cooled down as soon as possible to prevent its becoming brittle. The anilin oil may be previously dehydrated by distillation, or by dropping therein a piece of caustic potash.

It is doubtful if this method possesses any real advantage over that proposed by Lee. If the cedar-oil has the merit claimed for it, the above process might be abridged by transferring the object from the anilin-oil to the cedar-oil, and then direct to paraffin.

Paraffin Infiltration by Exhaustion.—Mr. A. Pringle states that this method is of great value in ordinary work. The preparation in melted paraffin is placed in an air-pump and the pumping continued as long as the air-bubbles arise. The paraffin is to be kept melted the whole time. The advantages claimed are : "great celerity, certain and complete infiltration, certain removal of the solvent, absence of distortion of the tissue-elements, obviation of necessity for prolonged heating of the objects, possibility of using the same paraffin over again, pecuniary economy." Preference is given to chloroform infiltration.

The rolling up of paraffin sections is often a source of great annoyance to the biologist. It is said that after the removal of the paraffin by turpentine or benzine, the sections, if brought into concentrated carbolic acid, will unroll themselves safely and float on the surface of the liquid.

Fixation of Sections to the Slide. *Method for Fixing and Flattening Paraffin Sections.*[59]—The sections are placed on a dry slide or are moistened with seventy per cent. alcohol. The slide is placed on a horizontal metal plate kept sufficiently warm to soften paraffin. Enough alcohol is poured on to just float the sections. As the paraffin warms the wrinkles disappear. When all the alcohol has evaporated the paraffin may be just melted and then dissolved with benzol or xylol, and finally mounted in balsam. Care must be taken that the metal plate does not get too hot, for if the paraffin melts completely the sections are unsupported. This is a modification of Canini's method, devised by Mr. H. E. Durham.

Gulland's Method.[60]—For serial sectioning, care must be taken that the side of the paraffin block meeting the razor, as well as the opposite edge of the block, is coated with a layer of soft paraffin, and that these edges are parallel with each other.

The ribbons are cut to the proper lengths, floated on warm water (not warm enough to melt the soft paraffin). The ribbons in their proper position are floated upon the slide, which when full is set up on end until the water is thoroughly drained off. The slide is then exposed to a temperature a little below 50° C., where the paraffin of

the sections is not melted, but the water rapidly evaporates. When the evaporation is complete the sections adhere to the slide. The time varies according to the thickness of the section. One hour usually suffices for thin sections. The important point is that the *paraffin must never be melted until the last trace of water has disappeared from the slide.* After complete fixation the paraffin is melted and then washed off with turpentine or xylol.

Gaule's Fixative.[61]—The slide is brushed over with weak alcohol (forty to seventy per cent.); stronger alcohols evaporate too quickly. The sections flatten out on this film, and, if thin, adhere with great pertinacity when the alcohol has evaporated and the slide is perfectly *dry.* "This is no fixative in itself, but simply a means by which the albumin molecules of the section are brought into the same adhesive contact with the glass as those of ordinary fixatives."

Born and Wieger's Fixative.[62]—It is claimed to surpass Giesbrecht's shellac, Mayer's albumin, and Schällibaum's clove-oil and collodion fixatives. It is prepared by adding to every two volumes of quince mucilage (mucilago cydonii) one volume of pure glycerin and a little carbolic acid to prevent fungi. A thin layer of the fixative is spread upon the slide and the paraffin sections placed thereon. No heat is employed; the glycerin prevents the adhesive layer from drying too quickly. Put in a warm place (30° to 40° C.) for twenty minutes or longer. When the water has all evaporated the paraffin is washed out with turpentine, and the slide transferred to absolute alcohol for half an hour at least. Stain with any kind of dye, wash, and proceed as usual. Adhesion remains perfect throughout, and the fixative takes no trace of color; even under the microscope can it scarcely ever be perceived. Two important points in this process are to be remembered: The first is that the slide must be perfectly clean, otherwise the fixative may fail to adhere properly. It is recommended to lay the slides for half an hour in cold soap and water, and dry them carefully with a clean cloth. The second point is, don't transfer the slide from the alcoholic bath directly to water; it should pass at least through one intermediate grade (fifty per cent.), otherwise the diffusion currents are quite likely to separate the section from the slide.

Collodion Imbedding.—Various opinions exist as to the relative merits of collodion and celloidin. The latter is said to be "merely a patent collodion." Lee inclines toward Duval's view, that celloidin has no real advantage over collodion, while the former has the advantage of being more transparent. Apáthy's recommendation, that the celloidin be allowed to dry until it becomes yellow, transparent, and of a horny consistency before dissolving in ether and alcohol, is a great advantage.

After the imbedding of the object in collodion, the collodion may be further hardened, after a short exposure to the air, by immersion in chloroform or alcohol. For general use, except for large objects, chloroform is to be preferred, because it is more certain, rapid, and gives a better consistency to the mass. Alcohols from thirty to ninety per cent. have been recommended for this purpose. The stronger the alcohol, the more likely it is to soften the mass and prevent good results in cutting. From seventy to eighty per cent. alcohols are commonly used, and are to be recommended.

Bumpus's New Method of Using Celloidin for Serial Section Cutting.[63]—"It allows a perfect orientation; the entire object is visible during the process of cutting. Yolk-bearing eggs offer no serious difficulty; sections of large area and of unusual thinness are easily secured; crimping and curling during the process of clearing are avoided, and the sections may be readily arranged in series. After imbedding in a paper tray and hardening in chloroform, and after the paper is removed, the hardened block of collodion containing the object is put into a vial of white oil of thyme, or some other similar oil. The block will become as clear as glass. The specimen is then oriented, and the side of the block to be fixed to the object-holder is wiped dry of the oil and immersed for a moment in ether, and then smeared with thick collodion. The object-holder, a block of wood rather than cork, is smeared in the same way, and the two collodionized surfaces are brought together. The holder and collodion block are now immersed for a few minutes in chloroform, or long enough for them to become firmly united. The preparation is now screwed between the jaws of the object-carrier of the microtome, and covered by means of a camel's-hair brush with oil of thyme. The microtome knife is flooded with the same oil. The oil which thus takes the place of the alcohol commonly used has the advantage, because of its lubricating property, of not only permitting thin sections to be cut, but its slow evaporation allows one to leave his work at any time for minutes, or even hours, without injury to the object. The object satisfactorily oriented, is now cut, and the sections at once transferred to the slides, covered with balsam, and mounted, or, if they are not immediately needed, they may be kept indefinitely in a vial of the oil.

"If the sections are to be arranged 'in series' they are simply placed upon the slide one after the other, care being taken not to flood the slide with oil but to keep it quite dry. After the sections are arranged the slide is tilted up to allow the excess of oil to drain away, fifteen minutes generally being sufficient. Balsam is now placed on the sections, and a warm cover is allowed to fall gently over the series, no section of which ought to leave its place. The above method is especially useful in the preparation of larger yolk-bearing eggs. . . ."

The following method of Eycleshymer's[64] is of great practical utility and abridges considerably the ordinary manipulation of collodion technique. The knife is kept wet with seventy per cent. alcohol. "As fast as cut the sections are drawn back upon the blade of the knife by means of a needle, and arranged in a single row until the blade is filled. To remove them a heavy paper spatula is placed directly upon the section to which it adheres, and may be drawn off the edge of the knife and transferred to the slide. By slight pressure, together with a rolling movement, the section is left in the desired position, sufficient alcohol is kept upon the slide to prevent drying, but not enough to allow the sections to float. When the requisite number have been arranged they are covered with a strip of toilet-paper, which is held on the slide by winding it with a fine thread. [The thread should pass between the sections; if across, the stain is not likely to act there, and a clear disfiguring line will be the result.] The sections being thus firmly held in position may be stained, etc. They should not be placed in absolute alcohol but cleared from ninety-five per cent. in a mixture of equal parts of bergamot-oil, cedar-oil, and carbolic acid. When cleared the excess of fluid is removed by a piece of blotting-paper; with gentle pressure sections which are by chance loose are firmly fixed in position, the thread is now cut, the strip of paper rolled back, balsam and cover applied.

"If the object can be stained *in toto*, which is often the case, much time may be saved by the following method: The stained object is imbedded in the usual manner, but after hardening in chloroform and removing the paper, the celloidin block is transferred to ninety-five per cent. alcohol for twenty-four hours, then to carbolic acid (Bumpus advises white oil of thyme) or glycerine, in which it becomes as transparent as glass (Eycleshymer has since found that the clearing mixture given above answers the same purpose as the carbolic acid but requires a little longer time). The block is fixed in the usual manner.

"Orientation is now accomplished with the greatest ease. In cutting, the knife is wet with the clearing medium given above. The sections may be arranged in serial order on the knife-blade until a slideful is obtained, when they are transferred and balsam and cover applied. By this method long series may be readily handled. Glycerin is used only when the mounting medium is glycerin; in this case the knife is wet with glycerin."

Kultschizky's Celloidin-paraffin Method.[1]—The purpose is to combine the advantages common to each method. After the object is removed from the ether and alcohol

bath it is put into a solution of celloidin of any strength, where it remains for twenty-four hours; it is then transferred to origanum-oil, and then to a mixture of paraffin and origanum-oil, which has been heated to 40° C., and finally to melted paraffin. Its stay in these various solutions varies according to the characteristics of the specimen to be imbedded. The advantages claimed are that very fragile objects can be imbedded; that very thin sections, owing to the celloidin, do not break up, even though the paraffin has given way; that it is not necessary to use an alcoholic drip while cutting; that sections of the same tenuity as those from paraffin imbedding can be obtained.

Ryder[65] modifies the above method by substituting chloroform for the oil of origanum. The sections may be mounted direct from the chloroform (clearing-bath), but the chloroform must not be allowed to evaporate before the section is covered with balsam.

Soap Masses.—These possess many good qualities, they are transparent and very penetrating, and a good mass is said to cut much better than even paraffin. Cutting may be done dry or with alcohol. The mass is alkaline, which is against it for the preservation of tissues, but, according to some, an advantage in clearing up the specimens. It has also been claimed that less shrinkage is produced than with paraffin.

Poli's Glycerin Soap.[16]—A mixture of equal volumes of glycerin and ninety per cent. alcohol are heated in a water-bath to 60° or 70° C. Into this are dropped as many small pieces of glycerin soap as will dissolve. A flask with its neck plugged with cotton, to prevent evaporation, is best adapted to this process. The liquid thus obtained is yellow and transparent, but with a slight opalescence. It is then poured into a capsule or paper box. While it is still warm the object to be cut, and which has been removed from strong alcohol, is fixed in the desired position by means of needles until the soap has solidified. Large pieces must be soaked for some time in a cold saturated solution of soap before they are removed to the warm fluid. The imbedding mixture, which should be kept in a stoppered bottle, melts easily at about 40° C. Very small objects may be imbedded by placing them in a drop of the warm solution on an object-holder and covering them with another drop; with such small quantities the soap gets quite hard in about a quarter of an hour.

The sections are freed from the soap by washing in lukewarm water, while the alkalinity of the soap aids in clearing up the object.

In practice it is found advisable to use two solutions, one for firm and the other for delicate objects. The strong solution is:

Ninety per cent. alcohol	32 c.c.
Pure glycerine	32 c.c.
Soap	64 gms.

The weak solution contains only one-half (32 grammes) as much soap, and is consequently much softer. The mass is said to work very well indeed with delicate botanical objects, and is also recommended for its great transparency and easy solubility in water.

Clearing Agents.—The functions of a "clearer" are to displace alcohol, to render dehydrated preparations transparent and to facilitate the penetration of balsam or any other resinous material in which the specimen is to be mounted. For rendering thick sections transparent a mixture of cedar and clove oil has been recommended.[47] The proportion varies with the quality of the oils. A convenient rule is to begin with two-thirds oil of cedar and one-third oil of cloves, stirring with a flint glass rod. When the rod is no longer visible in the mixture, the correct index of refraction is obtained. A small proportion of Venice turpentine is sometimes added.

Mounting Media.—Under this head will be considered a few forms, chiefly resinous, intended for the permanent preservation of microscopic objects. Canada balsam and damar are in such common use that a mere mention of them is sufficient. Kleinenberg has recommended a solution of *Colophonium* in turpentine. The medium sets slowly but gives good definition.

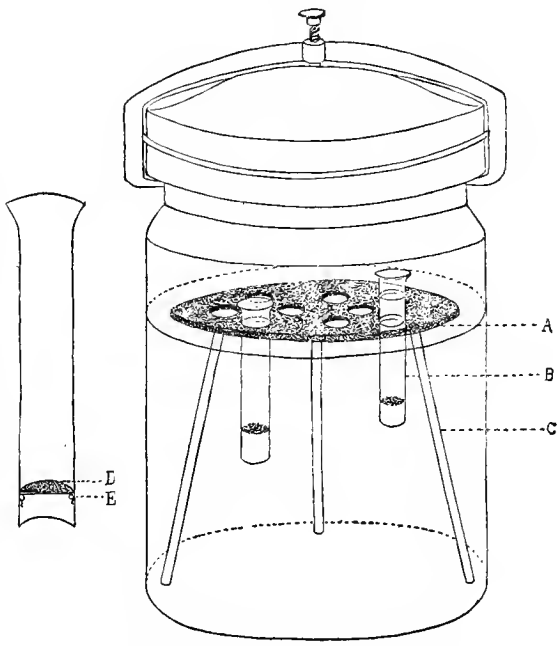
Lavdowsky's Medium.[66]—Two formulæ are given, the first for a thick, and the second for a thin, solution.

Gum sandarac	30 gms.
Absolute alcohol	50 c.c.

For the thin solution dilute this with an equal volume of absolute alcohol. This medium also clears the sections.

Venice Turpentine.[29]—All the advantages and some superiority over the ordinary resinous media are claimed for this preparation. Commercial Venice turpentine is mixed in a tall cylinder glass with ninety-five per cent. alcohol and allowed to stand for three to four weeks and then decanted. A clear yellowish, or sometimes greenish mixture is obtained. And this is at once ready for use. The ordinary solution of Canada balsam is the most suitable consistence for the Venice turpentine. It is stated that most objects can be mounted in this without previous clearing. It sets as closely as damar. Its index of refraction is lower than the above-named balsams, and delicate details are well brought out. Stains are well preserved.*

Cassia-Oil.[67]—This has been recommended as being



Figs. 274 and 275.—Dehydrating Apparatus.

very successful in showing the markings of diatoms. Its refractive index is 1.640.

Levulose (Fruit-sugar).[68]—This substance is found accompanying grape-sugar in fruits and honey. It is uncrystallizable and preserves carmine and aniline stains well (hematoxylin fades somewhat). Objects may be brought into it from glycerin. Its refractive index is somewhat higher than that of glycerin.

Miscellaneous.—*Thomas's Modification of Schulze's Dehydrating Apparatus.*[69]—A disk of plaster of Paris (Fig. 275, A) is supported at a suitable level by glass legs (C) in a museum jar. In the disk are perforations through which the dehydrating tubes are passed (Fig. 275, B). The disk is easily made by pouring a mixture of plaster of Paris and water in a mould of convenient size and depth. The holes for the tubes and the insertion of the legs are attended to while the mass is yet soft. A dehydrating tube (Fig. 274) may be prepared by cut-

* See also a paper by Dr. H. Suchanneck, Zeit. f. Wiss. Mik., vii., 463, 1891.

ting off the bottom of the test-tube, and placing a diaphragm of chamois skin (D) near the bottom. The diaphragm is fastened in its place by means of a spring made of steel wire (E), and forced inside of the chamois skin in the tube, thus pressing the former firmly against the latter. A rubber band around the tubes prevents their falling through the holes, and can be made to regulate the depth to which they shall be lowered into the alcohol. The tissue is placed in the tube containing some weak alcohol, the tube is then lowered until the two liquids are at a level. After twelve or forty-eight hours the two liquids will be of the same strength. The tissue is then taken out and put at once into the infiltrating tube.

With very delicate plant tissue it is well to immerse in as low as five per cent. alcohol in the tube (fifty per cent. suffices for ordinary tissue), or in the case of some algæ even as low as one per cent. The strength of the alcohol in the jar is kept up by adding calcium chloride from time to time. This is said not to injure the alcohol in the least. It is stated that picric, chromic, acetic, or osmic acid can be used with equal success. [It is a question if the presence of the wire supporting the diaphragm of the tube is of any advantage, especially when "acids" are used, and if the same purpose may not be subserved by simply fastening the diaphragm around the end of the tube with a thread.] The advantages claimed are: That not more than twenty-four hours is necessary for dehydrating and hardening nearly all kinds of plant tissue, as no sudden transition from solutions of different strengths occurs the tissue is less liable to shrink. The simplicity of the apparatus places it within the reach of all. Various materials can be used for a diaphragm, and almost any desired speed of dehydrating obtained. According to its size the apparatus may be either for private or general laboratory work. Experiments were not tried with animal tissues, but there is no apparent reason why they should not be successfully dehydrated by this method.

Gage's Drawing-board for the Abbe Camera Lucida.[70]—In order to obtain accurate and undistorted drawings the axial ray from the camera must be at right angles to the drawing surface. To accomplish this the mirror should be tilted to an angle of forty-five degrees. With most microscopes, however, the lateral extension of the stage is so great that a portion of the image falls upon it and renders drawing impossible at this angle. If a lesser angle than forty-five degrees be employed, the axial ray will no longer be at right angles to the drawing surface, although the image may appear clear of the microscope, and an obviously distorted picture will be the result. The board was designed to prevent this difficulty. Upon a board of convenient dimensions is hinged a shorter board (A B), near the attached end of which the microscope is placed (Fig. 276). The drawing surface (A B) may be raised or lowered to any desired angle by simply shifting the wedge (W). The figure with the mirror at thirty-five degrees illustrates clearly the direction of the rays of light, and shows obviously enough the distortion that would result if the board were not used. "*The general rule is to raise the drawing surface twice as many degrees toward the microscope as the mirror is depressed below forty-five degrees.*" A camera with a longer arm attachment would enable the image to fall clear of the stage or base of the microscope with the mirror at forty-five degrees, and a drawing, without distortion, could be made upon the ordinary surface of the table. A quadrant may be easily made and attached by any skilled mechanic.

To Rectify Turpentine for Microscopical Use.[71]—Mr. Charles C. Faris suggests the following method: "Take one-half liter of the common turpentine and mix in a liter bottle with one hundred and twenty cubic centimetres of ninety-eight per cent. alcohol. Agitate well, and let stand until the two fluids separate. Decant the turpentine (which will form the lower layer) from the alcohol and mix it with one-half liter of clear water. Agitate thoroughly, and let stand until these two fluids separate; then from the water decant the turpentine (which this time will form the upper layer), and finally mix with the turpentine about thirty grams of powdered starch and filter through paper.

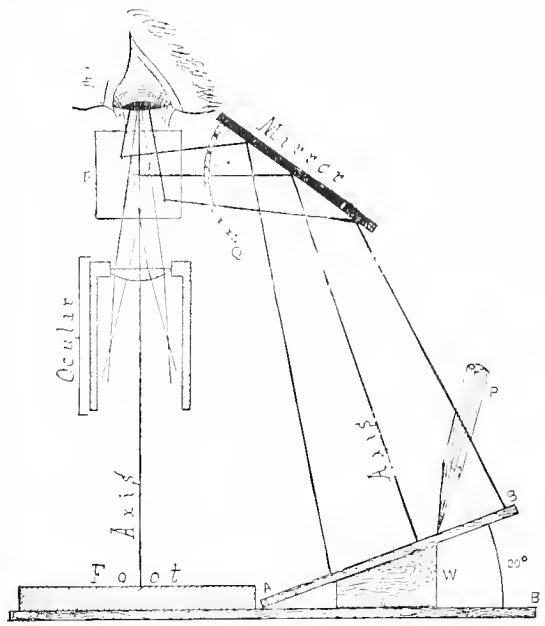


Fig. 276.—Drawing-board for Microscope.

"By pursuing the foregoing plan any one may secure a pure, limpid, and brilliant turpentine. The alcohol used in rectifying it need not be wasted, as it will do to burn, to clean slides, or for other purposes. I usually make a large quantity and recover the alcohol by distillation."

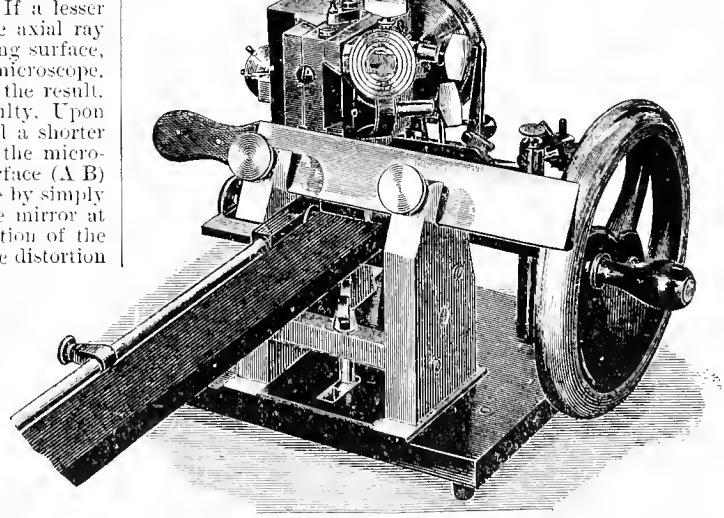


Fig. 277.—Minot's Improved Microtome. Front view.

Microtomes.—The following brief description is confined entirely to instruments of American design, although Figs. 277 and 278—the front and rear views of Minot's microtome[72]—show some modifications very recently introduced by a foreigner (Zimmerman). The principle of the microtome is to secure sections by

moving the object to be cut in a vertical plane past the knife, which is held in a fixed position. The slide A (Fig. 277) moves up and down. In this figure it is represented at its highest level above the knife. To this (the vertical) slide is attached another, the horizontal slide, which is moved by a micrometer screw, the head of which is a cogged wheel, B. In the knife end of this slide is clamped the object-holder. This may be turned until the object is in the desired position and then fastened by screws. From a movable bar attached to the vertical slide is a hooked lever, which catches in the teeth of the large wheel B.

The free end of the bar projects far enough beyond the hooked lever to strike against one of the six arms of a windlass arrangement at the side; this causes the lever hooked in the wheel to be pulled down, thereby turning the wheel and moving the horizontal slide with its object-carrier toward the knife. The arms of the windlass are of different lengths, and the distance through which the horizontal slide moves is proportionately greater or less, thus regulating the thickness of the sections. These can be made to vary from three to twenty *microns*.

For thinner sections the small wheel C (Fig. 278) is adjusted so that its cogs will fit into those of the large wheel B, the windlass of which is not now used, but in place of it one regulating the turning of the small wheel C. With this arrangement sections can be made from one to six *microns* in thickness.

Fig. 277 shows a belt attachment fastened to the knife supports, for the purpose of enabling the worker to more easily manipulate his "ribbons" of sections. By simply turning the wheel, section after section can be cut with the greatest rapidity.

Compressed Carbonic Acid Gas for the Freezing Microtome.[73] — The gas, or liquid carbonate, as commonly known, is obtainable in ten- or twenty-pound cylinders. For laboratory use certain changes must be made in the cylinder. "A circular block of iron, an inch in thickness and of the diameter of the handle of the valve, was fastened to the latter by two screws with nuts. Into this block were bored four holes ninety degrees apart, and of a size sufficient to admit the end of an eight-inch handle, B (Fig. 279). This greater leverage affords much better and more even control over the escape of the gas.

"The cap covering the escape-pipe was unscrewed, and a hole bored through it large enough to admit of a small brass tube with a fine bore being driven tightly into it. The cap thus prepared can be kept and used on any other cylinder received. One end of a small but thick rubber tube, C, was then slipped over the brass tube and tied firmly on; the other end was fitted over the tube leading into the freezing-chamber of the microtome, but was not tied on, so that it might act as a safety-valve and slip off if the pressure became too great; otherwise the tube is likely to inflate and explode. In connecting the cylinder with the freezing microtome it must be inverted, so that the valve handle is below, and raised enough above the table to bring the escape-pipe on a level with the freezing-chamber. A projecting support at A and two bands

Fig. 279.—Carbonic Acid Gas Cylinder, for Freezing Microtome.

at D, sufficiently snug to keep the cylinder from turning, were found necessary. The freezing chamber of the microtome should be shallow (about five millimetres) so that the gas, which by its own evaporation becomes frozen solid in it, may continue to free the specimen above it. The brass plate above the chamber should be thin, but still strong enough to stand considerable pressure, and the floor of the chamber ought to be made of a block of solid hard rubber, in order to render the loss of cold as small as possible." (F. B. Mallory.) This method is much cheaper than that by ether or rhigolene. If a specimen is frozen too hard, so that it chips, simply passing the finger wet with water or salt solution over its surface, will soften it. A carpenter's plane properly mounted makes the best knife for cutting.

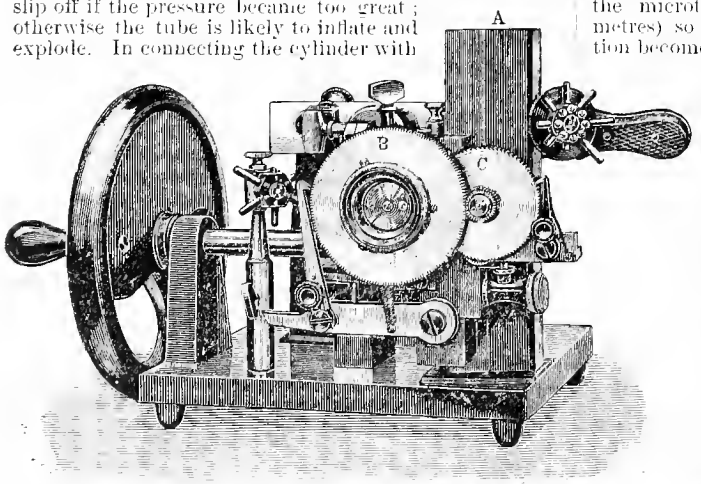


Fig. 278.—Minot's Improved Microtome. Rear view.

Ryder's Automatic Microtome.[74] — "The working parts are an oscillating lever, which is provided with a clamp at one end into which the paraffin-holders are adjusted, and at the other with a simple handle. This lever rests upon trunnions on either side, and these in turn rest in triangular notches at the top of the two pillars between which the lever oscillates. At the cutting end of the

lever a spring pulls the lever down and effects the sectioning and also the adjustment for the next section. The lever is pushed over and adjusted for the successive sections by a hollow screw, through which passes the trunnion on the side away from the knife. This screw is fixed to a toothed wheel, three inches in diameter, which revolves close by the side of the oscillating lever. The toothed wheel and screw are actuated by a pawl fixed to the side of the lever near the handle. The number of teeth which this pawl can pass in a single vibration downward is controlled by a fixed stop screwed into the under side of the oscillating lever near the handle; the end of this stop striking on the top of the bed-plate thus brings the lever to rest at a constant point in its downward excursion. An adjustable sector by the side of the toothed wheel throws the pawl out of gear after a given radius of the wheel has been turned through an arc embracing the desired number of teeth. This adjustment is also effected before the block containing the object to be cut reaches the knife. The adjustment for the next section is therefore effected while the surface of the block is not in contact with the under side of the knife, so that no flattening or scraping effect is produced on the surface of the block in its upward passage past the knife.

"The movement of the vibrating lever being arrested at each down-stroke at one point, and the pawl

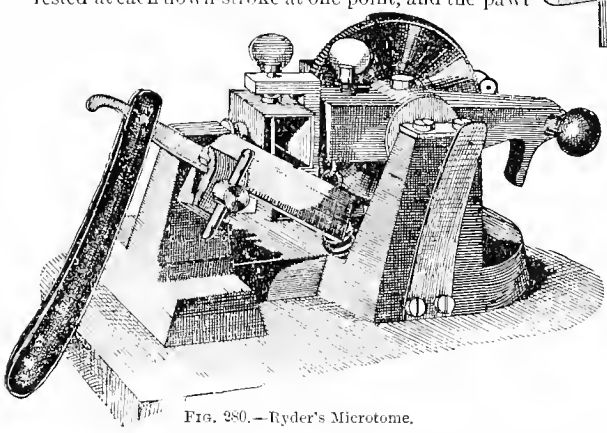


Fig. 280.—Ryder's Microtome.

which catches into the notches in the toothed wheel being released at any desired point by the action of the adjustable sector, it is possible to adjust the apparatus with great accuracy for cutting sections of any desired thickness. If a given radius of the wheel is moved through the arc embraced by a single tooth, sections are cut having a thickness of only two and a half *microns*, a thickness which is only practically possible with paraffin imbedding and a very keen razor. If more teeth are taken by the pawl, any thickness of section is possible up to about sixty-two and a half *microns*.

"A freezing attachment which has lately been appended to the apparatus shows that frozen sections can be made with as great rapidity and success as those cut from objects imbedded in the paraffin block, and very nearly, if not quite, as thin. The freezing attachment is as simple and efficient as the self-adjusting and cutting devices of the instrument. Other auxiliary apparatus makes it possible to cut celloidin sections. This is effected by means of alcohol, conducted by a tube from a reservoir to the knife, over which the fluid will run and drain into a tray below in such a way as not to come in contact with any other part of the machine. This tray fits into a recess in the side of the bed-plate of the instrument, just below the knife, and into this tray the celloidin sections may be allowed to drop as fast as cut. The knife can be placed at any desired angle, which, for some kinds of work, is quite a desideratum."

King's Microtome.—A microtome designed especially for hard service in botanical work or for cutting any hard material which requires absolute rigidity in the instrument. The knife is attached to a heavy nickel-plated iron carriage *A* (Fig. 281) by a steel clamp and shoe, *b* and *c*, with milled-head screws, *a*. The carriage runs on a solid iron track, *h* and *B*, which is held to a table by clamp screw, *k*.

For cutting very hard objects, like the wiry stems of plants, or the chitinous skeletons of insects, there is an attachment with a very stout blade, on the principle of a carpenter's plane, *d*, which screws on to the carriage in place of the knife, and like it can be used for transverse or oblique cutting. Two forms are made; No. 1 will cut paraffin objects to two and a half *microns* in thickness; No. 2, only to twelve and a half *microns*.

An Inexpensive Section-smoother.[61]—A very simple device. It is prepared by cutting off the head and point of an ordinary pin and fixing it parallel to the edge of the knife by pressing its ends into two small pellets of beeswax. (Fig. 282.) The proper elevation can be determined by experimenting on waste paraffin before the object is reached. The pin is used only for transverse cutting.

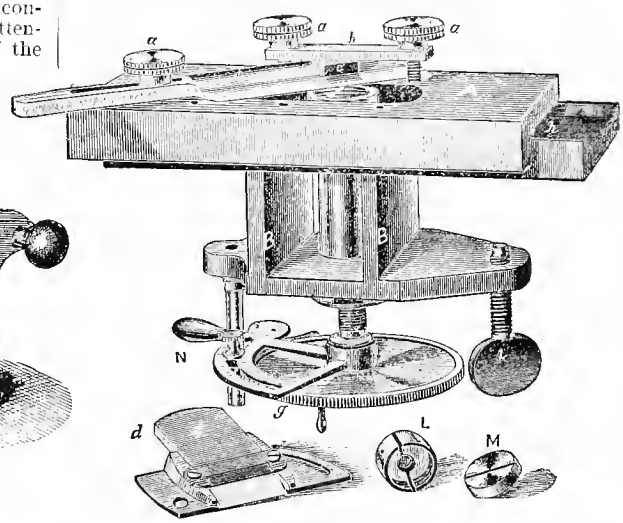


Fig. 281.

Decolorizing Preparations Over-blackened by Osmic Acid.[45]—Dr. E. Overton reminds histologists of a method introduced by Fol. The solution is not permanent and should be prepared afresh whenever needed.

Commercial peroxide of hydrogen. . .	1 part.
Alcohol (seventy to eighty per cent.).	10–25 parts.

The treatment lasts but a few minutes, after which the preparations stain excellently.

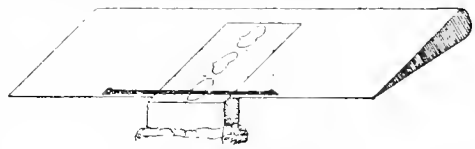


Fig. 282.—Section smoother.

Schieffердecker's Microscope Screen.[72]—The general form and relative size are well shown in the figure (Fig. 283). The framework is made of light wire, around which is sewed some dark cloth. At the lower part, and forming a support to the screen, is a metal rectangle; from this there extends upward a vertical strip which a little above the level of the coarse adjustment is bent at right angles to join two pairs of arms embracing the tube of the microscope. The base of the rectangle rests upon the front of the stage. By moving the tube of the microscope the whole screen is moved up or down. From the lower edge of the rectangle there hangs down a small piece of cloth to screen the condenser, while the main portion

amply protects the eyes and the object under examination. With a little ingenuity less elaborate but equally efficient screens may be made; their usefulness is well worth the time expended.

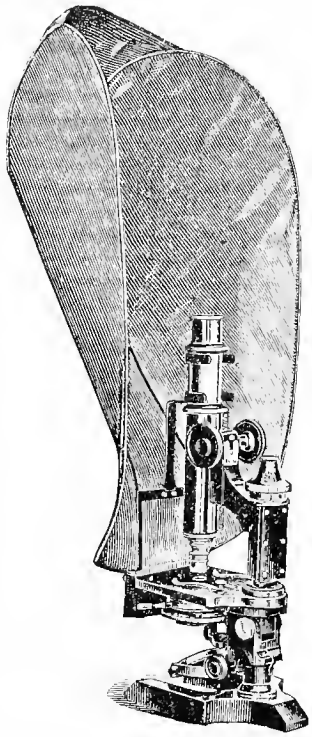


Fig. 283.—Screen for Microscope. (Schiefferdecker.)

The Removal of Aniline Dyes from the Hands.[76] — Some dyes resist very stubbornly the action of alcohol or hydrochloric acid, and require some bleaching agent. Unna recommends washing first in a solution containing a little common salt (about five per cent.), and then in a solution of hydrogen peroxide of about the same strength, and finally wiping with a cloth moistened with alcohol.

Ward's Eye Shade.[70] — This device consists of a black disk, from which extends an arm curved at its end and somewhat elastic, in order to clasp the ocular. By its use both eyes may be kept open, thus avoiding fatigue.

Fig. 284.—Eye Shade. (Ward.)

Blum's Regeneration of Hematoxylin.[72] —As hematoxylin is rather expensive, a method for restoring it may be worth knowing. To about 200 c.c. of the used hematoxylin, add from five to ten c.c. of baryta water (an aqueous solution of barium hydrate). A stream of carbon dioxide, made from marble and hydrochloric acid, is then passed through it, and after twenty-four hours it is filtered. The filtered solution is said to be as good as the original.

The Restoration of Osmic Acid Solutions.[77]—Osmium tetroxide, OsO_4, is readily reduced in the presence of organic matter, giving up two atoms of oxygen and forming the deutoxide, OsO_2. The tetroxide affects fatty substances first, and these are the substances that most readily undergo oxidation. After some preliminary experiments with peroxide of hydrogen, (H_2O_2), with uniformly good results, it was found that the restored solutions, with the exception of a gradual weakening, acted in the same manner as the fresh solutions and produced the same results.

The chemistry of the restoration and the bleaching further demonstrate that no injurious factor enters into the result, as is shown by the following equations:

OsO_4 + organic substance = OsO_2 + oxidized organic substances.

$OsO_2 + 2H_2O_2 = OsO_4 + 2H_2O$.

That is, in bleaching a tissue its OsO_2 is converted into OsO_4 and water is formed.

To restore 100 c.c. of a one per cent. solution of osmium tetroxide requires from ten to twenty drops of fresh peroxide of hydrogen, and clearing goes on better in full sunlight. To bleach tissue with peroxide requires about the same amount in 100 c.c. of water, and the bleaching takes place in the sunlight also. The amount needed cannot be stated with any more precision, because the peroxide loses its strength somewhat with age.

Reconstruction Points.[63]—An ordinary metallic imbedding box, Fig. 285, made of two L-shaped pieces, *a* and

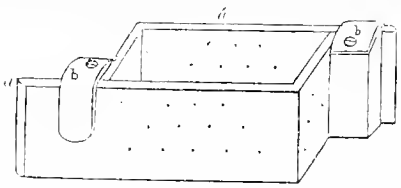


Fig. 285.—Imbedding Box.

a', held in place by the overlapping strips *b*, is perforated at the ends and sides, in as many places as are desired, by a very small drill. These should be so arranged that the silk threads when drawn through are parallel. The threads are cemented to the sides of the box with five or six centimetres left hanging. A heavy piece of blotting-paper is fitted in for a bottom. The object is placed upon the threads in the desired position and the imbedding mass poured in. When hardened the celloidin holding the thread is dissolved with ether. The loose ends are soaked in a weak solution of celloidin to which has been added some lamp-black. The threads are then drawn through, leaving the lampblack adhering to the celloidin, thereby forming excellent reconstruction points.

For small objects, where reconstruction points are not needed, Mr. Eycleshymer recommends the following method: The heads are clipped from fine insect pins, which are then placed in handles in such a way that they may be easily removed. On these pins the objects are oriented in the desired position; the pins are then removed from the handles and fixed in a cork, *a* (Fig. 286), previously perforated by a somewhat larger pin. As fast as the pins carrying the objects are inserted, the cork is replaced in the tube, which is filled with alcohol. A half-dozen fish or amphibian ova may be oriented on the same cork. If desirable to draw the objects *in situ* a piece of lead may be pinned to the cork and the whole immersed in a small beaker of alcohol. The corks carrying the oriented objects are transferred successively to tubes containing the different solutions. When ready for final imbedding, a piece of porous paper is wrapped about the tubes and cork, and pinned. The cork is now removed, allowing the imbedding solution to fill the paper tube thus formed. A lead is fastened to the cork and the whole placed in chloroform until hardened, after which the paper is cut from the mass and the pins drawn through the cork, when it is ready for sectioning. Several objects may be cut at the same time, drawings may be made after

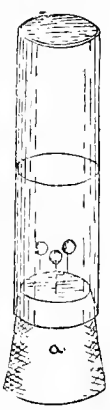


Fig. 286.—Vial for Orienting Small Objects.

orientation, and the objects may be transferred more rapidly from one solution to another.

A Breath Screen.[29]—In order to avoid the accumulation of moisture along the tube of the microscope, especially in winter, Dr. P. Schiemenz has devised the screen shown in Fig. 287.

It is made of a piece of stiff paper, the principal part of which is nearly circular (diameter, about 8 ctm.). The

Fig. 287.—A Breath Screen. (Schiemenz.)

smaller portion is pierced by two holes, through which passes a string by which the apparatus is attached to the microscope tube. The screen is easily fixed and moved to any desired position.

Accurate Drawings by Amateurs.[60]—A blue print, not too dark, is traced over free-hand, with China ink. When dry the picture is passed through an aqueous solution of caustic potash, 1 in 500 or 1,000, and washed afterward with water and dried. The potash removes the blue printing, leaving the ink lines distinct. If the print is too dark, delicate outlines are not easily seen and the bleaching process is not so thorough, a brownish tint remaining.

The drying is an important part of the process. As soon as washed the picture should be placed between some sheets of blotting-paper, and dried quickly by rubbing the hands over it a few times. If this precaution is not taken, the ink particles are likely to run, giving blurred and indistinct lines. "In this way drawings, with all the accuracy of photographs, and all the clearness of woodcuts or etchings, may be produced by persons who cannot make anything like an accurate drawing or a good picture of any natural object. There is a minimum of trouble and expense."

A Waterproof Drawing Ink:[76]

Powdered bleached shellac	4 parts.
Borax	1 part.
Water	24 parts.

Dissolve by the aid of heat. To this solution the coloring principle, as India ink, lampblack, the different tints and shades of anilin colors, etc., is added after being dissolved in, or triturated with, a small quantity of water.

An Inexpensive Reagent Block.[59]—"It is a plain white-wood block, 15 ctm. square and 4 ctm. thick. On the upper side of this three grooves are cut, each 1.5 ctm. deep. The first is 1 ctm. from the edge, and 1 ctm. wide; the second is 1 ctm. from it and 3.5 ctm. wide. The third is 1 ctm. from this and 2 ctm. wide. Into one end there is glued a closely-fitting block, 1 ctm. long, and in the other end one 5 ctm. long, leaving a trough for slides about 9 ctm. long. In the place where this last block is glued, is bored a hole 1.5 ctm. in diameter, and 1 ctm. deep, into which tightly fits a paper pill-box for covers. The remainder of the block is provided with two rows of five holes, each 2 ctm. in diameter, and 3.5 ctm. deep, for reagent vials.

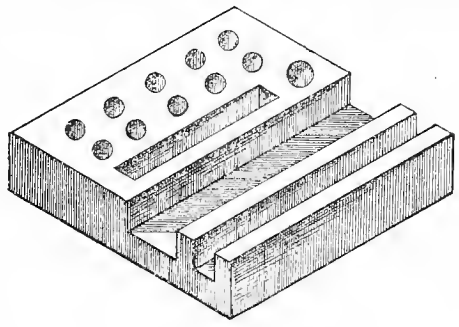


Fig. 288.—Reagent Block.

The first groove is used for razor and the second for pencils, pipette, forceps, etc. The block is easily made, costs very little, is very neat in appearance and convenient in work."

Bausch and Lomb's Cover-glass Gauge.—The stand is made of japanned iron; at the top, cut horizontally, is a thread $\frac{1}{50}$ inch pitch and $\frac{3}{16}$ inch outside diameter. A recess is cut below the line of the screw and at a right angle to it, for placing the covers. The portion of the stand at the side of the recess which receives the micrometer screw, is slotted longitudinally to the depth of the screw, and is provided with a set screw to take up wear; the other side has the "fixed" screw, which is, however, adjustable. The end of the micrometer screw is milled so that no force can be exerted sufficient to endanger the cover-glass. Fixed to the screw is a wheel, the surface of which is one-half inch wide. A knife-edge index-finger attached to the top of the stand pro-

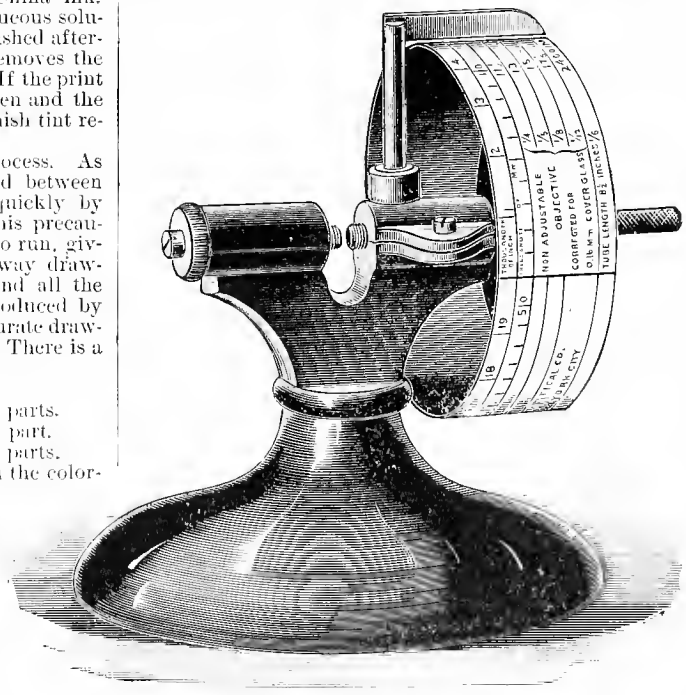


Fig. 289.—Gauge for Cover-glasses.

jects over it. Along the circumference of the wheel is fixed a strip of glazed paper provided with a series of divisions. The first series gives the thickness of cover-glasses to one-thousandth inch, the second to one-hundredth millimetre, and the third indicates the proper tube-length with various thickness of cover-glass, with a non-adjustable ¼-inch objective corrected under a tube-length of 8½ inches and cover thickness of 0.16 mm.;

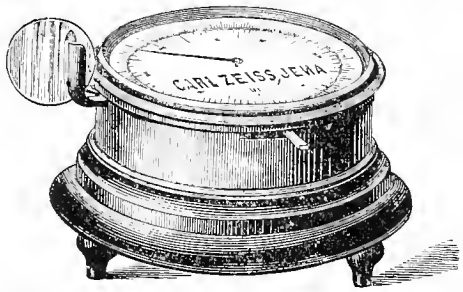


FIG. 290.—Zeiss's apparatus for Measuring the Thickness of Cover-glasses.

the fourth gives the tube-length of a ½-inch objective under the same conditions; the fifth for a ¾, and the sixth for a $\frac{1}{12}$; the seventh is for a ⅙-inch objective with the same cover and tube-length of 160.0 mm.

Zeiss's Cover-glass Tester.—For determining the thickness of cover-glasses, etc. A small lever projecting from the side of the apparatus regulates the opening and shutting of the jaws for holding the cover-glass. An indicator moving around a circular scale on the face of the box, registers the thickness of the object. The divisions of the scale show hundredths of a millimetre and thousandths of an inch.

Micrometer Caliper.—Used chiefly in the "mechanic arts." It is, however, perfectly well adapted for testing the thickness of cover-glass. It can be obtained with either the English or metric scale, and is of convenient size so that it may be carried in the vest-pocket.

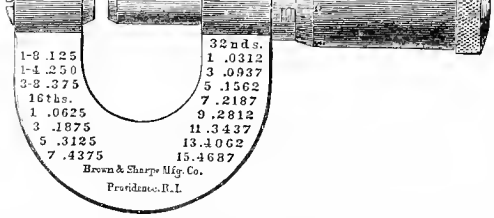


FIG. 291.—Micrometer Caliper.

Cleaning Mixture for Glass.[70]—Various formulæ have been given for cleaning new and used slides and cover-glasses. The following have been well-tested and deserve high recommendation:

Bichromate of potash	200 gms.
Water	1,000 c.c.
Sulphuric acid	1,000 c.c.

Dissolve the bichromate in the water by the aid of heat, pour into a bottle wrapped with a wet cloth, and add the sulphuric acid slowly and at intervals. The mixture may be used more than once, but when markedly of a greenish tinge it should be discarded. Another good mixture is:

Nitric acid	200 c.c.
Sulphuric acid	300 c.c.

The two acids should be mixed slowly and, like the preceding, kept in a glass-stoppered bottle. It is a more rapidly acting mixture, but the fumes render it less desirable.

Waste Bowl.—The apparatus is easily constructed and exceedingly useful. The ends of two glass rods of the proper length are fastened into two strips of lead, slightly curved to fit around the margin of an ordinary bowl. Between the glass rods is a tin funnel, held in position by flanges of tin which may be bent around the rods and permit the funnel to slide back and forth. The rods are a convenient resting-place for the slide, while in

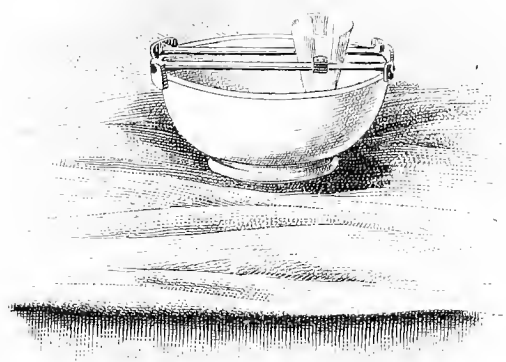


FIG. 292.—Waste Bowl.

process of preparation. The various solutions used in treating the sections may be readily drained from the slide by placing it for a few moments in the funnel.

Pierre A. Fish.

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In compiling these formulæ it has been the aim of the writer to consult the original papers. It has been impossible in some cases, with the limited time at his disposal, to do more than to secure abstracts of them in other periodicals; but it was deemed better, on the whole, to give the reference directly to the complete article.

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HONFLEUR. A seaside resort facing Havre, on the other side of the river Seine. Although the place is decidedly popular and even fashionable, the beach is muddy and bathing is not of the best. The sea-air is, however, bracing, and many English have selected Honfleur as a place of residence. The hotels are fairly good, the principal one being the *Cheval Blanc*, situated on the quay. There are good opportunities for excursions, both by land and on the sea. The town itself is not especially attractive. *Edmund C. Wendt.*

HOSPITALS, CONSTRUCTION AND MANAGEMENT OF. The history of hospital construction during the last decade is especially interesting in some of its particulars. There has been ample evidence of advancement in the application of the principles that were largely evolved from the experiences of the civilized world in the care of the sick and wounded of the great wars in the third quarter of the century. There is now not only a more general understanding of the way to build good hospitals, but other influences have been at work, making it comparatively easy to build, administer, and support them.

The science of hospital construction has been taking a more definite form, as is shown by the literature of the subject, which has received some notable additions since the publication of the valuable work of Mouat and Snell, ten years ago. The description of the Johns Hopkins Hospital, in a quarto volume, with its plans admirably complete in the detail they give, is an instructive source of information for all builders of hospitals. The recent publication of Burdett's great work on the "Hospitals and Asylums of the World," with its four volumes and portfolio of plans, is the most excellent presentation of the subject, in all its departments, that the world has yet seen.

A distinctly new phase of hospital work has reached a fuller development than ever before. It is the more general distribution of small hospitals in the smaller cities and towns. The tendency in this direction, though long existing, has been slow in its results until the rapid progress of the last few years. It is not many years since there were few hospitals for general medicine and surgery outside of the large cities. The great hospitals, while being local charities for the treatment of the more ordinary ills, were almost the sole seats of hospital work and its medical and surgical clinics, with their notable cases, and capital operations by notable men. But there was bad hospital construction, with its evil consequences, and the lack of modern skilled nursing, that now makes it possible to do good work even in some bad hospitals. The physician in private practice, at that early day, had conditions often better than those of the hospitals for the splendid work that was done by individual men under circumstances in many ways adverse to success. Almost any healthy house gave the sick man a better chance than the hospitals, except for the pre-eminent skill derived from the experience gained in them.

The great change that has come about in hospitals and their work, particularly in that of surgery, was first largely due to the use of anæsthetics. After that the world learned how to make hospitals healthy, and the skilled nurse came to multiply the resources of the physician and surgeon. But while the mechanism of hospital work was becoming more complex, it became more precise. Successful surgery, for example, formerly demanded certain qualities of boldness, swiftness, and the like, as well as scientific knowledge. There were fewer surgeons then than now. Modern progress has tended to the development of specialties, particularly in those involving surgical manipulations. These are now applied with more deliberate judgment, and more of the precision of an exact science. With the safeguards of asepsis, conservative surgery, and medicine as well, have made possible some of the greatest scientific advances. The modern surgeon may achieve success through study, time, and practice of very definite methods. Boldness and swiftness are largely supplanted, or tempered, by caution and painstaking attention to details. These are still consistent with the courage that is based upon better knowledge. With more complexity of manipulation in the art, special conditions for its practice have become more necessary. The increasing wealth of the country and its growing philanthropy, are in happy union with the greater need of hospitals, which has come because so many things can be done only in them, or so much better done than in private homes. The appreciation of this has led to the establishment of many small hospitals within a few years. They are aided in their support by the custom that requires patients to pay according to their means. In New England especially many of the smaller towns have their hospitals, or are beginning to get them. They have become possible also, as to their successful management, through the services of trained women.

We are witnessing, in one generation in civilized countries, both a great change in social life in some of the particulars here referred to, and the evolution of preventive and conservative medicine in ways that were never possible before. The skilled nursing that was at first taught only in the schools of the great hospitals, was elsewhere chiefly the luxury of the rich. It is now getting nearer to the poor in their homes, and becoming the boon of the greater public that has heretofore been so much beyond the reach of the common hospital privileges of the large cities. It is not meant to say that these conditions are peculiar to New England, but in the eastern section of it they have reached a further development than elsewhere in this country. Within less than a dozen years a number of small hospitals have been built in that section, and it does not need a prophet to predict the coming of the time when there will be the "cottage" in every town adapted to hospital uses for its locality, and supported in part by public money. They will be the common schools of nursing for the local service.

While there has been an extension of hospital construction, on the lines of the correct principles now so well established in these small hospitals, a departure has been made from previous ideas in the invention of special constructional devices for promoting aseptic surgery. A few unique examples of such surgical buildings are now in existence.

The great advances in bacteriology have also stimulated much attention to infectious diseases, and the building of special hospitals for their isolation and treatment is becoming more common. This affords another example of the progress of preventive medicine, and the village hospital should become a part of the general system of preventive care of infectious diseases.

The purpose of this article is to note recent progress in hospital construction in the three ways that have been mentioned. The first of these relates to the extension of the English cottage hospital system in America in recent years. In some cases dwelling-houses have been inexpensively adapted to the purpose; and slow progress was made, at first, because the cost of specially constructed buildings was beyond the available means. But while it has been sought to get what is wanted at a moderate cost, the value of the thing itself has become better appreciated. The ways of raising money for such purposes have been learned, and there is more liberal giving. Still the demand is for small effective hospitals at such an expense that every thriving community in the country can make available for the common need the proper conditions for modern medical and surgical treatment.

The City Hospital of Quincy, Mass., is an excellent example of what has been done in providing a hospital that, in the three years of its existence, has made a creditable record, and become a model of construction that others have followed. The hospital, with the administration house and one of its two wings, cost when completed for use $16,500, and with three and one-quarter acres of land, valued at $8,000, was given to the city by Mr. W. B. Rice. The furnishing cost about $3,000, and, with almost all the equipment, was paid for by societies and individuals; the hospital on completion was free from debt. The endowment fund for free beds reached the amount of $33,600 in the second year. The support of the hospital is aided by the city, by receipts from private patients, and by collections from various sources. A "Hospital Aid Association" also makes valuable contributions from its membership of seven hundred, at an annual fee of one dollar each, besides rendering aid in other ways.

The hospital has a capacity of twenty-five beds; it was opened in June, 1890, and admitted one hundred and two patients the first year, and one hundred and forty-six the second year. The net cost of support is something over $8,000 per year.

The building, designed by W. P. Wentworth, the architect, is of wood, and occupies a fine, elevated site with a southerly aspect. The plan (Fig. 293) shows two one-story pavilions, one of which is not yet built. The pavilion contains fourteen beds; there are six rooms for private patients and a small ward in the second floor of the administration house. The heating is by steam, by indirect radiation; there are ventilating openings under the beds leading to a vent shaft two feet square, and others in the ceilings are connected with ventilators in the roof; there are also fireplaces in the wards and rooms. All rooms have rounded corners in the plastering; the hard-pine floors, and white-wood finish, also have all angles rounded. The plumbing is modern with all pipes, etc., exposed, and the drainage is good.

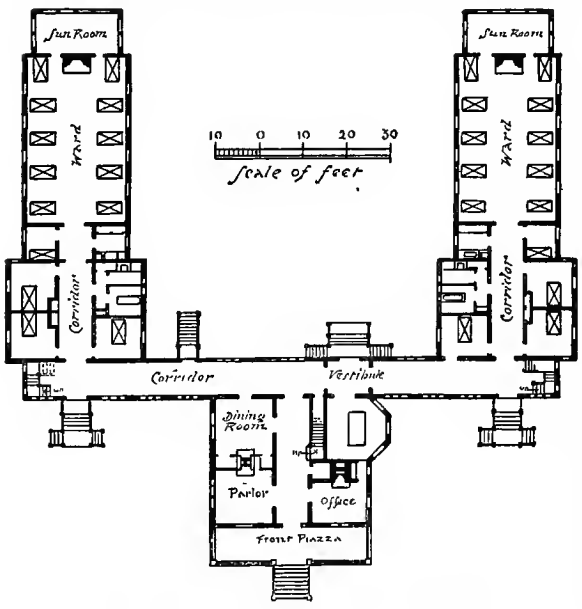

Fig. 293.—City Hospital of Quincy, Mass. First Floor Plan.

The hospital is under the charge of a matron, who is required to be "an educated and skilful nurse." There

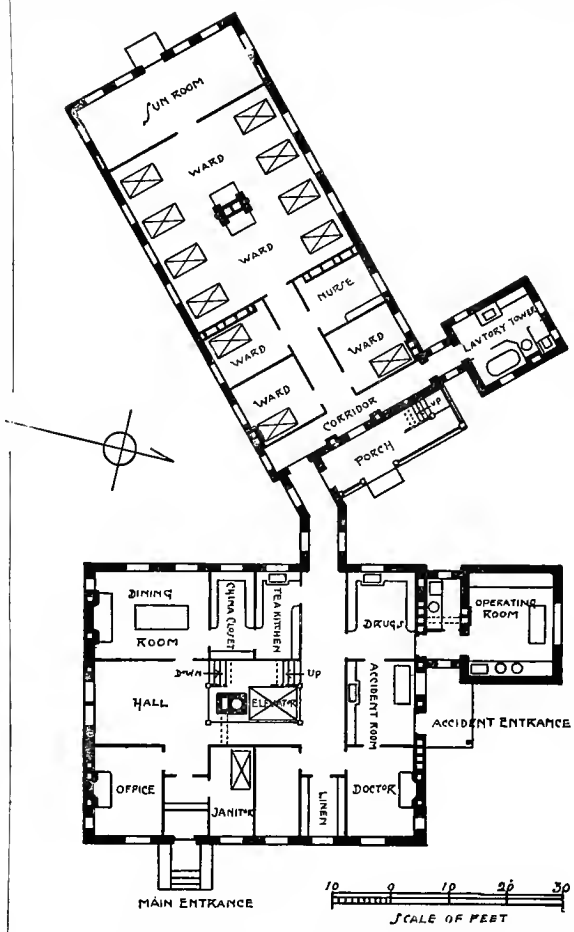

Fig. 294.—The Waltham Hospital. First Floor Plan.

is a regularly organized training-school, and some income is derived from the employment of pupil nurses outside of the hospital. A corporation of over three hundred members elects twelve trustees, who control the management of the hospital through an executive committee. There is a medical board that nominates the members of the medical and surgical staff, which includes physicians of both regular and homœopathic schools. The details of organization and management here given afford a good example of the method adopted in many of the small hospitals.

A new hospital at Waltham, Mass., opened within the past year, is built upon a plan in which the "mill principle" is applied for the first time in such a structure, "thereby securing numerous advantages at a comparatively small cost." The architect was William Atkinson. There are two plain, rectangular, substantial buildings of brick. The administration house, three stories high, contains the offices on the first floor, six private rooms on the second, and the kitchen and laundry on the third floor. A two-story pavilion contains on each floor a ward of eight beds, and one bed in each

of three separate rooms. The capacity of the hospital is twenty-eight beds, and Fig. 294 shows the general arrangement of the buildings. Their oblique position is due to the peculiar conformation of the lot upon which the hospital stands. The outside walls diminish four

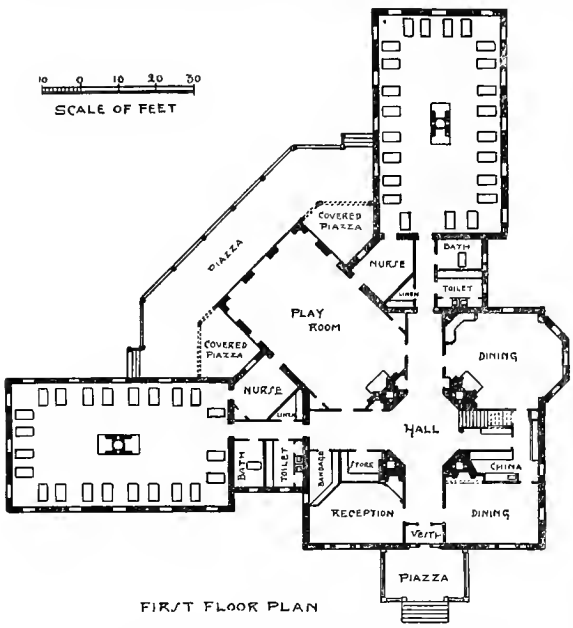

Fig. 295.—Convalescent Home for Children, Wellesley, Mass.

inches in thickness at each story. The peculiarity of construction is that the floors and roof are of plank, laid on hard-pine timbers; and the interior partitions are of three-inch spruce plank, grooved and splined and set up vertically. The walls and ceilings of the ward building are finished throughout in adamant plaster, as are also the six pay-wards for single beds, and the accident and operating-rooms of the main building. For the rest of the building, the brick walls and the plank partitions are finished in varnish. The object gained in this method of construction is that it is economical and "slow-burning," it being possible to have no concealed spaces in the walls or elsewhere. The heating is by steam, and the distribution of the warm air is aided by a propulsion fan. The inlets are seven feet above the floor, and the ventilating outlets are at the floor level; all the flues are built into the brick walls. The cost of the completed building, including plumbing and heating apparatus, was about thirty-eight thousand dollars.

There is an endowment fund for free beds, and substantial contributions to the support of the hospital are received through the work of the "Ladies' Hospital Aid Society." The executive officer of the hospital is a matron, who is a trained nurse. The nursing service is entrusted to the Waltham Training-school for Nurses, which is a peculiar institution; it was a successful organization before there was any hospital, and the training was given entirely in the work of "home nursing." The novel plan of this school and its foundation are due to Dr. Alfred Worcester; it is worthy of careful study and imitation, for it makes possible the advantages of trained and skilful nursing in places where hospitals cannot be afforded. It provides also a way for the helpful enlargement of the facilities for instruction in the small hospitals. The trustees are preparing for the reception of infectious and contagious cases, a disinfecting station, and an ambulance service.

An interesting variation of a one-story pavilion plan for a general hospital is given in Fig. 295, showing the arrangement of wards and rooms in the Convalescent Home, at Wellesley, connected with the Children's Hospital in Boston.

The building is of brick; it is beautifully situated in grounds that have liberal space and shade; and it is admirably adapted to its special purpose. It is so situated that the windows opening upon the piazza look to the south. The administration building is of three stories; and each of the pavilion wards contains twenty-three beds. The cost of the completed hospital approximated fifty thousand dollars.

A fine example of the double pavilion plan of construction has just been completed at Hanover, N. H., in the neighborhood of Dartmouth College. The Mary

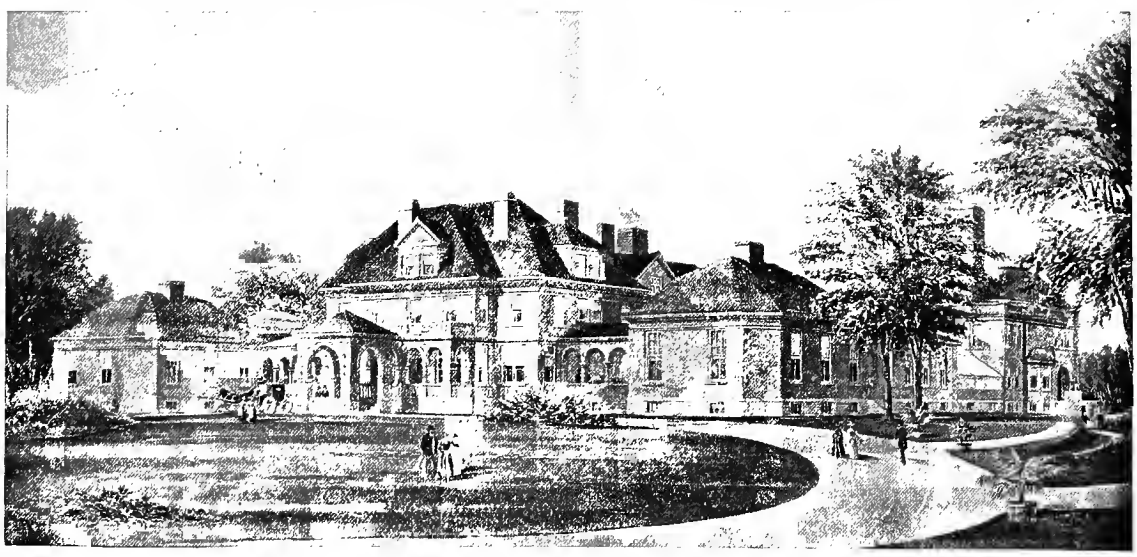

Fig. 296.—Mary Hitchcock Memorial Hospital.

Hitchcock Memorial Hospital is the generous gift of Mr. Hiram Hitchcock, of New York: its benefits will be felt by the College, Medical School, and the town and country around. The perfection of the building is due to the aim of the donor to provide everything desirable as a hospital requirement, and the construction is of the best in materials and workmanship. The architects

were Rand & Taylor, of Boston, and the writer has acted in an advisory capacity. A brief description will be given here, and for a more detailed one, reference is made to Burdett's new work on hospitals.

The hospital consists of four buildings, three belonging properly to it, and the fourth, a surgical operating theatre, being designed for the special purposes of the medical college. The cut (Fig. 296) shows in part the exteriors of the four buildings. The material is of Pompeian brick of a mottled yellow-gray color, and the ornamentations are in a light-colored terra-cotta. The roofs are of light-red Spanish tiles. Their domed form is an outward expression of the fact that the interior construction throughout is of the "cohesive system," by which

leading to the pavilions, there are tiled floors. In the lavatory and bath-rooms, operating theatre, and conservatory or sun-room, and in all of the basements, the floors are of granolithic cement. The stairs are of marble, slate, or cement. The outer walls are hollow, and the plastering is upon the brick. The cost of the building, ready for use, will be something over one hundred thousand dollars, exclusive of the surgical building.

The plan of the first floor (Fig. 297) presents the arrangement of the wards and rooms with much detail, to which little need be added.

The entrance hall of the administration building, which faces the south, leads to a rotunda which is finished in marble and oak, with an appropriate tablet giving it a

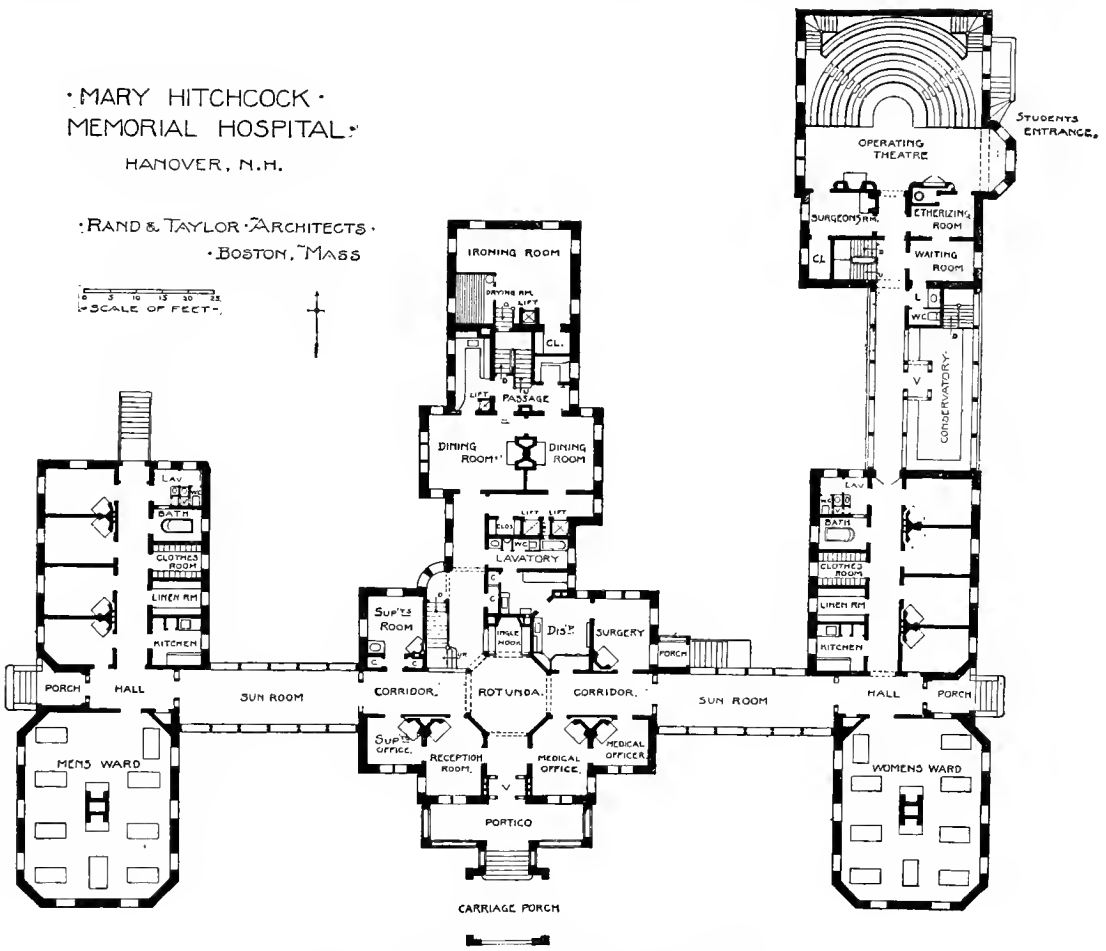

FIG. 297.—Mary Hitchcock Memorial Hospital. First Floor Plan.

all ceilings are formed of layers of vitreous tiles laid as shallow arches, or higher domes, over the rooms, and sustaining the floors above. This is an adaptation to modern use of the early Italian and Spanish dome-construction, and this building is the first in America planned especially for the modern application of this method throughout. The inner partition walls being all of brick, there is a unity of fire-proof construction, largely of vitreous and non-absorptive materials, including the outer walls. There is no iron or wood for the support of stairways or other construction, and only the floors and slight finishing around doors and windows are of hard pine, except where the woodwork is of oak, in the first and second stories of the administration building. Here, in the main hall, the first floor is laid in marble mosaic; and in the connecting corridors, serving as sun-rooms and

memorial character. The second floor contains eight private rooms in the main building, and the service rooms, etc., are in the rear extension, with an intervening cross lobby. The third floor has accommodations for twelve nurses. The one-story pavilions contain each a ward for ten beds and four private rooms; the capacity of the hospital is thirty-six beds. The ward, 28 × 36 feet, has an arched ceiling at the height of 13 feet, and while it has all the advantages of a round or octagon ward with a central chimney and vent-shaft, its general rectangular shape is better for convenience of service and arrangement of furniture. The bath-room and lavatory, with a screen between, form together a lobby surrounding the inner apartment containing the water-closet, etc. The surgical building has a high-domed roof, showing handsomely the tiled construction, in which are ample sky-

lights. The heating is by steam and indirect radiation in all wards and rooms. The warm air inlets are near the floor and mainly under or near to windows. The boilers are placed in a deep basement under the surgical building. The ventilation of the latter is by the chimney with a central smoke-flue. In the wards it is by the central chimneys also; elsewhere there are vent-chambers in the roof to which the ducts are led from the rooms. There are openings under the beds in the large wards, connecting with the base of the large chimney, and in other rooms near the floor and ceiling into ducts, which rise mainly in connection with the chimney stacks. The rooms for nurses and servants, in the second and third stories, are warmed and ventilated by the transom system, the warm air abundantly supplied in the halls enters through the open transoms, and after traversing the room, aided by the chilling it receives at the windows, makes its exit by vent-openings near the floor in the interior walls. The ventilation, as a whole, is accomplished by a simple and effective application of the extrac-

the St. Luke Free Hospital and the Michael Reese Jewish Hospital in Chicago. In England two especially interesting plans are those of the West Bromwich and the Swansea Hospitals. In Germany the Augusta Hospital at Berlin is particularly noteworthy.

The Presbyterian Hospital in New York is an important example of a recently constructed large hospital, it having been rebuilt and greatly enlarged since its destruction by fire a few years ago. It now has 315 beds in 30 wards, mainly in three pavilions of three stories each, with one or two subjacent stories used for other purposes. It is expensively and finely built, fire-proof, and at a cost of $875,000. Its arrangements are elaborate, and include a model operating pavilion, a dispensary, and pathological department. In the value of the land upon which it stands, its high buildings, and the consequent complexity of its heating and ventilating arrangements, it illustrates the tendency that sometimes prevails under such conditions, to depart from the rule of simplicity of construction. The Methodist

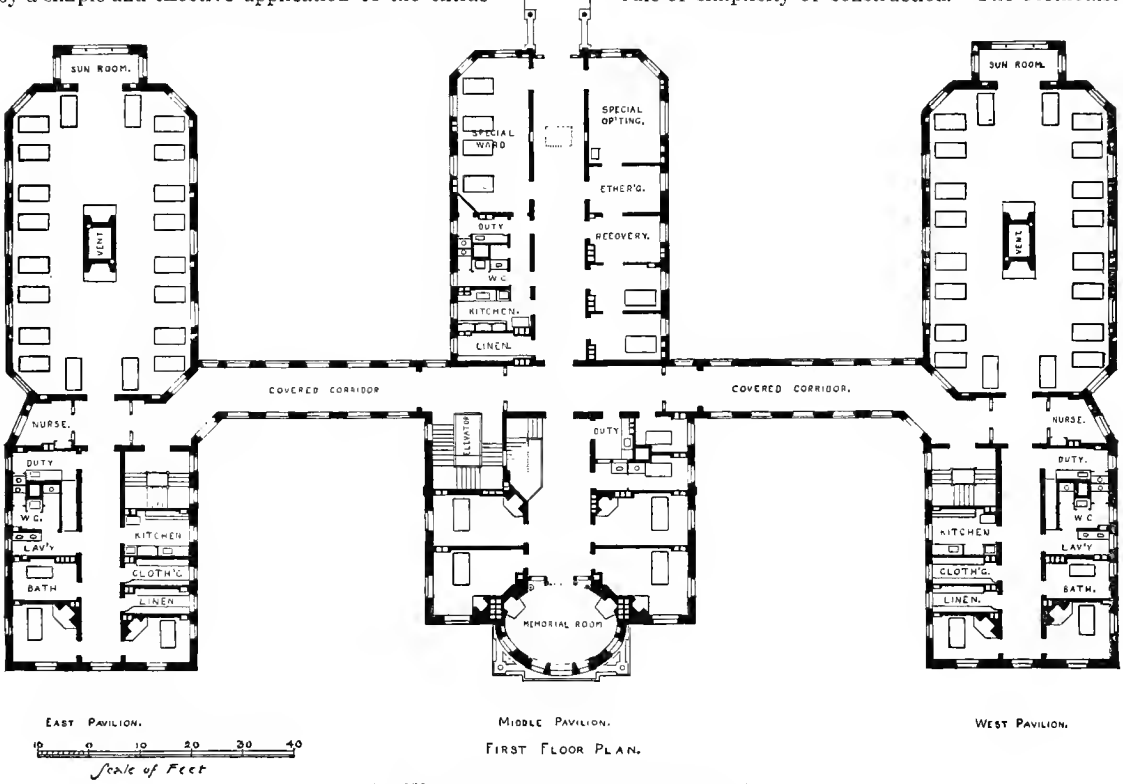

FIG. 298.—Memorial Wards, Pennsylvania Hospital.

tion system, and renders it easy to change the air of the wards and rooms at least three or four times per hour when desired.

The plumbing is fitted with the best modern appliances, all pipes and traps are exposed, and discharge into risers of soil-pipe in pipe-shafts which serve also for the ventilation of these special apartments. All water-pipes also have their risers in these shafts, the waste heat from those for hot water aiding the ventilation. The furnishing selected by Mr. Hitchcock is of the best materials and admirably suited to the strictest hospital requirements.

There are now, in this country, so many small hospitals of the class here illustrated that the mere mention of them would make a long list. Among the newer and notable ones are the Arnot-Ogden Memorial Hospital at Elmira, N. Y.; the Margaret Pillsbury General Hospital at Concord, N. H.; the Memorial Hospital at Worcester, Mass. Burdett gives some interesting examples of small hospital construction. Among them there are, in this country, Episcopal Hospital in Philadelphia is an excellent example of a two-story pavilion hospital built upon a plan admirably elaborated by Dr. Billings, and designed to accommodate, when fully carried out, 300 patients. The Presbyterian Hospital in the same city has some new surgical wards that well represent the strict application of the principles of construction of one-story pavilions.

The Pennsylvania Hospital has an excellent new house for nurses, and an out-patient department; and a new surgical hospital is now in process of construction on the grounds in Pine Street of this historic institution, which was built in 1750. There will be three separate pavilions built upon plans by the architect, Addison Hutton, in conference with the writer. The limitations as to the area and form of the lot, led to a variation from the generally adopted plan of construction in the pavilions, in order to utilize best the whole space for these and future structures, and preserve the pavilion principle. The buildings are of brick and granite, and harmonize with

the colonial style of the old hospital; they are so placed that their head-houses face in the opposite direction and toward the northern boundary of the lot, at a distance from it of twenty-five feet. The grade becomes lower here, permitting, for the central building, a carriage approach and an *entresol* entrance in the basement story, which is ten feet high. A large bay is formed upon this end of the building and affords a fine oval room on the first floor, which with this mode of entrance is treated to give a special memorial character to this part of the structure. Beyond this the basements are mainly used for purposes of ventilation and warming.

The first floor plan of the three buildings is given in Fig. 298. They are connected by a basement corridor which extends to the central part of the old hospital; the corridor forms a covered way with open sides between the pavilions on the first floor, and a terrace on the second floor. The distance between the buildings is 45 feet at the narrowest, and 50 feet where the large wards are. The sides of the buildings are free from projections. The central pavilion is of three stories; the rear half of the corridor on the first floor being a passage to the other wards, the adjoining rooms are arranged for special uses, and are not commonly occupied by patients. The memorial rooms and four special

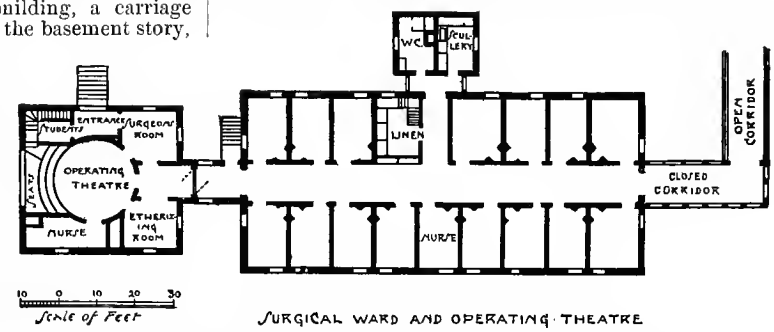

FIG. 300.—Bradlee Memorial Ward, Massachusetts General Hospital.

wards occupy the front end of the building. The east and west pavilions, two stories high, have each two large wards of 20 beds each, and two special wards, besides the service-rooms. The large wards are 35 by 60 feet, with a central chimney and vent shaft, and fireplaces. The height is 13½ feet, and the ceiling is somewhat arched at the sides and ends. It may be described as a long octagon ward with the advantages both of that and of the rectangular form. It is exposed to sunlight and air on the east, south, and west, and nearly all of its exterior walls.

The second floor of the central pavilion is shown in Fig. 299. This is for the gynecological service, with a large ward of 10 beds, and smaller special wards, an operating-room, etc. The third floor has a similar arrangement of rooms, to be used for women and children; the latter have two wards containing 19 beds. The total capacity of the three pavilions is 140 beds.

The floors of the first story and all rooms in which there is any water-service will be constructed throughout of iron beams and hollow bricks. The finish is to be plain and substantial with all angles rounded; marble and tiles will be freely used in appropriate places, including the operating-rooms, etc. All toilet-rooms have plumbing exposed, and are arranged with a central shaft for all pipes and for the independent ventilation of these special apartments which are cut off by a screened lobby from the main halls.

The heating is by steam and indirect radiation. Elsewhere than in the large wards, which have special vent-chimneys, the ventilation is by ducts leading to chambers in the roof. The outflow in all of these may be accelerated by heat from steam-pipes. The extraction system is applied in its simplest form, so as to work automatically with the smallest need of attention.

The demand for aseptic conditions in modern operative surgery has been met by the invention of special constructional devices in rooms to be used for that purpose. The first notable building of this kind was erected at the Massachusetts General Hospital, in 1888, as a memorial building. It is a one-story pavilion, and its plan is shown in Fig. 300. The building is approached from the other parts of the hospital by an uncovered way.

The ward itself has the general arrangement of rooms designed for isolation, the corridor between them being 8 feet wide and 24 feet high, with a monitor roof with many windows that may be freely opened. This gives the corridor, in relation to the rooms, the effect of their opening upon the outer air. The lavatory, scullery, etc., are outside of the building, with an intervening lobby protected at the side only by a screen. The passage is guarded by double doors swinging both ways. The heating is by steam and indirect radiation, the inlets being under the windows. These have transom lights over them. The ventilation is by an independent duct in the chimney for each room. The walls and ceilings are

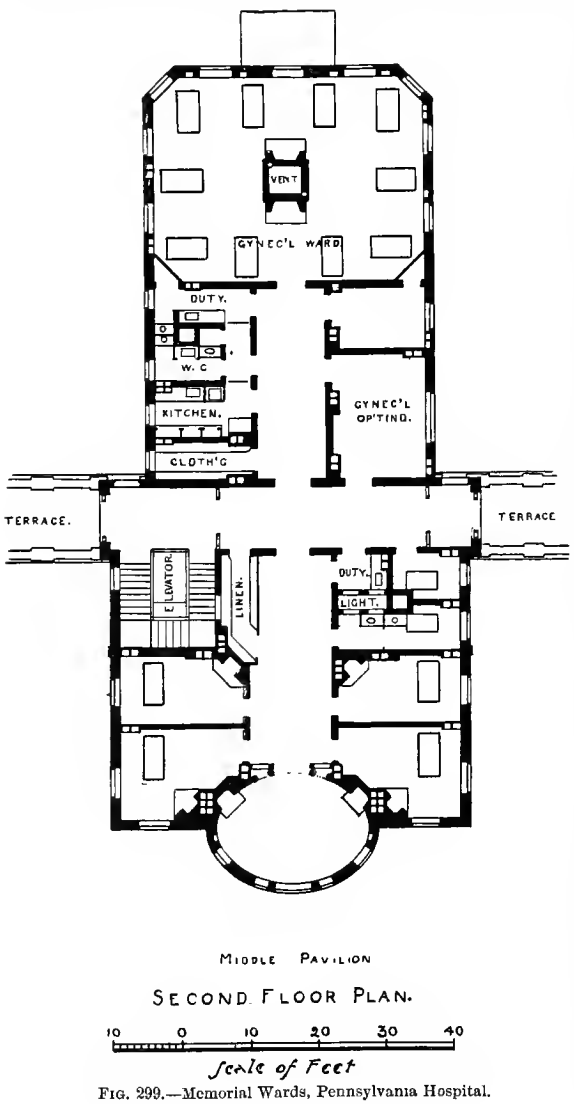

FIG. 299.—Memorial Wards, Pennsylvania Hospital.

painted, the floors are of hard pine, and the finishing in wood and plaster has all corners rounded.

The special feature of the building is the operating theatre. At the northerly end a door from the main corridor opens into a connecting lobby, which is divided midway by swinging doors. A door to the right opens upon a flight of steps intended for the entrance and exit of the hospital attendants. Beyond the swinging doors, one in front opens directly to the amphitheatre floor, one on the right to the surgeons' consultation-room, and one on the left to an etherizing-room. Doors from either room connect with the theatre. The walls are of pressed brick; the floors, like those of the corridor and theatre, are of asphalt.

The floor of the amphitheatre is circular in outline, with a diameter of 18 feet. Directly over this is a monitor roof of hammered glass, with an area of 280 square feet. Contiguous with this glass roof, at the northerly end of the theatre, is a window made of four sheets of plate glass, the combined area of which is 192 square feet. Beginning at either side of this window is a wainscoting of polished white Italian marble, continued so that it encircles the whole operating space. Above this wainscoting, and projecting over it, is the first circle or tier of the balcony, guarded in front by a heavy iron and brass railing. The balcony affords standing room for about one hundred spectators. Opening out of the amphitheatre, on the westerly side, is a general supply-room. The corresponding space on the easterly side is a passage-way from an outside entrance to a flight of granite stairs leading to the balcony. From this passage-way, through an arched opening in the marble wall, access is had to additional standing-room for twenty-five spectators. This standing-room is obtained by three semicircular tiers of marble and flagging, extending from the amphitheatre floor to the sill of the large northern window. The entire basement is concreted. It has no stairway connection with the floor above. The ward and theatre are lighted by electricity.

The gynecological department of the Johns Hopkins Hospital being found to need a place to be used exclusively for operative work, a building was erected for that purpose in 1891. It was placed conveniently near the private ward for women. A plan of it is shown in Fig. 301. Its convenient and simple arrangement, and its ingenious special devices, make it an admirable model of a fitting provision for its work.

The building comprises a large operating-room, 25.8 by 25.9 feet, the floor of which is covered with Sinsig tiles laid upon lime of Teil arches, and the walls are wainscoted to the height of four feet with Tennessee

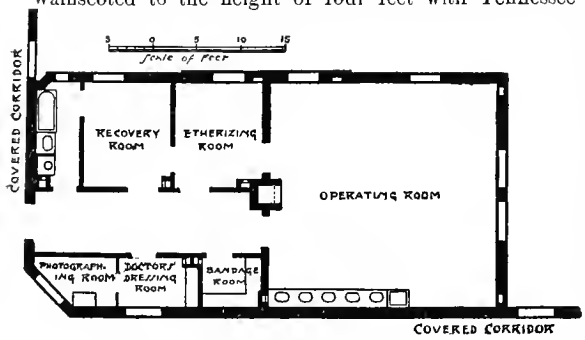

FIG. 301.—Gynecological Operating-room, Johns Hopkins Hospital.

marble. The walls are plastered with King's cement, which furnishes a hard, smooth, and non-absorbent surface, with little opportunity for the lodgement of infectious germs. Adjoining the operating-room is an etherizing-room, 10 by 12 feet. Communicating with this is a recovery-room of the same size, with an adjoining bath-room and water-closet. The building has also a supply-closet, dressing-room, and photographic room. It is heated by steam and ventilated by a shaft. The floor of the building is on a level with the floor of the main corridor, and the building is one story in height. The operating-room is lighted by two windows looking west, a large double window looking north, and a large skylight. The windows and skylight are of obscured glass, so that the light which enters is thoroughly diffused, and strong and annoying cross-lights are prevented. The interior lighting is both by gas and electricity. The structure is of brick, with a slate roof, and corresponds in general appearance with the other buildings upon the grounds. The only departure from the

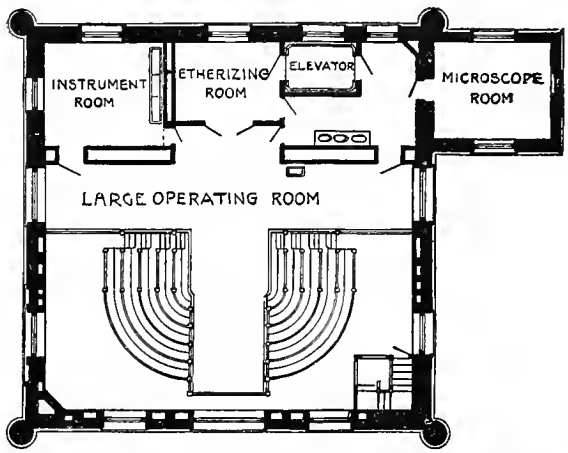

FIG. 302.—Presbyterian Hospital, New York. Operating Pavilion.

method of heating adopted in the remainder of the buildings was in the location of the heating flues at a height of six feet from the floor, it having been found by experience that this arrangement prevents annoying draughts of air upon patients.

The new operating pavilion of the Presbyterian Hospital in New York has just been completed. The seating capacity of the main amphitheatre is one hundred persons; it is in the upper story of the two in the building, and is shown in Fig. 302. It is finely lighted by large skylights and three great side lights on the north, south, and east. The wainscoting and floors are of marble, and the doors are heavy slabs of the same material. In the basement story, which is on a level with the corridor communicating with other parts of the hospital, there are two other operating-rooms to be used when seclusion is desirable; there are also a recovery- and an etherizing-room, and those for instruments, etc. This building is a remarkable example of the adaptation of stone and iron to special devices of construction, excluding the use of wood almost entirely.

The Roosevelt Hospital, in New York City, presents the most remarkable structure of this kind that is now in existence. It is the William J. Syms operating theatre, a memorial building for which the bequest was $350,000. It has just been completed and equipped at a cost of about two hundred thousand dollars, and the residue provides a fund for its maintenance. It is two stories high in front and three stories in the rear. The amphitheatre occupies the centre of the building, and is lighted by a glass dome with a northern exposure, admitting the rays of light above and behind the audience; as far as possible, the light that illuminates the operating-table is made to enter the room from behind the observer, and nearly parallel with his line of vision, with the exclusion of all cross-rays. The plan of the first floor may be seen in Fig. 303.

The architect was W. Wheeler Smith, but Dr. Charles McBurney, the Attending Surgeon to the Hospital, was made responsible, in the will of the donor, for the construction and equipment of the building.

The main entrance on Fifty-ninth Street is intended for the students of the College of Physicians and Surgeons that stands on the opposite side of the street. The broad

vestibule has a marble mosaic floor, and Italian marble is used for the interior finishing and the stairway leading to the upper seats of the amphitheatre. This has a seating capacity for 185 students, but 330 could easily be accommodated within its space if it were desirable to admit that number of persons to a clinic. The seats, in six tiers, are of wood, with wooden backs only; they are supported by being fastened to iron standards. A wainscot of pure white marble, 5 feet high, encircles the room at the top of the amphitheatre, while behind the operator an unbroken surface of marble rises from the pit to a line on a level with the top of the wainscot before referred to. Part of the pit extends backward to a recess lined with marble on every side, including its ceiling. The floor is of marble mosaic, and its immediate surroundings are finished in marble and iron. The steps leading to the seats of the amphitheatre are of slate. Under the seats the sloping surface is of asphalt over thin concrete on wire lath. At the top of the entrance stairway are two rooms, one for surgical records and the other for the house staff.

The front part of the building rises to two stories, and the central and rear portion to three stories above a basement. On the ground floor the outer rooms, east and west, are only one story high and admit light by skylights as well as by large windows in the outer wall, which, from their situation, have to be fitted with semi-opaque glass. The rooms are carefully and ingeniously fitted for the uses indicated in the plan; the instrument-rooms, for example, have cases of metal frames with glass doors, sides, and shelves, which were imported especially for their purpose; and there are many devices for promoting asepsis. An inclined plane has been provided, in place of an elevator, by which patients may be wheeled to the recovery-rooms, four in number, on the second floor.

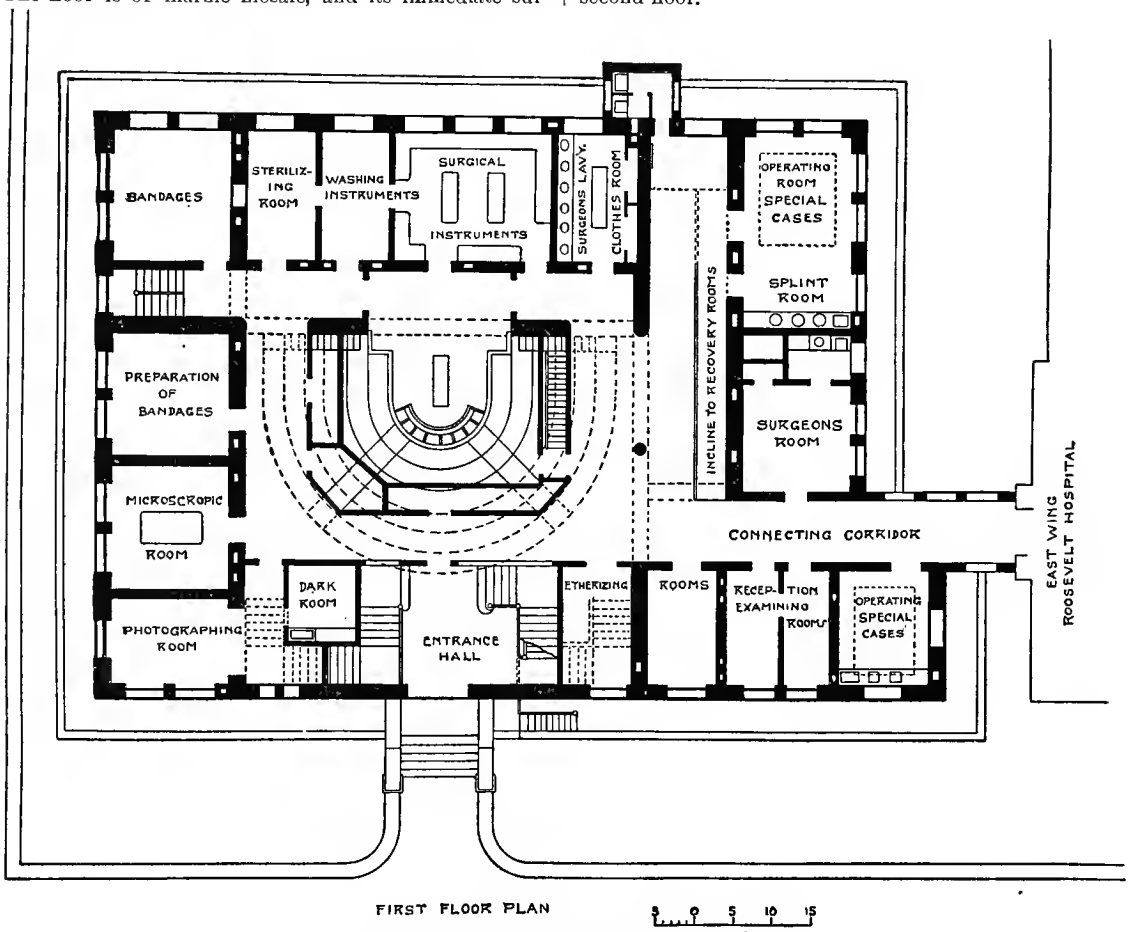

FIG. 303.—Roosevelt Hospital. William J. Syms's Operating Theatre.

A covered corridor leads from the Hospital to the first floor of the building, all of which is laid in marble mosaic with angles rounded to meet a marble wainscot 5 feet high.

Several of the most important rooms, where it is desirable to promote aseptic conditions, are fitted with doors of pure white Italian marble, 1¼ inch thick, hung on massive metal hinges, a single slab in each case forming a door. The special operating-rooms for septic and other cases are fitted with all conveniences, the interior and equipment being chiefly of marble, glass, and metal.

The amphitheatre, as indeed every other part of the structure, is supplied with gas as well as electric lights, to insure the building never being without efficient means of lighting.

The warming is by steam, the air, taken at an elevation of 22 ft. 8 in. from the ground, passes over steam pipes in great inlet ducts in the basement, and is forced by fans throughout the building; it is driven by one fan to the amphitheatre alone, and by a second fan to all other parts of the building.

Fresh air, either hot or cold, as may be desired, is supplied to the amphitheatre through one hundred four-inch cast-iron inlets, commercially described as goose-necks, penetrating the inclined plane under the seats and directing the air, as it is received from the chamber underneath, upon the surface of the inclined plane. Ventilation is by aspiration through a large register near the

ceiling, into a heated chamber which thence discharges its contents, at the highest point of the structure, to the outer air. In all other rooms of the building separate vent-ducts rise directly upward to their exit openings, like chimney-flues—a system which entails the risk of down drafts of cold air in some of them if a careful balance of the forcing and extracting power is not always maintained.

Mention should be made of the sterilizing apparatus, occupying a room by itself and adding, in a marked degree, to the efficiency of the agencies employed to promote asepsis. The building is a most notable one in its elaborate perfection and practical fitness for carrying the work of operative surgery to the last degree of refinement.

The rapid development in recent years of the relation between the hospital and the community is bringing it about that the hospital is less exclusively the refuge of the poor, but a "palace of health" for all. In a recently published book on "The Nationalisation of Health," Havelock Ellis advocates a more complete legislative control than is now had, of these interests in which the guardianship of life is concerned. It is his view that, "in the end every medical man in the country would be attached to a hospital, and every person would be living within the district of a great institution of health."

In England there is greater advancement in these matters than in America. But it may be that here the great ends of preventive medicine are to be gained in a different way, by the more general distribution of smaller centres of sanitary control, and the education of the local practitioner through the reflex influence of the local hospital in which he works. One needs to go no farther than Waltham to witness the invention, already referred to, of a new kind of training-school that is destined to popularize the principles of nursing as a matter of common knowledge and use, and to find also the beginning of a movement which should be successful there and elsewhere in bringing into the smaller cities and towns the life-saving appliances of a disinfecting station, of which there are too few even in the largest cities of the country. To the social economist, whose doctrine is that public health is public wealth, no more helpful aid has come than by the advancement of knowledge of the causation of disease, which teaches the means of prevention. A broader socialism, acting upon the highest motives of philanthropy, is being developed in like manner through better knowledge of the laws of life which must be obeyed to cure both physical and moral ills.

The admirable work of the Metropolitan Asylums Board in London stands as a model for the effective organization of hospitals and disinfecting stations for the protection of the poor, and the whole community alike, from the dangers of infectious and contagious disease. It has been demonstrated by experience that the value of a permanent isolation hospital is in its providing the means of isolating at once the earliest cases of disease, and thus preventing the epidemic, instead of leaving it to be battled with when it has got full sway. In Burdett's work the admirable chapters on this subject are most instructive. Valuable and precise information as to the best methods may be found in this work, and in Dr. Thorne's report "On the Use and Influence of Hospitals for Infectious Diseases," which forms a part of the "Tenth Annual Report of the Local Government Board for 1882." Among the plans given by Dr. Thorne is that of the Warrington Hospital. As a good type of such English hospitals, a plan of one of its small pavilions is shown in Fig. 304.

A common arrangement is to group together a number of such small pavilions, and to connect them by a covered way, open at the sides, with an administration block.

The Warrington Hospital is of brick; its arrangement is shown in the block plan, Fig. 305. There is a two-story administration block, *a*; two ordinary ward pavilions, *w*, *w*; a special detached pavilion with like interior arrangements, except that its wards are reduced to a capacity of one bed each, *w*; a lodge at the entrance, *e*; and two groups of out-buildings, *b*, *d*. One of the latter contains a laundry, disinfecting chamber, ambulance-shed, mortuary, and store for wood, coals, etc.; the other contains two hand-vans to be used in connection with the stove, and a store for garden tools, etc. These forms of pavilions are two of the four prescribed by the Local Government Board.

The disinfecting apparatus is a "Ransome stove," otherwise well known as the Nottingham self-regulating

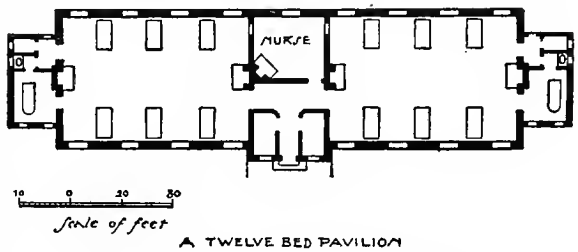

FIG. 304.—Warrington Infectious Diseases Hospital.

disinfecting apparatus, in which articles passed through it are subjected to a temperature of 250° F. by dry heat. It consists of a cubical iron chamber encased in wood with an intervening layer of felt, access to the interior being had by double doors. For disinfecting stations the chamber has doors on opposite sides, and is placed in the partition wall between two rooms, an "infected" side into which articles are carried, and a "clean" side from which they are removed. The furnace is placed at a lower level, and heat is generated by burning gas. There is an automatic regulator. A full description is given in Dr. Thorne's Report, pp. 210 to 214. An approved form of apparatus employing steam confined under pressure, is Lyons's patent steam disinfector, one of which is in use at the Johns Hopkins Hospital. This is an expensive apparatus and somewhat difficult in its method of working. These and other forms of appara-

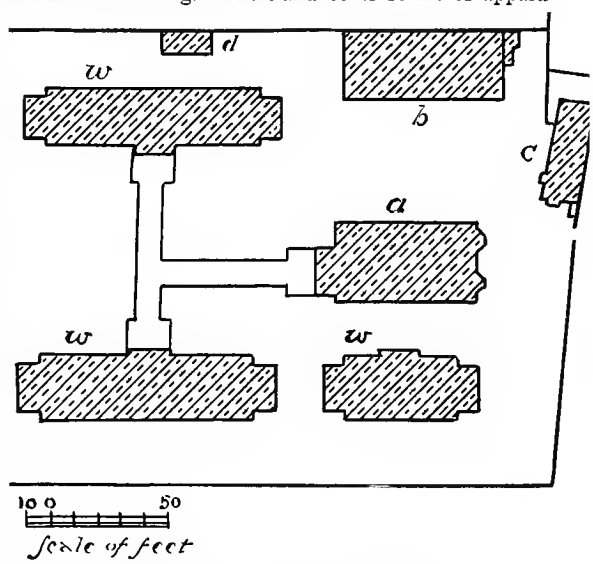

FIG. 305.—Warrington Hospital. Block Plan.

tus and experiments in testing them are described by Dr. Parsons in his report on disinfecting by heat, to the Local Government Board, in 1884.

The Fever and Small-pox Hospitals of the city of Glasgow form an extensive establishment, which was completed in 1887. The Small-pox Hospital has ten wards in five pavilions, and the Fever Hospital has twenty-six wards in thirteen pavilions. The pavilions are of one story and are alike in form and arrangement; they are detached and arranged in groups with respect to their

isolation, and to the administration and service buildings. One of these pavilions is shown in Fig. 306. The two hospitals occupy a country estate of 33 acres, with large gardens and pleasure-grounds, at Belvidere. The Fever Hospital was begun in 1870, the first pavilion being of wood. In 1879 the erection of brick pavilions was begun, and now all are substantial structures of that material. Ample and excellent accommodations are furnished for physicians and nurses. The cost of the Fever Hospital was about £76,000. The Small-pox Hospital is

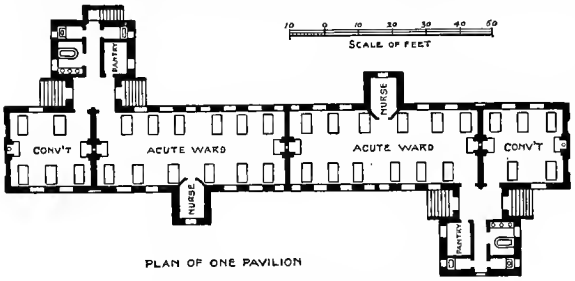

FIG. 306.—City of Glasgow Hospital.

completely isolated by a boundary wall. The whole cost of it was about £30,000. A remarkable reduction has been made in the death-rate of the city since the opening of this hospital, due to a variety of causes, not the least among them being the efficient labors of Dr. Russell, the Officer of Health. This hospital affords the most striking demonstration of the profit of guarding the public health.

The Cambridge Hospital, in Massachusetts, has recently received an addition of a building for infectious and contagious diseases. It is on the grounds of the hospital, at an effective distance from it, and near the bank of the Charles River. The material is brick, and the symmetrical halves of the building are so arranged as to be entirely independent, and without means of communication except by going around the house, out of doors. It is of one story, except that a nurse's room in the attic for each section is accessible by an outside stairway.

The plan is shown in Fig. 307. The construction is simple and substantial, as designed by Dr. Wyman; it is for the treatment of diphtheria, scarlet fever, etc.,

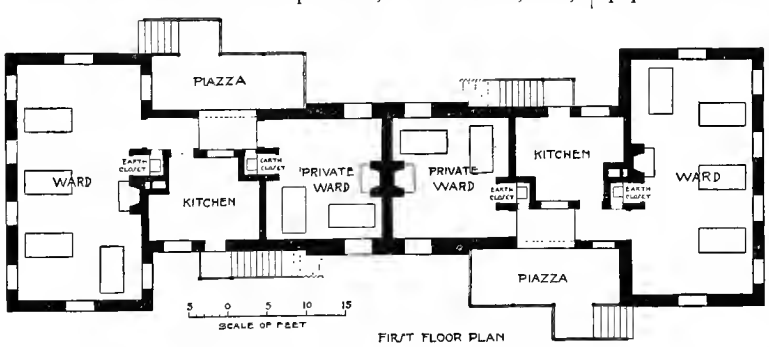

FIG. 307.—Contagious Disease Ward, Cambridge Hospital.

such cases as may occur in the hospital, or may be received from the vicinity. This plan is a modification of one of those of the Local Government Board already referred to. Here it is improved by entrance lobbies to the wards, more windows, and access to closet without exposure in cold weather. A bath-room would further improve it.

An interesting example of a building for isolating the cases that may require it, occurring in a large hospital, is to be seen at the Presbyterian Hospital in New York. The plan is given in Fig. 308. It is situated within the hospital enclosure in the limited area of a paved court. At the level of the main floor, shown in the plan, there is an outside platform or balcony from which there are separate entrances to the rooms, for four patients, occupying the corners of the building. From the ground level the balcony is reached through an opening therein, and by a stairway. The serving-room in the centre of the

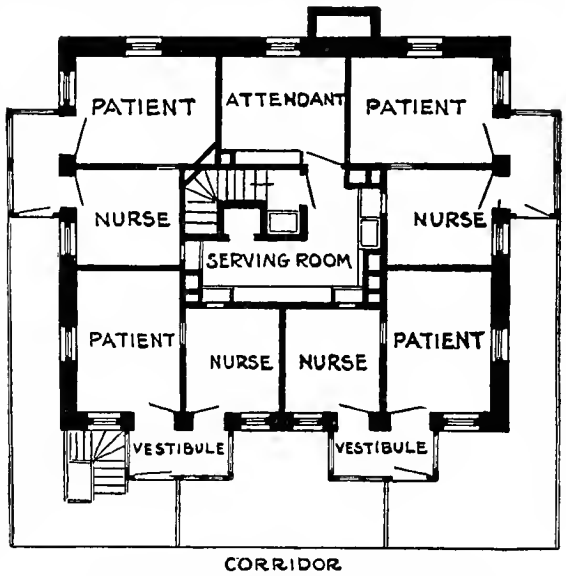

FIG. 308.—Isolated Pavilion, Presbyterian Hospital.

building, and that of the attendant in charge of it, are accessible only by way of the basement.

The Boston City Hospital is now being enlarged by a new and important hospital for contagious diseases. It is known as the Chester Park Hospital, and is subject to the limitations of a city lot. It is to receive cases occurring in the wards of the hospital proper and from the city at large. There is requirement for its accommodations to be centrally situated in so large a city, rather than in any suburban locality that is available, which would be at a great distance from the major part of the population it serves. It is a handsome structure of brick, consisting of six principal buildings, with the adjuncts of a boiler-house, laundry, and morgue, and room for a small pavilion to be added in future. These adjuncts are not shown in the first-floor plan, which is given in Fig. 309. In the lettering of the plan *B* is bath-room, *D* duty-room, *E* elevator, and *O*, operating-room.

The plans were designed by the city architect, Mr. Wheelwright, in conference with Dr. Rowe, the superintendent of the hospital, after an extensive study of the subject, and with the approval of its medical staff.

The entrance gate is at the centre of the one-story lodge, which all persons who enter the hospital must pass through. The administration block, occupying a central position, is three stories high, and contains offices, and quarters for officers, nurses, and servants. Covered passageways, with open-air walks over them on the first-floor level, connect the basements of the buildings. The domestic building in the rear contains the kitchen, etc.; a dispensary, and a dining-room for servants, their chambers being on the second floor. A nurses' home, not shown in the plan, is a detached building to accommodate sixty nurses.

The wards are in two pavilions, each two stories high, and are designed to accommodate 136 patients, including men, women, and children. At the junction of the communicating corridors with each pavilion there are steps

leading up from the ground level to the first floors, and others to the basement floors underneath. Here there is an open way across the corridor from side to side, at the basement level, disconnecting the covered passage in the corridor from the building.

The conditions for the treatment of patients in these wards require a classification, not only regarding the sex of patients and their being adults or children—permitting the latter to have their mothers with them in some cases—but there must be proper provision for isolating extreme cases of each of the special forms of disease, and the varying and numerous complications of different contagious diseases. This grouping and isolation of patients is accomplished by the division of each floor into four wards. There is an open ward of ten beds, and four beds in three rooms, in the rear section. This large ward is for convalescents and looks southward. This section is separated from the middle section by a cross corridor, opening broadly to the outer air at each end. An isolated stairway, starting from the outside of the building, here leads to the second floor. The middle section is, in like manner, isolated from the front section, which also is divided in two parts in the same way by a broad opening leading to a wide loggia on the front of the building. Here are the two small probation wards near the front entrance. The floors of these rooms are of asphalt, the walls of white enamelled brick, and the ceiling of Keene's cement. They have their own service- and bath-rooms, as does each section of the whole building. The walls of the isolating passages are also lined with enamelled brick, have mosaic flooring, and cement ceilings. The toilet-rooms are finished in like manner, and are surrounded by an air-space like a lobby, isolating them from the main hallway. The plumbing fixtures of each section are arranged around a shaft affording independent ventilation for these apartments, and a pipeway for all waste and supply pipes. Each section has its own linen and medicine closets; and the shutes to the basement for soiled clothing are from the open-air cross corridors.

The basements, reached by separate staircases from each section, contain the rooms for patients' clothing. At the entrance to the building, in the basement, is a series of rooms through which all visitors must pass. In the first room the outer clothing is left; thence by a lobby another room is entered where a gown is put on to be worn while visiting the sick. On returning, this gown is left in a room on the opposite side of the building, and thence through another lobby the visitor reaches the first room, where the outer clothing is resumed. Like precautions are exercised by the attending physicians.

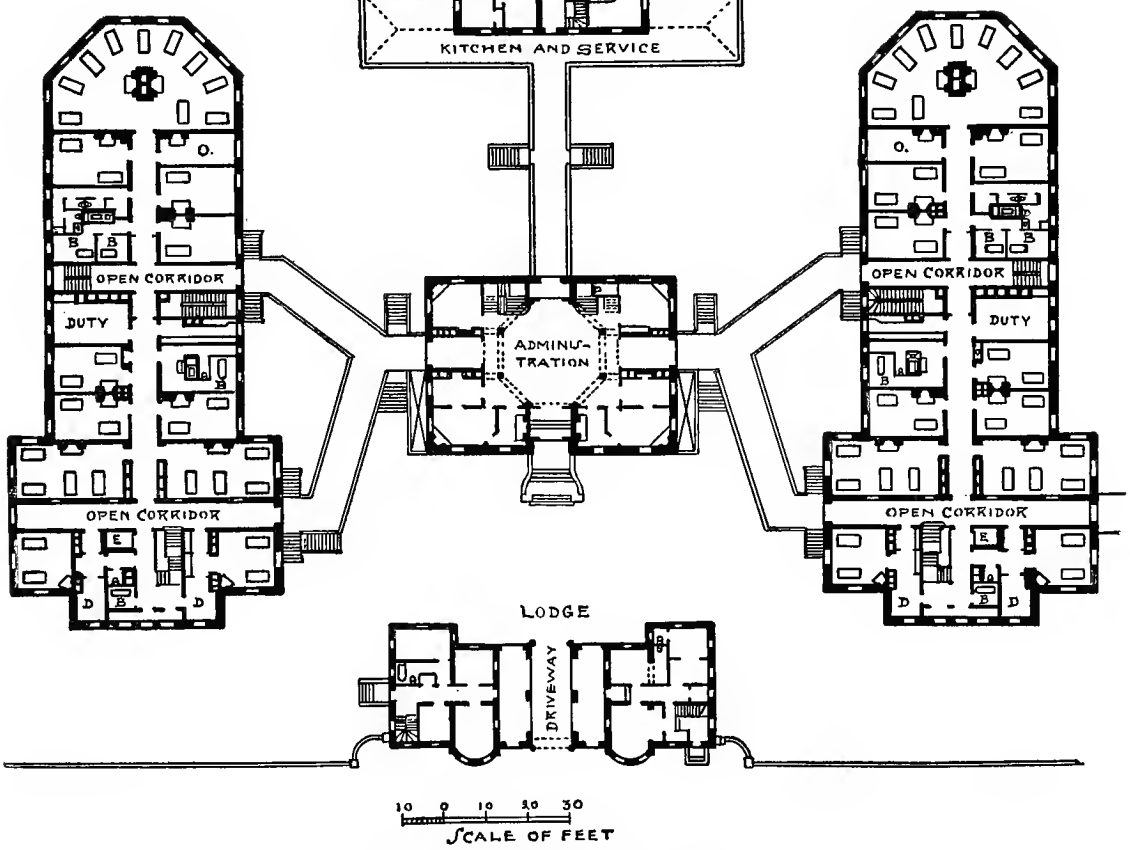

FIG. 309.—Boston City Hospital for Contagious Diseases.

The heating is by steam and indirect radiation. Each room has one or more ventilating outlets, one near the floor and ceiling for every duct in each room. These ducts lead to a vent-chamber in the roof for each division of the building. The whole lot is enclosed by a brick wall eight feet high.

The application of sanitary science has made very slow progress in America, considering the great advancements in knowledge of the causation of disease. In the few States and cities where attention has been given to this subject, experience has shown the necessity of governmental control of sanitary matters. The work of the States of Massachusetts and Michigan in this regard has reached a development of methods that ought to be fol-

lowed in every State. A department of public health, to be established by the national government, is the demand of the time.

The definite knowledge that has now been gained by the scientific tests of disinfection establishes a basis for its practical application. According to Parsons, Sternberg, Blyth, and others, heat is undoubtedly entitled to the first place among the agents available for the destruction of infectious material external to the bodies of living animals. In nearly all the important infectious diseases of man and the lower animals, it is safe to assume that the temperature which kills the tubercle bacilli, 212° F., will be sufficient to accomplish disinfection. Ample allowance is made, in directing the disinfection of all kinds of infectious material, by subjecting it to a boiling temperature for half an hour, either in water or steam. Exposure for ten minutes to steam under pressure to raise the temperature to 221° F., will accomplish the object. The fact that the spores of certain bacilli found in the soil resist a considerably higher temperature than this has led to undue exactions in the use of heat. Esmarch has shown that dry heat is less effective than moist heat, superheated steam being less so than streaming steam at 212° F. Exposure to the moist heat of steam at twenty pounds pressure—temperature about 230° F.—destroys the most resistant spores in twenty minutes. A temperature of 240° F. is effective almost immediately. The simplest way of disinfecting articles of clothing and other articles not injured thereby, is to immerse them in boiling water. Cholera germs are killed at 126.6° F., and typhoid germs at 138.8° F., by exposure for four and ten minutes, respectively. Infectious excreta of these diseases may be disinfected by adding three or four times their amount of boiling water. Sulphate of iron or chloride of zinc, in solution therewith, will deodorize and disinfect at the same time. This is a good rule for domestic and hospital use. The chemical disinfectant that is of practical value, and prompt in its action, is good chlorinated lime, which should contain at least twenty-five per cent. of available chlorine. A solution in the proportion of six ounces to one gallon of pure water being made, one quart of it may be used for the disinfection of each discharge in typhoid fever, cholera, vomited matter, etc. Then the contents of the vessel being well mixed, it should stand for at least one hour before they are thrown out. Infected sputum should be discharged directly into a cup half full of the solution.

The warming and ventilating of hospital wards is rightly regarded as a matter of great importance. The history of the subject, for the last thirty years or more, shows some curious changes of usage. There had previously come about the development of very complex systems in large hospitals, and particularly in asylums. Forced distribution of air, and ventilation aided by the propulsion of a fan, were much in vogue. The experience in military barrack hospitals, and in those of the simple construction that followed, taught hospital men the effectiveness of natural means when employed in the use of simple constructional devices, under the laws governing the movement of heated air. Very satisfactory results were gained by the adaptation of the principles of the extraction system, by means of vent-chambers and chimneys, even in such establishments as the Massachusetts General Hospital, Boston City Hospital, and Johns Hopkins Hospital, without the use of fans. It is perhaps through some failure to apply correctly the methods found so effective there, that there appears to be a reviving tendency to resort to mechanisms driven by steam power or electricity for the propulsion of warm air into buildings, or for extraction of foul air. The practical fact is that the more machinery there is, the more the trouble from defective working, inattention, or ignorance in managing it, or its disuse after a time as ineffective or too expensive. The best way is to devise a simple system that will work if let alone, or requires the least possible interference. It is only necessary to follow the simple law that a body of air relatively warmer than that which surrounds it will rise. Let it be conducted from the room to be ventilated to a chamber at a higher level, so that a body of warm air is held at a point intermediate between the room and the outer air. Artificial heat may sometimes be an aid in giving that chamber the requisite excess of heat. Under these conditions the chamber will discharge itself upward and outward through proper openings, without any danger of the reversal of currents downward through the ventilating ducts. Such reversals will occur in vent-ducts that open upward like chimney flues. Difficulty often arises simply from making the air-ducts and chambers inadequate in size, or attempting to combine too many ducts, of different lengths, in one system.

Hospital management comes next in order after the hospital is gained. A good hospital may become a bad one by bad keeping. Administrative troubles are often relatively worse and more disastrous in a small institution than in a large one; when there is a tempest in a teapot there is no room even for a small tempest. In the organization of the small hospitals the same principles should be regarded as in the larger ones; there should be only one resident head of the administration, and all other resident persons should be subordinate. This is a simple business principle, and it is remarkable that intelligent people of business experience will, as trustees, try over again experiments in organization and control that have so often proved the error of departing from a fundamental principle. It requires experience in the governing board, as in any other business, before this special business can be understood.

The small hospitals are being successfully managed by women trained in nursing, and who become skilled in executive work by doing it. The paramount object of the hospital is the business of caring for the sick. The position of the skilled nurse at the head of a small hospital is precisely the same in principle as that of the medical superintendent of a large one. The maxim of Dr. Mouat is equally applicable in each case: "Those are best qualified to conduct a business successfully who are best acquainted with its requirements."

There are two special sources of trouble—fundamental conditions from which trouble and failure are sure to come some time or other. They are either faults of the system, which even good people cannot get on with; or faults of the individual under a good system. It is true that a dual arrangement is sometimes successful; that proves the goodness of exceptional persons. Again, when the organization is correct in principle there are examples of the failure of individuals in executive capacity and tact, and the governors proceed to change both the individuals and the system. A vast amount of heart-breaking care and trouble could be saved, and disaster averted, in a struggling hospital that means so much to the community that supports it, by the recognition of a simple truth. There should be one head of every hospital household, who, under the controlling board, should have the sole and entire direction of its business. That head should be a person educated to the business, a medical man or woman, or an educated and skilled nurse.

There is one fundamental element in this matter that strangely appears never to be recognized as it ought to be. It is something more than the recognition of the business principle of the executive head. It is worth the utterance of many words to get it made clear, for the sake of the helpfulness it may bring to many a devoted and hard-working hospital officer, whose life is one of trial at the best. This fundamental principle is that, while the management of a hospital is a business, it is not like the business of managing a factory, or a mercantile house. The hospital, besides being the *place of business*, is the *home* of all the people in it. The household element is there; it is a family. The head of the family has a personal, protective relation to its members, controlling their peace and comfort. The fundamental rule therefore is, never disregard the principle of family headship in the hospital household. This applies alike to the man or woman who is at the head of it. A woman superintendent should be a trained and skilled nurse to

begin with; she should have executive capacity; and she should be helped by affording her time in the work to gain the efficiency that only experience can give. All other persons in the hospital should be subordinate to her. After this is done there remains one most important principle to be regarded: give the superintendent full authority, and hold him or her responsible for all that happens, but afford a chance for the exercise and protection of the responsibility. Above all things, the subordinates should not be meddled with, they should be managed only through the head of the house. This is perfectly safe, for they can always be accorded the right of appeal. Then it is fair, and only then, to expect successful work from the executive officer; and then, if there is failure of a well-supported officer to get good results, it is the fault of the individual alone, and the course to be pursued is plain. By such a plan of organization the relations of all concerned are made definite and intelligible, and there is no going against nature and the family principle, which always underlies the mixed organization of a civil hospital. *Edward Cowles.*

HOSPITAL STEWARD, DUTIES OF, IN THE U. S. ARMY.—The Hospital Steward is the executive officer of the hospital, in the post and in the field. Under the supervision of the medical officer, on the steward devolves the care of property, the maintenance of official records and correspondence, the management of food supplies, the dispensing of medicines, the extraction of teeth, and the application of minor surgical dressings. He fills the place of the house physician of a civil hospital in minor accidents and emergencies; he is responsible for the instruction and discipline of the members of the hospital corps under his command; on his vigilance largely depends the zeal and efficiency of the cook, nurses, and other attendants; he must see that all orders are obeyed, all work fairly apportioned and properly done.

To fit a steward for these multifarious duties he must have served at least a year in the line of the army, than which there is no better school of discipline; he must have served at least a year as a private of the hospital corps, and at least another year as an acting hospital steward. He is given access to works on chemistry, pharmacy, anatomy, and minor surgery. For his instruction there is a Handbook for the Hospital Corps, The Soldier's First-Aid Handbook, and The Drill-book for the Hospital Corps. He can study Army Regulations, General Orders, and Circulars, and the blanks for the various reports. Beyond all these there is still much to be learned that has heretofore been left to haphazard observation of the methods—not always the best methods—of the stewards under whom he has served. Unwritten tradition perpetuates error, shackles truth, prevents progress; to gather and arrange these neglected trifles, to till the ground uncovered by the above-mentioned literature, is the aim and scope of this article.

I. In Garrison.

The Routine Duties of a hospital steward in the United States Army intermit for sleep, remit for recreation, but are practically one continuous round. Where the cares of the passing day overlap the prospective duties of the morrow is a good initial point for their survey. We will begin with the

Meteorological Observation, taken at 6 P.M., and entered at once in the Register and on the Blank Report which is to be forwarded at the end of the month to such Weather Bureau centre as may be directed for the station. Both must be kept neatly; there will never be a more leisure moment. Scratch-block memoranda are so much extra work, increase the chances for errors, and are a useless waste of time. After the last observation for the month, totals and averages are computed on the Register and Blank separately, results compared to detect errors, and both are ready for signature.

After recording the meteorological observation the events of the day will be recalled to discover any possibly unfinished business—to be completed now. The desk is put in perfect order, with an eye for memoranda possibly overlooked. As far as possible to-morrow's Morning Reports for the sick and for the hospital corps will be prepared. In a blank-book, ruled as in Table I., are entered the names of all the sick remaining, or taken up during the day, arranged by organizations.

Table I.

May 15, 1900.

Name.	Rank.	Co.	Reg't.	Dis.	Diagnosis.	Treatment.
Stein, Jacob ..	S. M.	..	8 C.	H.	Sprain R. ankle. Misstep on parade.	Hot water; bandage; rest.
Pugh, Henry..	O. S.	..	G.N.C.S.	Q.	Powder burn R. hand and cheek. Def. primer.	Ext. grs. carb. oil, 1–40.
Atkins, Peter..	C.	I.	24 I.	H.	Ac. diarrhœa ...	Ol. ric., ½ oz.; tr. op., ♏ xx.
Jones, John...	P.	A.	9 C.	D.	Toothache	Ext'd R. U. A. molar.

This book is for convenience, and the following abbreviations are admissible if care be taken not to transfer them to the permanent records, viz., H., Hospital: Q., Quarters; D., Duty; G. N. C. S., General Noncommissioned Staff; P. Q. S., Post Quartermaster Sergeant; O. S., Ordnance Sergeant; C. S., Commissary Sergeant; S. M., Sergeant-Major; H. C., Hospital Corps; H. S., Hospital Steward; B. L., Band Leader; C. M., Chief Musician; S., Sergeant; C., Corporal; P., Private; F. Farrier. For regimental designation cardinal numbers are as good as ordinals; d, nd, st, and th consume time, occupy space, and obscure the record. 1 A., 3 C., and 8 I. are sufficiently distinctive for First Artillery, Third Cavalry, and Eighth Infantry.

If to-morrow will be the 10th, 20th, or last day of the month, Ration Returns will be prepared as far as practicable; also, if the last of the month, the Requisition for Fuel, Forage, and Straw.

"In the gloaming"—from six to seven o'clock—is the best hour for effective work, an hour of quiet and freedom from interruptions. If, habitually, all possible work is done at this time, daily tasks will be so lightened that fatigue will not now unfit for close application. With all work complete, the steward will have an evening for reading or recreation. With an assistant to put up the prescriptions that will come straggling in toward tattoo, he can safely leave the hospital.

Just before going to bed a look through the building and about the grounds must be taken. If anything be amiss, the proper man will be called to adjust it. The steward will do nothing himself; if he goes about at night putting out lamps, securing gates, and locking doors, his detachment will soon depend upon his vigilance, and negligence will grow apace.

The steward must see that helpless patients have provision for all their needs during the night; must satisfy himself that all—patients and members of the detachment—are present and in their proper places. Let everyone feel that absentees will surely be detected and reported. The hours allotted to repose are none too long; and effective work by day cannot be expected from men who travel about by night.

From Reveille to Surgeon's Call.—The presence of each member of the detachment must be verified. Breakfast is now on the table; consider its quantity, quality, and variety. The steward must see that the men who come to the dining-room are fully dressed, neat and soldierly in appearance. A bright dawn betokens a clear day; and men who habitually start right in the morning will rarely need correction before night. The patients must be counted, and each receive a careful scrutiny. There may have been changes during the night requiring an immediate report to the medical officer when he comes. Men in collapse, small-pox eruptions, and many other things ought not to await the surgeon's visit at a later hour. The steward will see that

the ward is properly warmed and ventilated, and have corrections made at once. Conditions, not seasons, must be the guide. After a cold rain in July, the ward may be chill and damp, and fire be as essential as in December. Quiet throughout the hospital will be enforced. Reveille is not sounded for the very ill. Undisturbed rest in these early morning hours may turn the scale toward health in critical cases. Let the invalids sleep; their breakfasts can be kept for them.

The steward now takes a complete survey of the building and grounds, and gets the general run of the hospital work. Frozen water-pipes, defective flues, things done improperly or left undone the day before, are all proper subjects for consideration in his early morning round. Each attendant knows his allotted task and will be doing it now; but the steward's judgment will be tried by never-ceasing variations. Each contingency must be met with prompt decision. If many helpless patients await their morning toilet before breakfast, the regular nurse is supplemented by utilizing the more intelligent convalescents and as many attendants as may be necessary. If snow-drifts are to be cleared away before Surgeon's Call, the man who attends to the outside police must be reinforced by other attendants, and less important work delayed.

A good beginning will save much trouble and annoyance throughout the day; but inattention to these duties may bring trouble and humiliation later. Should the steward offer for the surgeon's signature morning reports showing all present and learn later that a member of his detachment, or a patient, had been arrested in town during the night and was still in jail, he would justly forfeit the confidence of his superiors.

Surgeon's Call.—On the desk is the suitably ruled blank-book containing a list—arranged by organizations—of all excused from duty yesterday on account of sickness, with the rank, company, and regiment of each. An interrogation point in the appropriate column tells for which men a diagnosis is needed. As the Company Sick-books are brought in, they are compared with the hospital list and new names entered below. Care must be taken to get the full name, correctly spelled. This is specially important with the Sick-book for Prisoners; for sergeants of the guard are apt to know the prisoners simply as Brown, Jones, or Johnson, and so enter them in the book. Now, there may be several Browns, Joneses, and Johnsons in the command, and confusion may sometimes deprive a deserving man of a pension, or blot index and register with unseemly erasures. The time to settle doubtful points is now.

As the men are called in by the medical officer, record is made of whatever treatment may be directed. Should a new case be one of injury, what the man says was the cause is noted, also the limb or location, whether on the right or left side. These points are difficult to remember for even a short time; and now that outline cards are prepared for every recruit, the correct location of each new scar is important. Should a case be returned to duty with an interrogation point in the column for diagnosis, the medical officer should be asked for one now to complete the record. Should the man go away without this, the medical officer may forget the case entirely or confound it with some other, and great injustice may be done. In the column for disposition is entered a Q., H., or D., according as each case is marked for quarters, hospital, or duty.

Before returning the Company Sick-books to the first sergeants, an entry will be made of the numbers taken sick, returned to duty, or otherwise disposed of, in the proper columns of the Morning Report for Sick and Wounded. Each organization has a line for these entries. The sum of those remaining from yesterday and the new cases must equal the sum of those remaining, returned to duty, and otherwise disposed of. Footing the columns a like equality must exist between the totals. This double system insures accuracy; and now is the time to adjust discrepancies. It is humiliating to make errors in a report that is prepared every morning, and awkward to make subsequent corrections. If the post surgeon does not attend the call, the Morning Reports are sent to him for signature, and then to the Adjutant's Office. The steward must be prompt in this, for the sergeant-major compiles a Post Morning Report from these and has many other things to do before guard mounting.

Patients taken in Hospital must now be assigned to a ward, put in bed, and given such other treatment as may have been directed; those marked "quarters" are, presumably, better able to wait. For convenience of nursing, if there is more than one ward, it is well to place the more serious cases together. Among all men there are social affinities worthy of consideration. Sick "birds of a feather" do better if their gregarious tendency is respected. The victims of indiscretion—the men whom common frailties bring to hospital—should usually be gathered into one ward. The influence of example may be remotely beneficial—the mote in our neighbor's eye is frequently a useful guide to our own ocular defects. Men with barking coughs or noisy delirium must not be allowed to disturb the rest of critical cases of fever or pneumonia—the pay-day penitents are better able to endure this annoyance; and it may be better to so accentuate the bitter dregs from pleasure's cup. When the rosy-cheeked music-boy is brought to hospital, he will not be sandwiched between the reckless or the depraved; he will be better near that staid old sergeant whose grizzled hair and furrowed cheek may recall happy memories to cheer him in his loneliness—may inspire him with hope and courage to tide him over the hour of danger. The old man's friendship, now formed, may prove a useful ballast to the youthful bark throughout life's voyage. It is useless and unwise to be an outspoken reformer; but by attention to such details the steward can silently contribute his mite toward making better men, better soldiers. In a ward containing several helpless patients, to lighten the labor of the nurse and insure increased comfort for the sick, one or two convalescents may be utilized.

As a rule the American soldier is cleanly in his habits and does not need a bath upon admission; in exceptional cases it is for the steward or surgeon to decide. If this duty is delegated to a nurse, sooner or later a case of fainting and death in the bath-tub will bring sorrow. After men come under medical charge the steward is responsible for their condition and should see that they have a full bath once a week, in addition to daily ablutions. In all serious cases the directions of the medical officer must first be obtained.

Personal attention must be given to the effects that each soldier brings into hospital; and an inventory entered in the register for that purpose. The steward should be able to testify, from personal knowledge, what articles of clothing or other property are brought into the hospital; for, if the soldier has sold it before, he may claim to have lost it after, admission. Money, watches, and other articles of value must be enclosed in a suitably marked package and given to the post surgeon for storage in the hospital safe. If they so desire, patients may retain their money, at their own risk; but a nurse must never be exposed to the suspicion or temptation of picking the pockets of a drunken or delirious patient. Before leaving the hospital each patient must sign the Register as an acknowledgment that he has received all of his effects.

The Sick in Quarters will now receive their prescribed treatment. This is always an unsatisfactory class. The expenditure of medicines is much greater, the results less by far, than for an equal number treated in hospital. The steward can do much toward obviating the difficulty. If possible he should see that one dose is swallowed at the counter; he will dispense a quantity just sufficient for the twenty-four hours; will give directions clearly, both orally and in writing. Salts, salicylates, and many other drugs can be dispensed in powders, to be dissolved, when taken. If a bottle be necessary its return to-morrow will be enjoined; the contents may be poured on the highway, but the hospital will in this way recover a few vials. If only a second dose be required, it is

generally better to have the man come to the dispensary for it when needed. A stimulant narcotic, like Squibb's mixture, must be dispensed with great caution as to quantity; a toper may poison himself by taking all at once. Ulcers and abrasions will be dressed occlusively, so that the steward can tell if the dressings have been disturbed when the patient returns to-morrow. He will not improve its condition if he has access to it, and a small ulcer is sometimes considered less inconvenient than a detail with water-wagon or ice-cutting party. As the medicines are dispensed your list must be checked carefully, so that those who do not wait for their treatment may be reported to the surgeon. Care not to report the wrong man is important. The steward must treat all courteously, and never show signs of suspicion; to subject a sick man to unjust doubt is cruelty; to caution a malingerer is to render discovery more difficult. It is well to provide for the lame men last, and watch them depart; the non-commissioned officer has gone, long ago, and some of them may not limp all the way to their quarters.

After providing for the last sick man, a second round is made to see that everything is now in readiness for the surgeon's visit. The cook is told how many men are to be fed, and given orders for what he requires. Prepared for the post-surgeon's signature will be a list of needed commissary stores. It must be seen that all the men are employed—the morning is the time for work. The temperatures in all febrile cases will be taken and recorded—the surgeon will be sure to ask for them.

Before the surgeon's visit there will be time to enter all new cases in the register. The Index must be carefully searched, and the names not already there be entered; also the new hospital number of each case, and the last previous numbers will be noted on the Register. The age, nationality, previous service of each new addition to the Index will be ascertained. The record of each case returned to duty will be completed at once; if any point be doubtful, a memorandum for reference to the surgeon when he comes will be prepared. If the register be completed as far as practicable each day, the work at the end of the month will be greatly reduced.

Morning Visit of the Post Surgeon. — The steward precedes the surgeon, and, as he enters each ward, calls "Attention!" when each nurse and those patients who are out of bed will rise, and remain standing in a line at the foot of the beds until the officer's departure. Should much time be required in the ward, the surgeon may direct the men to sit down; then each will rise at the surgeon's approach, and remain standing until the next patient is addressed. The same direction may be given to individuals. The nurse in charge of the ward will follow the surgeon and steward from bed to bed.

The steward should verify the number of men in the ward and call attention to absentees. This is better than to have the surgeon call attention to a discrepancy between the Morning Report and the number of cases that he has seen. On a memorandum block is noted the prescribed treatment for each case and any operation done by the surgeon; if an abscess is opened, if a man complain of pain or lameness, the anatomical locality is noted; if a tooth be extracted, a record of which tooth. These seeming trifles frequently have a remote importance; and the completeness of the record will be a source of gratification to the surgeon and to the steward. Note is made of which cases are to be allowed to leave their beds, to visit the dining-room for meals, to have special diet, to be provided with crutches, etc. These memoranda will be carefully copied in the proper column, and opposite each man's name, in the blank-book described and illustrated by Table I., p. 457.

The prescribed treatment for each case will now be provided. The nurse should apply bandages, poultices, and other dressings, under the immediate supervision of the steward. Neatness, cleanliness, and efficiency must be secured. This may take more time than to do it himself, but this instruction given is like bread cast upon the waters—it will return as a diminution of labor hereafter. All unused vials are taken to the dispensary, carefully washed, and stored for future use. Corks, once used should be washed and kept in a separate drawer for use with liniments and other external applications. These little economies will prevent a shortage toward the end of the year. A mental inventory of medicines left in the ward will be taken, so that if a patient takes too much or too little, the defect may be discovered and corrected promptly. Instruction will be given the cook as to special diets.

The Daily Mail now lies on the surgeon's desk; he will indicate whatever action is to be taken upon each paper. Each communication will be stamped with the date of receipt, and such as have not already received that attention will be briefed. Each is numbered to correspond with the records. In the Letters-received Book will be noted the number, source, date, date of receipt, import, and disposition of each communication; if sent away, cross-reference will be made to the Endorsement-book; if a reply to a letter sent, make cross-reference to the Letters-sent Book, in which will be noted the number of this reply. If an important letter is not for file in the office, it is safer to copy it in full—a brief may not convey the full meaning of the writer. All letters sent must be copied in full in the proper book, and all endorsements in the Endorsement-book. The letter-press does not give an official record and can seldom be used to advantage. When bringing letters and endorsements to the surgeon for signature, it is well to also present the Record-book that he may verify and sign the retained copy at the same time, and the books are always ready for an inspector. Careful comparison will insure that all retained copies correspond exactly with the papers forwarded. This little extra work will often save misunderstanding, which ever breeds voluminous correspondence. If reports are returned for correction, a special list of such errors will be a useful supplement to the files of orders and circulars, and a safeguard against stumbling twice on the same stone. A growing list will warn the steward of a flaw in his habits.

The mail brings also general orders, circulars, letters of instruction, decisions, etc. These are compared with Army Regulations, the Epitome of Orders and Decisions, the Handbook of the Hospital Corps, or the Drill-book, whichever may be affected, and marginal references made to the new modification, giving the number, date, and source of order. An R for revoked, or an M for modified, will often save the necessity for searching the files.

First-Sergeant's Call will now summon the steward to the last of his morning duties. He goes himself to the Adjutant's Office and obtains with the Morning Reports a copy of all orders and circulars affecting the Medical Department for entry in the Order-book. The strength of the command is to be entered in the Morning Report of Sick, by the sergeant-major. The causes of any changes in the command will be ascertained, as they are required to furnish explanatory remarks.

Dinner is now ready to be served. The steward will look through the dining-room, kitchen, and wards, with an eye for defects. He will ask the seriously ill if there is anything else that they would relish; such little attentions are highly appreciated by invalids and make the days of confinement seem shorter and less irksome. The attendants, also, are cheered by his constant supervision; that his critical eye approves, is sufficient reward for what would otherwise be deemed thankless drudgery.

We have thus far considered duties that come every day with the certainty of each succeeding sun; others come periodically, at various intervals, and will sufficiently occupy the steward's afternoons.

Rations are usually drawn on the 10th, 20th, and the last day of each month. At surgeon's call a Ration Return, prepared as far as practicable the preceding evening, is completed. The columns for number of men and number of rations are filled in; the spaces for quantity of each component are left blank. It is specified for whom the rations are drawn: for so many sick in hospital, so many privates of the Hospital Corps; when a return is made for individuals, they are specified

by name and rank. Entered in the column for remarks is a tabular statement of balances due to, or from, each company. If the resultant balance is in favor of, or against, the hospital, the amount is added or subtracted from number of rations. The word Add (or Deduct) will render the matter sufficiently intelligible.

This settlement with the companies is a matter for frequent dispute; and the steward will save himself much annoyance if he is careful to be always right. To verify the work, find the sum total of the sick in hospital for all the days covered by the previous return, as shown by the Morning Report; to this amount, add one ration for each man admitted to hospital after surgeon's call, and before dinner, during that period. To this amount add the present balance due companies, or deduct the present balance due hospital; and the result should equal the product of the number of men drawn for on the last return, by the number of days. When men are admitted after dinner, it is better to lose a supper and breakfast than to dispute about fractional trifles; but when a man is fed an entire day, the ration belongs to the hospital and must be insisted upon. This may seem a trifle, too; but economy in trifles is the secret of successful hospital fund management. A ration so lost but once a week will in a year amount to the subsistence of a man for fifty-two days. Further, if the steward is found careless in this matter, first sergeants may soon find valid excuses for having sick men reach the hospital too late for surgeon's call, to the inconvenience of the medical officer and decided loss to the fund. Keep a separate memorandum of these cases, as an account of them does not appear on your Morning Report. Table II. is a convenient form for this: the first column is a list of all organizations with which accounts are kept; the second column shows how many rations are drawn for men of each at the commencement of the period; a column for each day of the period shows how many men of each are fed. These numbers should be entered every evening, and, when a new return is made, the numbers in hospital that morning are entered and balances computed.

Table III. shows the dates included in a return and the total number of rations. The first column is a list of the several components of the ration; the second shows the number of each to which the hospital is entitled; the third is the number left in the subsistence department, to be paid for in cash at the end of the month; the fourth column shows the number of rations of each component that you desire to draw out; the fifth, and last, is the cook's column, and tells him the exact quantity of each article that he is to receive. He takes this paper with him when he goes for the rations, and there can be no errors of computation.

Table IV. is a convenient slip to have on your desk when you make the computations in Table III. It it well to compute quantities by two methods, as a check to possible errors; or to verify by reversing the process and reducing the determined quantities back to number of rations.

TABLE II.

Ration Memoranda.

Patients fed, May 1 to 10, 1896, inclusive.

Organization.	Drawn.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Due Cos.	Due Hosp.
Band, 9th Cav.	10	1	1	..	..	..	..	..	1	1	.	6	
Tr. A, 9th Cav.	40	3	4	2	5	4	3	2	4	3	..	10	..
Tr. C, 9th Cav.	20	..	1	3	4	5	5	4	3	3	2	..	10
Bat. A, 5th Art.	..	..	1	1	1	2	2	1	1	1	1	..	11
Co. D, 8th Inf.	10	2	2	2	2	1	1	1	1	2	2		6
Co. G, 8th Inf.	20	3	3	4	5	4	1	1	1	1	2	..	5
Ord. Sergt.	10	1	1	1	1	..	..	..	..	..	..	6	..
Ind. Scouts.	10	1	1	1	1	1	..	..	..	..	..	5	..
Casuals	20	2	2	2	1	1	1	..	..	..	..	11*	..
Totals												38	32
Due U. S. for two men three days †												6	..
Deduct from next return												..	12
												44	44

* Due U. S., one transferred, one discharged. † Field rations issued.

TABLE III.

Rations drawn, May 1 to 10, 1896, inclusive. Number 140.

Components.	Rations.	Saved.	Drawn.	Bulk drawn.
Salt pork	20	4	16	12 lbs.
Bacon	24	8	16	12 lbs.
Beef, fresh	98	14	84	105 lbs.
Soft bread	120	..	120	.....
Flour	20	20	...	15 lbs.*
Beans	60	..	60	9 lbs.
Rice	44	14	30	3 lbs.
Hominy	20	..	20	2 lbs.
Coffee, green	140	40	100	10 lbs.
Sugar	140	..	140	21 lbs.
Soap	140	15	125	5 lbs.
Salt	140	15	125	5 lbs.
Pepper	140	40	100	¼ lb.
Vinegar	140	15	125	1⅛ gal.
Potatoes	112	.	112	112 lbs.
Onions	28		28	28 lbs.

* Two ounces of flour is drawn for each ration of soft bread.

TABLE IV.

Ration of U. S. Soldier.

Components.	Rations to bulk.	Bulk to rations.	Quantity, 100 rations.
Salt pork	Deduct ¼ pounds	Add ⅓	75 lbs.
Bacon	Deduct ¼	Add ⅓	75 lbs.
Canned beef	Deduct ¼	Add ⅓	75 lbs.
Fresh beef	Add ¼	Deduct ⅕	125 lbs.
Salt beef	Multiply by 11 and divide by 8.	Multiply by 8 and divide by 11.	137½ lbs.
Flour	Add ⅛	Deduct ⅛	112½ lbs.
Soft bread	Add ⅛	Deduct ⅛	112½ lbs.
Hard bread	Number of rations is number lbs.	Number of lbs. is number of rations.	100 lbs.
Corn-meal	Add ¼	Deduct ⅕	125 lbs.
Beans	Add ⅓ and divide by 10.	Multiply by 10 and deduct ⅓.	15 lbs.
Peas	Add ⅓ and divide by 10.	Multiply by 10 and deduct ⅓.	15 lbs.
Rice	Divide by 10	Multiply by 10	10 lbs.
Hominy	Divide by 10	Multiply by 10	10 lbs.
Coffee, green	Divide by 10	Multiply by 10	10 lbs.
Coffee, roasted	Multiply by 8 and divide by 100.	Annex 00 and divide by 8.	8 lbs.
Tea	Multiply by 2 and divide by 100.	Annex 00 and divide by 2.	2 lbs.
Sugar	Add ⅛ and divide by 10.	Multiply by 10 and deduct ⅛.	15 lbs.
Vinegar	Divide by 100, gallons.	Multiply by 100	1 gal.
Soap	Multiply by 4 and divide by 100.	Annex 00 and divide by 4.	4 lbs.
Salt	Multiply by 4 and divide by 100.	Annex 00 and divide by 4.	4 lbs.
Pepper	Divide by 400	Multiply by 400	¼ lb.
Potatoes	The same number	The same number	100 lbs.
Onions	The same number	The same number	100 lbs.
Candles	Add ⅛ and divide by 100.	Multiply by 100 and deduct ⅛.	1½ lb.
Yeast powder	Multiply by 4 and divide by 100.	Multiply by 100 and divide by 4.	4 lbs.

Decimal Rule.—Rations to bulk: Multiply by quantity in one hundred rations and point off two decimal places. Bulk to rations: Annex two ciphers and divide by quantity in one hundred rations. Reduce common fractions to decimals and annex additional ciphers to dividend for each decimal place in divisor.

The Quantities to be Saved vary with the character of the cases under treatment, and can only be determined by judgment and experience. A number of cases on low diet, and severe febrile cases subsisting chiefly on hospital stores, will allow a saving of some rations of meat and flour. The allowance of sugar is always required for use. Beans, being a nitrogenous food and supplementing the meat ration, for use are preferable to rice—a pure starch; but, as the money value is greater, it is better to save rice than beans. You will draw enough rice to give variety and supply convalescents from severe illness. Generally, one-third of the coffee may be advantageously saved, and the money value invested in other luxuries. Tea can seldom be drawn or saved profitably. The quantities drawn should be, if possible, an even measure or weight, and all fractions computed in the savings; when the commissary-sergeant guesses at a fractional measure or weight, the hospital is sure to lose.

Where the fund is small, enough must be saved on each return to cover all purchases that it may be desirable to make during the ten days, to avoid indebtedness; otherwise, it is more convenient to draw all but fractional quantities on the first two returns of the month and make up the savings on the last. There should be a balance left over in the kitchen; if the cook thinks his quantities are for an exact ten days, he will not estimate the amounts required for each day, but will use one-tenth of the whole—with consequent waste.

Purchases from the Hospital Fund, under the supervision of the post-surgeon, will always be the steward's especial province—a duty that he can never delegate to an assistant. This is a subject of very complex bearings, about which a volume might be written. To expend the money received for uncousumed rations would be simple enough: to do so judiciously, to the best advantage, will deserve his life-long study and prove a subject about which he can learn something until the last day of his service. He must constantly consider the nutritive, the economic, and the commercial values of the various articles of diet, the habits and tastes of the men, the skill of the cook in the various methods of preparation, and the class of diseases under his charge.

The aim of any system of dietary is to supply in due proportion all the elements required by the human body under the conditions in which it is placed. The bulk consumed will be such as to secure a sufficiency of proportionately deficient elements. The sense of satiety comes with such a distention of the stomach as experience with the accustomed diet has shown to be necessary for that purpose. The surest and most economical method of securing all elements in due proportion is to give variety to the daily fare. The cook who provides but one dish for each meal will prove expensive and unsatisfactory. The Esquimau consumes an astonishing amount of blubber, not so much because the climate requires a large proportion of fat—of which he consumes a great excess—as because such a quantity is necessary to secure a sufficiency of elements proportionately deficient in such a diet. This lack of variety also explains the voracity of the American Indian. On our Mexican border, where the costume favors such observations, the protuberant abdomens of the little Mexicans is a subject for frequent remark; to a physiologist this tells a tale of a long-continued monotonous diet of jerked beef and tortillas.

The farmer's boy reared on a diet of salted meats, robbed of many of their nutritive elements by the brine, when he enters the army, astonishes by his gluttony the old soldiers accustomed to a diet of fresh meat, and grumbles at the insufficiency of the soldier's ration. It is well to give such recruits a proper sense of fulness by a liberal supply of cheap and bulky articles of low nutritive value, as potatoes, cabbage, fruit, etc. To freely supply such men with a concentrated diet is to make them ill. The excessive percentage of sickness among recruits is largely due to cloying the system with an excess of nutritive elements; and confinement to bed on light diet is curative of many ills. With such cases it is important to know that additional food is not smuggled into the ward byi njudicious friends. In diet as in other things, a few months will convert the recruit into a soldier. A captain told me of a man whose appetite excited general remark. A non-commissioned officer was detailed to observe and record the amounts consumed, with a view to making application for the man's discharge from the service. He ate forty ounces of bread daily, and other things in proportion, for a fortnight; then his appetite rapidly diminished until he ate no more than other men. The captain thought that the man discovered that he was being watched, or that a sense of incongruity aroused his self-denial; but a more probable explanation is, that his system became cloyed by excess, and that his stomach finally adjusted itself to the unaccustomed richness of a soldier's fare.

Purchases should be made with a view to present variety, and to effecting a saving of some component of the ration from which future purchases can be made.

Fresh Pork, at the contract price of beef, will give pleasing variety and prove an economy during the cold season, when it can be kept. The cook will render the lard and save all unconsumed grease for culinary use, so saving an otherwise necessary purchase from the commissary.

Turkeys, Chickens, and Oysters, bought for invalids or holiday dinners, often prove surprisingly economical investments. Much depends upon the market price, but the small percentage of bone, as compared with beef, must also be cousidered.

Eggs have a high nutritive value, but lack the bulk required to give a sense of satiety. Served in unlimited quantity, they seldom prove an economy. On toast, or in cake or custard, an egg will be highly relished, give pleasing variety, and allow of a certain saving of meat. But bulky food must be served at the same meal.

Milk is an ideal food, containing all the elements necessary to maintain life. An animal food, it will take the place of a part of the meat ration. When supplied freely it should be served with bread, oat- or corn-meal mush, or other coarse diluent, as its undigested residue is so small that troublesome constipation will result from long-continued use by itself. Except as a flavoring for coffee, occasional use in puddings and custards, and as special diet for invalids, the hospital fund will seldom justify the purchase of milk. Aside from adulterations, its market price generally exceeds its nutritive and economic value; the milkman must be paid for his life of drudgery, for the use of his horse, cart, and bell. Where there is sufficient fund to pay for her, a good cow is probably the best investment that can be made from the hospital fund. The attendant who does the outside policing will not feel the additional work; the kitchen waste will supply a large part of her food; and an unstinted supply of milk will reduce the demand for various components of the ration and cut off an otherwise necessary monthly milk bill of five or ten dollars. Where more than twenty men are fed, a second cow will be advantageous.

Butter is a judicious investment if the price is not more than three or four times that of beef. Where fresh beef is the chief part of the meat ration consumed, there is apt to be a deficiency of animal fats, and butter is a useful and highly relished addition to the soldier's fare. There is less demand for it when fresh pork and gravies are served. It is not essential, and may be omitted when a reduction of expenditure is required. Care is necessary to secure it of constantly good quality.

Cheese is a food whose nutritive value constantly exceeds its market price. A concentrated food, its economic value is impaired by its deficient bulk. If served in unlimited quantity, the excess taken to produce accustomed distention of the stomach will speedily induce digestive derangements; but a daily allowance of two or three ounces for each man will prove a useful and grateful substitute for a part of the meat ration.

Fresh Fish, when attainable, make a useful variation in the bill of fare; but money paid for transportation does not help to nourish the soldier. Salted fish are of but little use except to satisfy the longings of a petulant invalid. When fish are served at all, let it be on Fridays, to show a proper deference to the religious feeling of some of the men.

Oatmeal, Cracked Wheat, and Hominy may often be advantageously substituted for a part of the flour ration. Vigilance is required to insure that they are always thoroughly cooked.

Sirup is always a cheap and useful luxury, relished by all.

Fruits are a valuable addition to the dietary, where we pay for fruit only, and not for long transportation. At many stations, desiccated fruits and canned tomatoes are the only resource. The vegetable acids fill a useful rôle in the processes of assimilation; and their only representative in the soldier's ration is vinegar, of which the allowance, though small, is rarely consumed. Beans and boiled pork are the only components of the ration that are rendered more palatable by the addition of vine-

gar ; hence, as incentives to an increased consumption of a vegetable acid, such products from the garden as pickled onions, cabbage, and tomatoes assume in the dietary an importance far in excess of their trifling nutritive elements. The commissary substitutes are beyond our means, as we can ill afford to pay for glass, long transportation, and insurance to middlemen against breakage. Oranges, lemons, grapes, and the more expensive canned fruits can be served only as special diet for invalids.

Salt and Pepper, as condiments, require passing notice. Salt, being a constituent of every fluid and tissue of the body, except the dental enamel, is a very important nutritive element ; but it is naturally present in every article of food, and in drinking-water. Its culinary use to render food more palatable, is generally in excess of the requirements of the system ; and in such excess it must be considered as a condiment. The failing of nearly all cooks is to use these articles in excessive quantity. Salt and pepper must always be within reach, that each man may flavor his food to his taste ; and the cook should be instructed to limit his seasoning to a minimum requirement. We would not compel a horse to take more salt than he wants by mixing it with his oats ; and man is deserving of equal consideration.

These are a few general landmarks given to guide the steward in hospital fund management. He will add to and modify them as experience dictates. Curious fluctuations, beyond explanation, will be observed ; in some months there will be large savings ; in others, under apparently similar conditions, it will be difficult to avoid a deficiency. To provide for these refractory variations is an important function of a hospital fund. It is well to keep the expenditures well below the savings, accumulating a few dollars each month, until there is a constant balance on hand proportionate to the size of the post. Thirty or forty dollars is enough at a station of one or two companies ; a hundred and fifty or two hundred is not too large an amount for a regimental post. Until there has been accumulated such a fund, there will be constant trouble "to make both ends meet," and the hospital mess will be of the plainest. With a suitable reserve we can indulge in various luxuries ; a shortage of ten or fifteen dollars in one month, which may readily be made up in the next, will be of little importance. Expenditure for games, reading matter, etc., will then be proper ; but, to give variety to the soldier's fare, is always the main object of a hospital fund.

With constant attention the steward will improve his methods from year to year ; the ultimate possibilities of hospital fund management have never yet been attained. The steward of a lake steamer, whose table was laden with every luxury of the season, told me that the average daily cost to feed a passenger was nineteen cents.

Near the end of the month every item of receipts and expenditures is entered in the record of the hospital fund, and in an exact copy to be sent away. A careful steward will compare the two, item by item, and go over the computations again to know that they are correct, before he presents them for the surgeon's signature. We cannot rely upon the commissary sergeant's accuracy ; all are fallible, and he has much to do.

Fuel, Mineral Oil, Forage, etc., are obtained by requisition, sent to the adjutant's office on the last day of each month. The authorized number of fires and lights are required for, care being taken to ask for enough ; the quartermaster takes up unconsumed balances ; but should a change of weather necessitate more fires than have been estimated for, he cannot supply the fuel. The supply of these things is liberal, and it is our duty to guard against waste or misappropriation. We can compute the aggregate capacity of all lamps in use, they are filled but once a day, and a lamp rarely fails for lack of oil, and oil must not be used for kindling fires. When the daily expenditure of oil approaches the total capacity of the lamps, it is time for increased vigilance. Man is largely a creature of circumstance, and it is well to let all feel that the steward's supervision extends over everything about the hospital.

Where a large civilian population is unprovided with the means of obtaining fuel, the wood and coal bins will be subject to nocturnal visits. Gates will be left open, scattered coal will derange the policing, and in many other ways these visits are objectionable. All that can be done is to render access to the fuel as difficult as possible, with a hope that such visitors may go elsewhere, like electricity, choosing the course of least resistance.

The Monthly Report of Sick and Wounded is a record of completed cases, arranged to accord with the hospital numbers. As each case is returned to duty, or otherwise disposed of, its record in the register is completed, but the monthly report cannot be begun before the end of the month, unless all back numbers are complete. There is no trouble with cases admitted during the month, but without great care, some of the cases scattered through the records of preceding months will be skipped, and the sequence of the hospital numbers will be broken. To avoid this, at the end of each month prepare a memorandum slip of all remaining cases ; verify this with the numerical summary, and check off each number as the cases are completed. When all are checked off, the monthly report can be begun, and the record be brought down to the oldest remaining case, which will sometimes greatly reduce the work at the end of the month.

Changes in the command will be noted, and the required data concerning births, marriages, and deaths, be obtained as they occur. A careful record of the data given will relieve the steward from responsibility for future trouble about personal identification, legitimacy, and other points that may be raised by the Bureau of Pensions.

Muster- and Pay-rolls have sufficiently explicit printed directions. As is true of other papers, accuracy, legibility, and completeness are qualities which are essential to them. They cannot be prepared long beforehand, as changes may occur at the last moment. At the end of each alternate month, when no muster-roll is sent to the adjutant-general, a report of strength and changes in the command must be forwarded.

The Report of Examination of Recruits can be kept up with the record, of which it is an exact copy, and need not consume time at the end of the month. That a recruit is not "accepted" when he has passed the medical examination, but must be actually sworn into the service, is to be remembered.

The Report of Personnel, the Sanitary Report, and *the Personal Reports of Medical Officers*, complete the list of monthly papers.

Returns of Ordnance Property, of Quartermaster's Stores, and of Clothing and Equipage are made quarterly. In military departments where an extra copy is required by department orders, a memorandum of such orders should be found in the hospital steward's digest of current orders and decisions.

The Annual Return of Medical and Hospital Property is made at the close of each calendar year, and whenever a medical officer is relieved from responsibility. When this return has been examined and found correct in the office of the Surgeon-General, notice is sent to the officer interested. The receipt of this notification marks the time to begin one copy of a new Return. The quantities "on hand to be accounted for" can now be entered on the first line. Should the receipt of new articles during the preceding year have deranged the alphabetical arrangement—or classification—now is the time to make adjustment. Blank columns are left after each class for such new articles as may be received during the year. When invoices are received the amounts are entered at once in the proper columns ; the same is done under expenditures for property sent away, inspected and condemned, or otherwise disposed of. We shall thus have at hand a complete statement of accountability, and be ready at all times to prepare correct invoices. Should a change of station or other cause necessitate a transfer of property accountability, an intelligent inventory, general or partial, can also be taken with accurate knowledge of what

ought to be found. That an article will be speedily missed, is a safeguard against loss.

Care of Property.—Upon taking charge of a hospital the steward's first duty is to ascertain what there is in it to be accounted for, and the location and condition of each article. Before beginning his inventory he must remember that there are eight classes of property to be considered, and he should obtain from his predecessor the retained returns and subsequent invoices, showing what must be found.

1st. The post quartermaster issues stoves, pipe, lamps, bunks, and many other articles upon a memorandum receipt, of which the steward should possess a copy. The steward must go over this property carefully, that he may recognize the various articles and not confuse them with property of some other class—so counting the same article twice. For example, the galvanized iron bucket is stamped U. S., and a similar bucket, stamped M. D., is carried on the return of medical and hospital property. If we find a surplus of the one, we are likely to find the others deficient; used for kitchen waste, fatigue parties exchange them, and the shortage is of medical and hospital buckets. Once wrong, it is very difficult to straighten the matter.

2d. There is the return of quartermaster's stores—ambulances, harness, water-kegs, and other equipments, which it is very important to see in their proper places.

3d. There is a return of clothing and equipage, of which all articles of bedding should be found, separate and distinct from similar articles of medical and hospital property.

4th. The return of ordnance property.

5th. Certain books may be carried on the muster-rolls and also on the return of medical and hospital property, so that the steward must find duplicate copies.

6th. The return of durable property purchased with the hospital fund.

7th. The annual return of medical and hospital property.

8th. The return of record books. Of these the older ones have become ancient history and are liable to be stored in out-of-the-way places; the assistance of his predecessor may be required to find them, and he may save himself hours of fruitless search if he finds them now.

In taking the inventory it must be seen that every article is on hand; and any excess of articles not expendable carefully noted with the amount. Such excess is always a subject for suspicion, and may prove as troublesome as a shortage; it implies a blunder somewhere whose shade may arise again quite unexpectedly. An officer, in taking an inventory, found a surplus of several sets of tent-poles. Being a careful man, he took them up on his next return, "from source unknown." Several years after, he received official notice that a lieutenant claimed to have issued him this number of tents and poles, and, through error, to have omitted the poles from his invoices. The officer invited attention to his return for such a quarter of such a year on which these poles had been taken up and duly accounted for. Had he neglected this unaccountable surplus, the poles would have been worn out and thrown away, and he would now have found himself accountable for property that he no longer possessed.

It is the duty of the steward to know, at all times, where every article is to be found. To do this his memory must be aided by a systematic arrangement. Of the articles in actual use, lists must be made for each division of the hospital—office, library, dispensary, wards, kitchen, and dining-room. The attendant in charge of each must be furnished with a duplicate list, and warned that he must report promptly any missing articles, with the circumstances of their disappearance, to avoid responsibility for the loss.

Each soldier is charged with his accoutrements, which are verified at inspections and must be turned in before he receives his discharge.

Of property not in use, each class should be stored by itself; and the articles, as far as practicable, arranged in the order in which they are borne on the returns. This will greatly facilitate the taking of inventories, and prevent loss of time in searching for any article when wanted.

There will be noted in a memorandum-book the transfer of articles from one place to another. From this can be determined the rate of expenditure of medicines and stores from the dispensary and kitchen; and can be traced unreturned appliances used in the treatment of cases outside the hospital.

Attendants can be held responsible for the condition of articles in actual use under their charge; but the property kept in the store-rooms requires the steward's constant and particular attention. Blankets and other woollen articles must be secured from moths by tarred paper, marine lint, or other device. Hospital stores must be guarded from the inroads of mice. Wooden articles, buckets, wash-tubs, etc., will become rickety in dry store-rooms and require to have hoops tightened, or to be soaked in water. Water may be left in the kegs during the summer, but they must be carefully emptied before there is danger from frost. If harness is hung in a basement near steam-pipes, the leather will become hard and lose its pliability; if hung in the same basement without artificial heat, dampness may provoke the growth of mould. If the pack-saddle is not secured in tarred paper, the woollen pad must be protected from moths by frequent beating and exposure to air and sunlight. Garden tools must be carefully housed, and, after their season of use has passed, cleaned, oiled, and secured in a suitable store-room. The empty barrels will be needed again for sauer-kraut and pickles, and must not be allowed to fall down for lack of attention. In careful housekeeping eternal vigilance is a useful watchword.

The Ward is, to the hospital, the vital centre, the source of being; all other parts are but accessories to its welfare; and we may well study the conditions that promote its usefulness.

Upon the occurrence of sickness and death the savage moves his camp. This blind following of superstitious ignorance, or traditional experience, approximates in results the most advanced sanitary philosophy. But in the ward there can be no change of camp; suppurating wounds, gangrenous frost-bites, foul ulcers, erysipelas, consumption, pneumonia, infectious fevers, etc., form a continuous pathological chain of which some links are ever present; with modern knowledge of disease-producing germs, the illustrated annals of a ward would appal the stoutest-hearted patient, and attendants might indeed shrink from the performance of their duties. On the contrary, experience teaches that there is less danger in the ward of an army hospital than in the ordinary walks of life. A man with small-pox lands on a wharf and proceeds up a street, stopping here for drink, there for food, and again for rest; in a fortnight, a trail of yellow flags will mark his line of march, and those who came in contact with him on the street will furnish other victims. A man with high fever is admitted to a ward full of patients. On the third or fourth day a small-pox eruption appears, and he is then carried, with his bed and belongings, to an isolation ward or tent. Of the patients and attendants in that ward the probability is that not one will have small-pox. If one man does contract the disease, it will be the attendant who came in contact with the patient upon admission and handled his clothes. The same is true of other infectious diseases. When typhoid fever appears in a house, several of the inmates contract the disease; in a ward, the man with a broken leg is in no danger from the case of typhoid fever in an adjacent bed. Rarely will a patient contract another disease while confined to a bed in the ward. Convalescents, who are permitted to walk about, are in greater danger from the other inmates, but even they are more likely to have contracted the new complaint during surreptitious absence. When apparent exceptions occur, careful inquiry will generally elicit the fact that the germ of the second disease was received before admission; a man with two diseases may only complain of the one that causes him the greater inconvenience.

We must not depend upon fortunate accidents; we must study the conditions that give the ward its freedom from contagion—its salubrity—that we may not interrupt them by injudicious interference; that we may approximate them in other buildings, used temporarily as hospitals; that we may maintain the efficiency of the hospital corps by guarding its members, as far as possible, from contagion.

A hospital ward is a parallelogram of floor space 25 feet wide, whose length is determined by the number of beds that it is to contain. The beds are placed with the heads to the lateral walls. There is a window in each alternate interval between them. Commencing in a corner, we have a bed, a window, a bed, a space. Allowing 4 feet for each bed and each interval, 16 feet is the unit of length providing for two beds on a side. This unit may be repeated as often as desired; generally, for economy and convenience of administration, it is repeated three times, and, as the unit terminates with a space, an additional 4 feet is added for a seventh bed, and the last space provided with a window on one side, and, on the other, a door opening into the lavatory. This gives for each bed nearly 93 feet of floor-space and more than 1,000 cubic feet of air-space, with a ceiling 12 feet from the floor. With ordinary percentages of disease and accident this is satisfactory; in epidemics of infectious disease, without extreme care of the ventilation, such a ward will be overcrowded. Under all circumstances the corner beds are undesirable and should be assigned to sprains, bruises, and other slight ailments.

The ventilation of a ward should be entirely independent of doors and windows. In the centre of the ceiling an open shaft of 2½ feet in width, and 15 feet in length, should extend to a ridge ventilator. Twelve feet from each end of the ward, an opening of one square foot should be cut in the centre line of the floor, to communicate with an air-shaft extending across the building and opening at both ends outside. These shafts should have a sectional area of 16 by 16 inches, as the ends must be somewhat obstructed by wire netting to exclude small animals that might hide in the shaft to await death. Care must be exercised that the outer openings be not obstructed by snow or rubbish, and that the ground in their vicinity be kept scrupulously clean. No slop-barrels, cesspools, or sewer openings can be tolerated in their neighborhood. In malarial regions the areas near fresh-air inlets should be covered by an unbroken turf. Provision may be made for closing the windward end of these air-shafts, as rapidly moving air carries dust, bad odors, filth, and morbific germs for great distances; and it is safer and more pleasant to get the fresh air from the lee side of the building. This arrangement for closing the ends of the air-shaft is preferable to a closing flue in the floor opening which cuts off the supply of fresh air altogether. If the ward be warmed by stoves, they will be placed over the fresh-air inlets, and the pipes be carried out through the centre of the ventilating shaft. One stove cannot be so located as to satisfactorily warm a ward 52 feet long; the required heat will render adjacent beds untenable, while remote parts of the room are still cold; further, only the radiant heat can be utilized from a stove placed in the centre of the room, as air warmed by contact will pass directly up the ventilating shaft. The stoves and pipe should present a heating surface sufficient to warm the room in all seasons without the fires being forced. No approach to redness should ever be tolerated in a ward stove.

We will now consider the practical isolation of each patient in the ward. Disease germs may be communicated by contact, by food or drink contaminated by utensils used in common, and by floating particles of dust or moisture in the atmosphere drawn into the air-passages by inspiration.

Direct contact between patients need never occur. An attendant's duties expose him to some danger which can be minimized by trifling precautions. The clothing of each new patient should be removed from the ward at once, aired and dried if necessary, and then placed in a tight locker. If this is done in all cases, the unrecognized infective case will seldom cause trouble. Each patient has his own bedside table, medicine glass, spoon, etc.; his food is brought to him separately, and the soiled dishes are disinfected by boiling water in the kitchen. This obviates sources of infection more common than is generally supposed. I would not eat or drink in a house containing small-pox or diphtheria, and yet I attend such cases without anxiety. A cup of tea flavored with kerosene, and other similar observations, lead me to doubt the effective cleanliness of apparently well-regulated households, and suggest how germs may travel beyond the hangings saturated with antiseptics.

A drunken man besmears the sheets, or a patient uses a close stool or bed-pan in the ward without inconveniencing his neighbors. There is no need for the burnt sugar whose odor is so unpleasantly suggestive of poor ventilation in the sick-room of many a mansion. The reason is, that the heads of the patients are next the outside walls, and that all air-currents are toward the centre of the room, and upward toward the ventilating shaft. The man with the broken leg will wish to smoke in bed. Watch the course of the curling wreaths as they disappear; by them the air-currents are rendered visible. No stagnant strata lie above his head; no smoke crosses the interval to the next bed until it has risen high above it. If some smoke drifts against a cold window-pane, it grows heavy and falls directly to the floor—showing why it is not well to place a patient's head opposite a window, for all foul air takes the same course. This also illustrates the advantages in winter of double sash with a dead-air space between, and teaches us to provide for ventilation elsewhere. You will also see why longitudinal draughts are injurious, deranging the normal air-currents and carrying foul air across the beds. In summer, open opposite windows that the stream of air may pass between the beds and tend to draw impure air from the beds toward its centre.

A ray of sunlight through a shutter illuminates floating particles in the air; these are the omnipresent dust. The sailor in mid-ocean sweeps his deck and wonders whence it comes. There is danger in it—morbific germs may ride upon those little particles. We cannot exclude it from the ward; we can only change our dust as we do our air, by ventilation—judging that from the outside world to be less dangerous. The humble piece of soap, in the society of the rose, partook somewhat of its perfume; so dust, allowed a long sojourn in a ward, will acquire morbific qualities. Daily sweeping and dusting is a wise sanitary precaution. The direction of normal air-currents will be the guide for the sweeper—everything toward the centre is an invariable rule. The proceeds should be gathered on a dust-pan and consigned to the fire. To attempt to sweep through an open doorway, with the possibility that a gust of wind may scatter the dust over the beds, should be a punishable offence. There being but little travel through a ward, and all accidental litter being removed at once, but little dust will be raised at each sweeping; but a half-hour later, every projecting shelf, window-sill, casing, and cornice, together with the furniture of the room, must be gone over with a moist cloth.

The bed-linen is changed as soon as soiled, and at the departure of each patient; if there be a suspicion of contagion, it should be soaked in an antiseptic solution and dried before being sent to the matron. In all infectious cases the mattress, pillows, and blankets must be thoroughly fumigated; the surgeon will decide if destruction be necessary. Whenever a bed is vacant, the bedding should be exposed to air and sunshine. This will avoid the necessity for a complete change of outfit periodically. At times of little sickness patients may be so consolidated as to leave a ward vacant, which can then be fumigated and put in perfect condition. If such a ward can be allowed to lie fallow for a few days, this will make a desirable break in its pathological chain.

Surgical Operations bring important duties to the steward. The surgeon will select his instruments and give directions for antiseptics and dressings for each case; but the steward should be familiar with the general prin-

ciples underlying aseptic surgery, for his ignorance or inattention may nullify the most consummate surgical skill. To take antiseptic gauze from its hermetically sealed package, unroll it on a dusty counter, cut it with rusty old shears hanging in the dispensary for general use, and turn it over to the unwashed hands of a nurse for consignment to the first bedside table that he comes to, is a combination of errors too frequently excelled.

After every operation, however trivial, the instruments must be washed, dried, placed in a covered tray, and, after twenty-four hours, rubbed carefully with chamois leather; then, and not till then, can they be safely returned to the cases. The seams of a leather pocket-case may retain the germs of erysipelas while the ward is refloored, re-ceiled, and re-painted—in vain.

The Dying and the Dead will also claim the steward's consideration. The greatest tact and judgment must be used with the dangerously ill. We must not destroy the last chance of recovery by depriving the patient of hope; but the steward can lead him to think of the general uncertainty of life, and to confide to him the names and addresses of friends whom he would wish to have informed, should his case prove unfortunate. We must note his expressed wishes and parting messages carefully—the words may have a meaning for friends which we cannot understand. Should the patient ask to see a friend or a clergyman, a messenger must be provided promptly. These wishes may have an importance that you cannot appreciate. You cannot put yourself in his place, and the bitterness of helpless disappointment may be more cruel than his physical sufferings. There is a sharp distinction between the friends that the patient asks to see, and those friends who ask to see the patient; the latter may well be referred to the surgeon in charge.

Upon the occurrence of death, carefully, tenderly, reverently, but promptly, let the body be removed to the dead-room. The steward need not assume the solemn airs of a professional undertaker; but, if he considers the grief, the hushed awe, possibly the terror, of the other patients, his procedure will be marked by due decorum. The effects of the deceased will be collected and stored for safe delivery to his company commander. The post surgeon will be notified immediately, and a messenger sent to the first sergeant of the company to which the deceased belonged. The blank forms in the register of deaths and interments will be prepared for signature. There can be obtained through his first sergeant such required data as are not already at hand. After such an examination of the body as the surgeon may desire to make, it will be prepared for burial. After such preparation an attendant will await the visits of all who may desire to view the remains. We cannot exclude the idly curious, for the ties of a common humanity extend beyond our ken. We may not appreciate the importance of a parting caress, a kiss, a little prayer; but we must respect these as some of the mysteries of life.

Post-mortem Examinations.—The steward must know that all instruments are clean; must provide a bottle of olive-oil, buckets, sponges, etc.; must have the needles threaded beforehand, and see that their points are sharp. We cannot have the entire detachment present, but by rotation we can gradually disseminate some knowledge of human anatomy throughout the corps. Some of our men will turn faint and sick; we will send such into the fresh air and encourage them to try again. It is a matter of education, and preparation here will render them useful in operations on the living body. At the end of the examination, it will be the steward's duty to replace the various organs and close up the incisions. Let him aim at neatness and dexterity in the use of the needle, and accuracy and efficiency in the adjustment of parts. These accomplishments may be of use in repairing rents in living flesh. When all is done, clean all the instruments as carefully—more carefully than you do those after a surgical operation. There is something in the dead human body which causes a fatal poisoning, if, even in the smallest quantity, it is inoculated into that of the living. The slightest crack or abrasion of the skin may receive and absorb this fatal by-product of mortality. Before beginning a post-mortem examination the hands are protected by saturating the pores of the skin with oil, which can be saponified and washed away at its close, bearing away with it all other foreign matter. All bodies are not equally dangerous; those are more so in which the processes of putrefaction have begun. Erysipelas, gangrene, and other diseases in which putrefactive changes, in effusions or tissues, may begin before death, have long been known to furnish the most dangerous bodies. In a perfectly fresh cadaver there is little or no danger. Cannibals, with all their experience, seem to have remained ignorant of this peculiar quality in dead human bodies. The putrefying corpse of one enemy would have poisoned the arrows of a tribe, and yet, among the arrow poisons, this one seems to have been overlooked. Bearing in mind that this poison is a product of putrefaction, you will know that there is but little danger from a scratch received in an examination made soon after death; but you will understand that if you leave in the indentations of a knife handle, in the joint of the blade, or in the eye of a needle, particles of human flesh or oil, to putrefy in the cases, those instruments will be very dangerous when used again. If you are careful to clean your instruments immediately after use, I believe that those frightful cases of blood-poisoning will forever remain things that we read about but never see. Buckets, large sponges, in fact everything used in the post-mortem room must be carefully cleaned and put away for future use, care being taken to so plainly label them that neither you nor your successors may ever unwittingly use them for other purposes.

The Hospital Steward's Assistants.—This article is written to little purpose if its perusal does not convince all of the importance of having capable, willing men to assist the steward in the hospital work. He must appreciate the advantages of thoroughly understanding the members of the hospital corps; of knowing their capabilities and their defects; and of seeking the best methods for their training and management. It is the poor workman who grumbles at his tools—the best of steel has flaws; with even poor tools much useful work is wrought by skilful hands. Inferior tools require a careful consideration of their defects, and more constant care to keep them in serviceable condition. The study of defects is not a pleasant occupation; to render it an improving one, it must be pursued with a philosophic spirit. We unravel the intricacies of foul ulcers, of loathsome diseases, that we may the more intelligently apply remedial measures, and we find a sweetness in success to soften the harshness, to assuage the bitterness of our preliminary studies.

Of twelve carefully chosen apostles, one betrayed his Master, one denied Him, and one converted "Doubting Thomas" into a proverb. With every precaution, we cannot hope to improve that percentage among the members of the hospital corps. The men must be young, must have served a year in a company, and must voluntarily ask for transfer. Their pay is now greater, but their duties, if not so severe, are more continuous and irksome, their chances for advancement are but little better than they were in the line. To study the motive for this transfer is to gain an important insight into their character. A little more than a year ago the young man was dissatisfied with his prospects and surroundings in civil life; seeking novelty, he enlisted; after a year in the company he feels that his world still lacks in brightness; fancies that the Vale of Perpetual Content is just over the next divide, and he is transferred to the hospital corps. It is not surprising that such men become restless and discontented. This longing for change will pursue them wherever they go. No other class of men in the army will furnish an equal percentage of applications—for change of station to go anywhere—for transfer back to the line—for discharge. To a student of humanity there is a pathos in these appeals.

There is much in their duties to aggravate this spirit of unrest. In a detachment of eight men, two in the kitchen will begin their duties long before Reveille, and the preparation of three daily meals, with the necessary

dish-washing and cleaning-up, will keep them engaged until Retreat; two [one for each] must be constantly present, day and night, in the wards; one must attend to the office, dispensary, halls, and dormitory, and be ready to act as messenger if required; one attends to the outside police, keeps the ambulances and harness in order, milks the cow, and makes the garden. Six of our eight men are constantly employed; week days and Sundays the hospital work goes on. Change our men about as we will, the tours of duty are long, the intervals of relaxation, of freedom, are brief. Then this freedom is not absolute; the steward must know at all times where the men can be found. Accidents and emergencies are our especial province; and we must be prepared to give immediate assistance.

There is another restraint more irksome and continuous. The hospital is a place of sickness and suffering; patients must not be disturbed by noise. There can be no unseemly laughter, no merry jests, no rough and boisterous play, to smooth the sharp angles of life. No barrack-room ballad can originate or be repeated in the dormitory of an army hospital—the only day-room for the men off duty. The air of solemn decorum that hangs about the building is not conducive to cheerful gayety among the men.

This picture is not drawn to discourage. If the shadows are tinted too deeply, it is to more certainly fix the attention; if the obstacles are drawn in too rugged an outline, it is that the steward may so form his estimates as to surmount them the more certainly. The hospital corps is a still recent organization. Difficulties will continue to be remedied by legislation and orders as the conditions are recognized, and the means of correction fixed upon. A discussion now of many of them would necessarily be ephemeral; but certain general principles underlie all and will be true through all variations. These are worth careful consideration.

First in importance is the fact that the poorest man in the detachment is better for our purposes than the most promising recruit that comes to the post. There is something in that year of military discipline and training that improves the man; we must continue the good work. If the man does not go forward, he will slide backward; we must exact a continuance of those habits of order, of regularity, of prompt obedience. The polish of a shoe, the brightness of a button, have a direct bearing upon the welfare of the sick. Teach your men to be systematic—even in their vices; for regulation is a species of restraint, a step in the right direction. The steward's example is worth more than his precept. If he walks in the straight path, his men will follow him by instinct and without complaint; if he makes them his accomplices in trifling peccadilloes, he will lose a standing that he may never regain. Let the men be taught to regard regulations as they do the processes of Nature—which rains alike upon the just and the unjust. The rigid letter of the law does not abrogate the necessity for judgment and discretion. When a man returns from pass drunk and disorderly, consider that drunkenness, in itself, is a failing and not a crime; consider that the restoration of this man to the duties which others are now performing is our main object. Order him to his bed in the dormitory; when he has slept off his inebriation, he will be as useful as ever. Do not waste words in argument or reproof. If the man awakes in the guard-house, let him understand that this humiliation is not because of his drunkenness, but because he did not retain sufficient sense to comply with an order that was intended to shield him from trouble. Exclude all personality from this exercise of your authority. Aim to do these things as impassively as you wind the clock. In the maintenance of discipline, "In essentials, unity, in non-essentials, liberty, in all things charity," is a motto that we may well borrow from the Church.

For privates of the hospital corps much can be done to lighten the labor, to lengthen the intervals for recreation. The acting hospital steward has charge of the wards and does the dispensary work. After the morning work is done, he has little to do except to be on hand to put up occasional prescriptions. He will try to while away this leisure time by reading, and possibly by smoking. If left to himself, this sedentary life will have one of two effects: he will grow dyspeptic, morose, and irritable, or he will become apathetic and lazy. This loss of energy will be so gradual that the steward may not notice it until he is greatly annoyed by the man's inattention to details entrusted to him; and he injudiciously administers a sharp reproof, which makes him worse; he has spoiled the man, who is no longer a help, but an incubus. With an understanding of the causes, with foreknowledge of the certain results, all this is easily avoided. When the rush of the morning is over, we will encourage him to leave the hospital and seek open air diversion. A private can watch the dispensary and call the steward if a chance prescription comes in. Walking, picnics, hunting, and fishing will increase greatly the efficiency of our acting steward, and, in the end, reduce the steward's labors.

When the public health is at its best, the sick may be consolidated into one ward; for, with our small detachment, the liberation of one man is a large percentage of gain. We will try to reapportion the work so that all may experience the advantage. If our men know that we do our best to relieve them, they will continue their work more cheerfully.

With the present allotment of force, the necessity of utilizing the labor of convalescents is recognized in general orders. Every man who is able to be out of bed can make up his own bed, keep his bedside table in order, and, possibly, contribute his share toward the general police of the ward. The man whose sprained ankle permits him to be out of bed can get to the kitchen to pare potatoes and do other sedentary work. The musician whose sore lips will not permit him to blow his trumpet, is fit for any work about the hospital; if the change of avocation does not please him, he will take better care of his lips in future. The inebriate, too nervous to handle a musket, will sleep the better for handling a broom. With no critical cases in the ward, a sergeant or corporal may be charged to maintain order, and the nurse given a few hours for open air amusement.

This use of convalescents requires great discretion, and the surgeon's opinion must first be obtained in any case of possible doubt. You would not expose inflamed eyes to sunshine, wind, or dust; nor subject an inflamed arm to exercise. A convalescent who refuses to work is liable to punishment by court-martial; but there are many objections to such attempts to discipline men of other organizations; it is generally better to presume that the man is not able to work, that an error has been committed in allowing him to leave his bed so soon. If he cannot work, it is clearly right that he should go back to bed.

Men enjoy doing those things that they can do well. The steward will greatly promote the efficiency and contentment of his detachment by carefully instructing its members. Poets may be born, but cooks, nurses, gardeners, and the like must be moulded by education to fit those positions. If we spend our time seeking men exactly suited to each place, we will grow weary comparing square pegs with round holes—for us, the brightness of the world will be dimmed by many disappointments. If the steward evinces an interest in the work, his men will contract enthusiasm by contagion. If he shows his nurse the neatness, beauty, and efficiency of the reverses in a roller-bandage, the ease and comfort from its equal pressure, and the smooth skin, free from welts, upon its removal, the man will gladly peruse all works on minor surgery that may be given him, and soon become a happy adept in various bandages—spica and many-tailed.

Encourage your cook to experiment in new dishes, to accumulate a variety of recipes. Cook-books will soon be to him more charming than the latest works of fiction. While the plant is still in blossom, it is time to begin the discussion of the possibilities of a green tomato. From almanacs and cook-books he will gather a variety of recipes; encourage him to try small quantities by several of the most promising, and seek a decision of the rela-

tive merits from the gourmands among the patients and in the corps. When your hospital piecalilli attains a local celebrity, and ladies call to consult about ingredients and proportions, you will have a happy, contented, and useful cook. But something more must be obtained from him. Let him feel that passes and other favors depend upon the ability of his assistant to take his place, and we will soon have two adepts in kitchen mysteries.

If there is a hospital garden, there will be need of a gardener. The professed professional who seeks admission to the corps is of doubtful utility. He is in the army probably because he has failed in that vocation in civil life; and he will fail again, at the expense of the hospital. The old Greek was wise who charged a double fee to those disciples who had enjoyed the teaching of another master. The man raised on a farm is only a little better than the professional gardener. He left the farm in disgust; and it will be difficult to inspire him with enthusiasm for the work. If at home he dropped the corn in a depression made with his heel, he will despise a dissertation upon the advantages of sunshine and air, attained by scattering the seed in a broad hill; he will inwardly groan at the military tyranny which compels him to depart from the ways of his ancestors; and, when our back is toward him, he will revert to his original methods. We will have a much finer garden if we select a city-bred boy who has never seen a garden rake. There are many reasons for this. At the start, more personal attention must be given him. Then the charm of novelty will cheer him in his work. The proper adjustment of a clevis that the plough may glide easily to a proper width and depth of furrow, will be triumphs of his inventive genius. He will not take it as a personal affront if you show him that the wilted plant was simply hung by the neck, with roots dangling in space beneath. He will consider the success of the garden a victory for which he has reason to be proud. In times of planting and weeding, we will put convalescents in charge of the wards and turn out our whole force. The work is better done promptly; and our gardener will not become disheartened by the slowness of his achievement.

For variety, usefulness, and general charm, there is no study equal to the study of men. With these few hints to guide him at starting, may the steward pursue it with profit and delight.

Reading.—Considering the multiplicity of his duties, the steward may feel that he has no time for study; but, if he is systematic in this as in all things, he will accomplish more than the average man. When he considers that a half-hour of effective study every day is sufficient each year to learn a new language or master a new science, he will know that economy in small things is a secret of success. Because his time is limited, he will value it more highly, will use it more discreetly. The variety of learning required by his calling will suggest the importance of a systematic assortment of facts. He will make two great classes: those that he must have always with him, and those that can be found promptly when needed.

The first class must be acquired, thought over, reviewed, until mentally digested and assimilated into his personality, forming so many atoms of that sum total which the world calls common-sense. If one of these facts is used with a consciousness of the book from which he learned it, he has burdened his memory with a useless reference; he has not sufficiently mastered the thing itself. When we acquire a new fact, let us consider it as a many-sided crystal, each facet of which must exactly coincide with every other fact in our possession. We will revolve the thing in our mind, and test the accuracy of its various angles and planes. If there are apparent irregularities that we cannot adjust, we will bear the defect in mind and seek a better illumination by further reading. Let us arrange our facts neatly and compactly, and study the common lines that extend through all. We will estimate the relative importance of our various items; if we post our markers properly, all minor facts will dress into line without trouble.

The study of facts of the second class is the art of making useful memoranda. The steward cannot become a walking encyclopædia of useful knowledge. To burden his brain with useful formulæ and cosmetic recipes would be the sinful waste of an organ provided for better purposes. It is well to keep an index of things sought, in which can be entered every subject we are called upon to investigate, with references to the place or places where the information has been found. When we find the tale told better elsewhere, we enter a new reference. A scrap-book for newspaper clippings, a note-book for things that cannot be kept in the library, will often prove useful; but will grow cumbrous, without references in an index.

The newspaper, the record of current events, and light literature, the record of current human fancies, are useful relaxations from more serious study. They must be held as incidents, not objects, of life. We must look upon them as we look at the passing pageant, at the varying lights and shadows of the sunshine on the hills, as things to be looked at, admired, and forgotten. We take a Sunday walk to gather flowers by the wayside; there is no use in the flowers, but we are grateful for the ability to admire their beauties; we are better for having done so.

Intelligent attention to details, and a constant aspiration for improvement, have rescued surgery from the barbers and converted it into a science whose devotees stand among the first of mankind; by similar means may be elevated and improved the position and standing of hospital stewards; to point the way is the highest aim and best wish of the writer.

II. In the Field.

Detachments.—Small parties without a medical officer are frequently sent out to guard wagon trains, to cut logs or fuel, for hunting, and for many other purposes; sometimes under a commissioned officer, sometimes under a sergeant or corporal. Whoever is in charge of such parties must be prepared to administer to accidents and minor ills. The change in diet and other conditions is almost certain to cause either constipation or diarrhœa; and the officer in charge must be sent forth, like the apostles of old, with full powers to bind and to loose. He must be prepared to check vomiting before the occurrence of dangerous prostration, and to relieve a stomach of injurious contents. He must be able to allay pain, promptly and safely, and must give rest and protection to inflamed parts. There is no region where a change of conditions and habits may not reawaken the slumbering germs of malaria, and quinine must not be forgotten. Expectorant cough-lozenges will be also required for bronchial troubles. Rheumatic cases are generally sent back to the post, but salicylates and alkalies may sometimes prove useful, and a bottle of turpentine, or other liniment, for slight muscular soreness may well be added as an incentive to massage. Ready-made plasters of mustard or of belladonna frequently relieve local pain and give men a comforting sense of being cared for. Tincture of iodine is frequently useful, but is difficult to pack securely; if possible it should be issued in a bottle with a glass stopper carefully tied in with a string. A rag on the end of a stick for a swab, small enough to enter the neck of the bottle, is better than a camel's-hair brush, as, when lost, another is readily made; if the brush is lost, the amateur medicine-man may feel helpless. A similar bottle of water of ammonia for the stings or bites of insects will be useful. Vaseline, sheet-lint, roller-bandages, isinglass, and rubber adhesive plaster, absorbent cotton, and salicylated jute will make a very complete and useful medical packet.

Each article must be plainly labelled with the moderate and maximum dose and the interval of safety between doses. The packages should be enclosed in yeast-powder cans or other similar receptacles, with a list of contents pasted on the outside of each, and all securely packed in a wooden box. Security and compactness are essential.

In addition to the labels, it is well to prepare a list of contents with instructions for their use, that the officer in charge may take a frequent inventory of his medical

resources and select the required remedy with greater judgment. The following example is intended as a form, to be modified to accord with varying conditions, and with ever-extending experience.

Contents of Medical Packet for Ten Men, Thirty Days. —Ammonia, aromatic spirit of, two ounces. Dose, one-half teaspoonful in a tablespoonful of water every twenty minutes, if required. As a stimulant in fainting or shock. In drunkenness, or vomiting, first give a teaspoonful of common salt and a tablespoonful of ground mustard in a glass of warm water. After the patient vomits twice, give the ammonia, and repeat as required.

Ammonia, water of, two ounces. To bathe the bites or stings of insects. Will blister if confined by a dressing.

Bandages, roller, three inches wide, six. For pressure, protection, and support of inflamed parts, as blistered feet, ulcers of legs, etc.; for sprained joints, first soak the injured parts in hot water for half an hour.

Bandages, triangular, two. As sling to support forearms, also to retain dressings and protect wounds of scalp.

Bismuth, subnitrate of, one scruple, with powdered opium one grain in each paper. Twenty papers. In diarrhœa, first give a tablespoonful of Epsom salts and a teaspoonful of paregoric in a half-glass of water; after two movements of the bowels give one powder, and repeat after each movement, not exceeding four papers in twelve hours. In place of the salts, a tablespoonful of castor-oil with twenty drops of laudanum may be given. Keep the patient in a recumbent posture.

Castor-oil, six ounces. Dose, a tablespoonful. Acute constipation. Combined with laudanum in colic, or diarrhœa. [See Bismuth.]

Cotton, absorbent, four ounces. For an inflamed eye, douche with hot water, and apply a pad of cotton to closed lid; retain with gentle pressure by roller bandage. This will give rest and protect from external irritants. Dress twice daily. May be used instead of sponge in cleansing wounds or ulcers. A pledget soaked in laudanum may be packed in an aching tooth or ear.

Cough lozenges, one hundred. One every hour, if needed, in troublesome cough.

Iodine, tincture of, two ounces. Apply to inflamed tonsils externally, and, in severe cases, internally, with a swab made by tying a rag or a pledget of absorbent cotton on a stick; to the gums in soreness of teeth; to frost-bites; to indurations or painful swellings; to facial erysipelas; to chest, for pleuritic pains; over the breast-bone in painful cough. Prepare a new swab when you would exact one for your own person.

Iodoform gauze, a roll to fit in a half-pound can. Cleanse wounds with boiled water, allowed to cool sufficiently in a covered dish, approximate edges with rubber adhesive plaster, dry the surface, and apply several thicknesses of the gauze. A useful dressing for ulcers, also for abscesses after evacuation of contents.

Ipecac, powdered, half an ounce. To induce vomiting, give half a teaspoonful with copious draughts of warm water. May be repeated every fifteen minutes. In minute doses frequently repeated until nausea supervenes (vomiting is undesirable) in incipient colds; also in dysentery.

Jute, salicylated, one-half pound. A useful protective for wounds and ulcers. Gives elastic pressure under roller bandage.

Laudanum, two ounces. Dose, five to twenty drops, at four-hour intervals. To relieve pain—for local pain, see "Cotton Absorbent." For diarrhœa, see "Castor Oil" or "Bismuth."

Liniment, acetic turpentine (or some other), six ounces. Apply with massage to slight strains or soreness of muscles, chronic stiffness of joints, etc.

Morphine pills of one-eighth grain each, forty. Dose, one. Two, every four hours, is the extreme limit of safety, and if drowsiness last through the period, reduce and postpone the dose. To relieve pain. When the pain is not excessive, one pill every hour until pain ceases or four pills are taken, is safer.

Mustard, ground, two ounces. To induce vomiting, give a tablespoonful with a teaspoonful of common salt in a glass of water.

Paregoric, four ounces. Dose, a teaspoonful in colic, or mild diarrhœa.

Pills, compound cathartic, forty. Dose, two to four. Follow in six hours with Epsom salts, if required.

Pills, camphor and opium, forty. Dose, one every two hours, in colic, or painful diarrhœa.

Plaster, belladonna, six, each four by six inches. For chronic localized pain.

Plaster, isinglass, a roll. For slight abrasions.

Plaster, mustard, six. A counter-irritant for acute local pain.

Plaster, rubber adhesive, two strips, a yard long and one inch wide. To approximate the edges of incised wounds or ulcers; sometimes to retain dressings. Draw snugly around corns, bunions, or ingrown nails.

Quinine, forty five-grain capsules. Dose, one to four. In malarial fever or periodical neuralgia, give four at once as long before expected attack as possible; in fevers, during the sweating stage.

Salts, Epsom, eight ounces. In acute constipation, give a tablespoonful in half a glass of water; in habitual constipation, give a teaspoonful in a glass of water every evening, and, if required, in the morning; a like dose will relieve pain after meals in dyspepsia. In diarrhœa, see "Bismuth."

Salts, Rochelle, four ounces. In urinary derangements, a tablespoonful in a glass of water, to be taken in small quantity at short intervals, to consume this amount every twelve hours. Add two teaspoonfuls of paregoric to the above solution, in lumbago, and other forms of muscular rheumatism.

Soda, bicarbonate of, two ounces. Half a teaspoonful in water in nausea or acid dyspepsia. A teaspoonful in teacupful of water, as a lotion in burns—afterward cover with flour.

Soda, salicylate of, two ounces. In rheumatism, a teaspoonful every two hours until ringing in the ears or relief of fever and pain; afterward continue in smaller doses at longer intervals. Half a teaspoonful is a useful addition to a solution of bicarbonate of soda, in digestive derangements.

Vaseline and zinc ointment, of each six small impervious boxes. Protectives for chapped hands and lips, sunburn, chafing, and abrasions.

To Arrest Hemorrhage. — Secure absolute rest. Douche open wound with hot water. Approximate edges with rubber plaster and apply a firm compress under a roller bandage. If blood continues to ooze, compress the main artery above the wound by field tourniquet or knotted handkerchief and Spanish windlass; and secure surgical assistance as soon as possible.

N.B.—Please preserve empty bottles, boxes, and cans, and return to post hospital with all unconsumed medicines and dressings—when no longer required.

The above schedule will be a useful reference when we prepare to take the field with larger commands. Medicine panniers, orderly and hospital corps pouches contain a very complete assortment of drugs and dressings, but no list can be so complete that a useful supplement may not be made by comparison with such a list and consultation with the individual preferences of the medical officer. Favorite prescriptions can be more conveniently compounded in the stationary dispensary of the post hospital. Splint material, bichloride of mercury in weighed packets for a one-to-two-thousand solution in a quart bottle, carbolic acid, and styptics, should never be omitted when skilled attendance accompanies the command. A lamp with a reflector to concentrate the rays of light, candles, matches, and instruments, must also be provided.

Thorough study must be made of the various panniers and pouches supplied by the medical department, to know the existence, the quantity and the exact location of each article. In case of accidents, as a wetting, requiring that every article be set out to dry, or an

upset that throws all into a confused jumble, the steward should be able to recognize each article and restore it to its original position in pannier or chest. Let the privates remove the contents from a hospital corps pouch and try to replace them; rarely will they be able to buckle the strap at the first attempt. This art of packing is the first great lesson for field service; its daily importance extends from pannier and mess-chest to the army wagon drawn by six mules.

A thorough knowledge of the outfit provided by the medical department will be a useful guide for extemporized substitutes as well as for supplementary provision. The chief defect in the old pannier that came down to us from the Civil War, is the combination in one chest of medicines, surgical dressings, record books, and stationery. The tray containing dressings and instruments had to be removed, with unavoidable exposure of contents, before a dose of medicine could be administered. This suggests a division of the field outfit into medical and surgical, with a small, compact field desk for record books and stationery. Again, it is not wise to constantly expose our total resources to the many accidents of the field. It is better to divide them into medical and surgical packets for daily use, and medical and surgical reserve chests, to be drawn upon, as medicines are taken from the store-room to the dispensary of a stationary hospital.

The amount of supplies for daily use will vary with the probable nature and duration of the service, with the more or less ready communication with the base of supplies. For instance, with a command of several companies, going to occupy a position thirty miles off for an indefinite period, you would take everything enumerated in the Medical Supply-Table; for the same command going on a reconnoitring or foraging expedition to return within a week, and leaving all invalids behind, the supply above indicated for a small detachment would require but little increase of quantities, and the addition of such surgical appliances as the nature of the service might indicate. A permanent camp will justify the transportation of bedsacks, blankets, and folding cots, benches, tables, and chairs; for the bivouacs of the march, these things would be useless incumbrances.

To grasp a thread to guide us through these endless variations, to study intelligently the analogies and differences in the hospital steward's duties when the hospital becomes movable, we will take an eight company post to which an unexpected order comes for six companies with a medical officer and a proper detachment of the hospital corps to proceed to a point one hundred miles away to camp an indefinite period. By the order, thirty days' rations will be taken, and the hospital will be provided with one ambulance and one six-mule wagon.

The Detachment.—Upon the receipt of such an order, the first question to be decided, and this must be done instantly, is which men will go, which remain? This will be determined by the Post Surgeon; but, as in all questions of hospital administration, the steward must be prepared to give an intelligent opinion. The full complement of men at an eight company post is two stewards, an acting steward and seven privates. The allotment for a two company post is a steward, an acting steward and four privates. But in our problem, it is something more than a two company post that is left behind; the sick of eight companies are already here and the more serious cases will find their way back from the field. It is clear that in this division of force there is a shortage to be apportioned between the fractions. This will always be so. Non-combatants are impediments to an army; our problem will forever remain, to get the greatest amount of work from the fewest men. A steward, an acting steward and four privates constitute the maximum force that can take the field. The acting steward goes because the moving command is liable to further subdivision, and his skill may be urgently required.

The three privates left at the post must be thoroughly reliable, capable men. One must cook, one have charge of the wards and internal police, and one do the outside work, and be a general utility man to supply deficiencies everywhere. There is no margin for sickness or inebriation. Of the four privates for the field, one must be an efficient cook, and understand the management of rations; one must be able to drive the four-line ambulance team, and care for the animals. The latter has probably been milking the hospital cow; but, with forethought for such emergencies, there is another private in the corps who can milk, and who must be kept at the post for that purpose. The other two privates for field service are so from necessity—their qualifications may be a subject for regret, but there is no remedy. In the hospital corps, there can be no roster for field service; each man must take the place for which he is fitted.

Equipment.—On the march—as in the desert—no man is a friend. Each man carries on his person the provision for his individual needs; and, transportation being so limited, he only carries enough for himself, and has every incentive to take good care of his own. Under these circumstances, he who goes borrowing will go sorrowing, and the outlook is equally bad for beggar or thief. "We have drunk from the same canteen," awakens sympathies in the heart of the civilian; but to the soldier, the romance of this touching tie is crushed by the reflection that one-half of this friendship was misplaced, that one of the parties was a negligent vagabond who should have had a canteen of his own. This stern reality must be impressed upon the members of the hospital corps; and the men detailed for field service must be warned immediately, to give them all the time possible to provide for their probable necessities.

The official equipment is always ready · the extra pair of shoes, shirt, under-shirt, drawers, and socks are always on hand, ready to be packed with the blanket in the blanket-bag. The hospital corps pouch and canteen hang ready for use with the belt, knife, and scabbard, with the haversack always containing the meat-ration can, the knife, fork, and spoon. The overcoat, rubber blanket, and half shelter-tent with pole and pins, are ever ready to be rolled and strapped on the blanket-bag. When the hospital corps man has put on the above equipments, with a campaign hat and canvas leggings, he may think himself fairly equipped for the field; but there are many little things for him to provide. A hairbrush, a comb, a razor and strop, a tooth-brush, a cake of toilet soap, and a pocket mirror, should all be found in the small compartment of his haversack. Extra buttons, needles and thread, towels, pipes, tobacco, matches, possibly fish-hooks and lines, are things that he must provide now, or go without. In the camp, the men must present a neat and soldierly appearance; each will want shoe-blacking and brush, a button stick, and cleaning material. A few pairs of white gloves, for inspections and musters, will not greatly increase his burden.

Is the soldier's clothing, now seasonable, such as he will require with the changing season? Are woollen stockings, fur gloves, canvas-lined hood, and arctic overshoes, liable to be wanted? It is not enough that the soldier has these things; we must see that they are not left behind. The frozen members will be his own, but the resulting loss of service is an item affecting the general welfare.

The equipment of the hospital corps varies with the command with which it serves. Without specific instructions on the subject, our judgment must be guided by the necessities, conveniencies, and analogies of each case. When mounted, the blanket-bag is useless and inconvenient. Walking, this weight of twenty-four pounds moves with the body; when mounted, the motion of the horse introduces a disturbing element of serious import; the hospital corps man must learn to pack his saddle like a cavalryman, and turn in his blanket-bag for storage, until it is again needed. The rubber blanket may conveniently be replaced by a poncho with its central perforation to pass over the head and retain it in position without assistance from the hands. Vanity may inspire a longing for top-boots, but these are regarded

as useless and unnecessary incumbrances. The members of the hospital corps are mounted only for transportation—their duties are all performed on foot. The infantry canvas leggings answer every purpose when mounted, and, being light and pliable, will not impede the performance of any duty. When the command dismounts to lead up the hot side of a mountain, the feeling of the booted troopers toward the infantry leggings will be one, not of derision, but of envy. As the evolutions of a mounted detachment of the hospital corps will ever be of the simplest, spurs may also be dispensed with.

The accoutrements of a private of the hospital corps form a considerable burden; and his efficiency will be increased by every pound of diminution. What the weight is, and how it may be lightened, are important questions. The belt, belt-plate, knife, and scabbard weigh one and one-half pounds; the empty haversack with knife, fork, and spoon, and meat-ration can, weighs three pounds; the canteen filled with water, weighs four pounds; the hospital corps pouch weighs four pounds; the blanket-bag containing one blanket, one pair of shoes, one dark-blue shirt, one undershirt, one pair of drawers, and one pair of stockings, with one overcoat, one shelter-tent half with pole, and one rubber blanket strapped upon it, weighs twenty-four pounds. The mere adjustment of these things to a man's person, so that his arms may hang naturally by his sides, so that the heavy blanket-bag may not impinge upon the hospital corps pouch and cause chafing, so that the canteen may be readily accessible, is a very difficult problem, further complicated, in savage warfare, by the revolver with which he is to be armed. Every increase of this burden is a serious matter. Leaving the post on a warm October day, he cannot be expected to carry arctic overshoes, canvas-lined hood, fur gloves, and German socks, that he will only require six weeks later.

Without specific provision, it would seem advisable to have a packing-box with the cover secured by a padlock, or a detachment property chest, of sufficient capacity to hold all accoutrements not in actual use. To prevent confusion every article must be marked with the owner's official number. The likelihood of loss will be much less if the many packages are secured in one chest. In a battle, the men detailed for bearers will go upon the field, only equipped with a canteen of water, the hospital corps pouch, the belt, knife, and scabbard. The remainder of their accoutrements and their extra clothing must be left at the temporary field hospital. If secured in a property chest, the men may find their own again after the battle; in case of a sudden move, the chest will be carried along; if the ground be suddenly occupied by the enemy, the Geneva cross may afford this property protection. In no case can individual lockers be carried into the field.

Mounts.—Upon the receipt of the order to accompany a moving command, the number of horses that will be required is a question for immediate decision. A requisition for that number of horses upon the post quartermaster, and for a like number of horse-equipments upon the post ordnance officer, must be prepared for the signature of the medical officer, and the approval of the post-commander. These may not be on hand for issue, but these requisitions will be on record to relieve the medical officer of responsibility for the defective equipment. Never ask for what is not wanted; and we do not want surplus animals to give the small detachment extra work in caring for them. Army Regulations specify the number; but I know of no better illustration, that no general order can obviate the necessity for individual discretion and judgment. With a mounted command, say the Regulations, every member of the hospital corps shall be mounted; but if one of the men drives the ambulance he will be mounted in the driver's seat; the cook will habitually accompany the wagon containing his outfit; to look out for his kettles and pans in case of accidents on the road, he will be much better mounted on the top of the wagon. It must first be ascertained if the quartermaster will send a civilian driver with the ambulance mules, as there will then be required an additional horse.

The number of horses being determined, we must ask for an equal number of complete saddles, curb bridles, watering bridles, and halters; also curry-combs, horse-brushes, lariats, snap-links, double spring snaps for lariats, picket-pins, nose-bags, saddle-blankets, pairs of leather saddle-bags, surcingles, and side lines (or hopples). There is a choice between side lines and hopples. Where Indians may try to stampede the herd, side lines will give greater security; if an animal is a vicious kicker, the side line will render grooming a safe operation. Generally, the hopple is to be preferred; after a fatiguing march, we ourselves would not rest well with a hand and foot tied together. In an exhausting campaign, when the abandonment of worn-out horses was of hourly occurrence, it was observed that those horses went through all right whose riders began the campaign by losing their side lines.

These horse equipments introduce a new kind of property. With an ordnance list in hand, the various articles must be gone over to see that the saddles, bridles, and halters are complete; we must learn to recognize and name the several components, that we may know what to charge for on the muster roll, if any part be lost. The bridles, halters, and saddles must be fitted to the horses, and then an attempt should be made to assign them so that each man may fit his saddle. Now is the time to discover disparities and to remedy them by exchanges with the ordnance officer.

Arms.—If the war is to be waged against savages who do not recognize the Geneva cross, the members of the hospital corps will be armed with revolvers. One revolver and twenty rounds of ammunition for each man will be obtained from the ordnance officer. Each revolver will be loaded with five cartridges when issued to the man; the vacant chamber under the hammer will supplement the safety notch in preventing accidents. The balance of the ammunition must be kept for issue as required. This provision will give the men greater assurance in searching for wounded over a field where a crippled savage may retain sufficient vitality to be dangerous. After camp-fire legends of skulking savages creeping into camp, the man will sleep better for having his revolver within reach. His rest will be undisturbed by the reflection that he would be more likely to kill a good ambulance mule than an Indian, and the camp guard is ample security against such an unfortunate occurrence. All must be impressed with the fact that, in untrained hands, a pistol is a public danger; that the general weal will require the confiscation of all self-cocking bull-dogs, and other private weapons upon discovery. The medical officer may make an exception in the case of a shotgun that may help the hospital mess.

Tents.—The post quartermaster has suitable storerooms for these and keeps them on hand for issue when required. Suitable requisition must be prepared for the signature of the medical officer and the approval of the post commander. Army regulations fix the allowance "in camp or garrison" at three hospital and one common tents. Again, each varying circumstance of climate, season, and soil demands forethought and discretion to adapt a general order to the necessities of a special case. Those hospital tents will be wanted upon arrival in a permanent camp, but they cannot be used on the march. Here, as everywhere, economy of labor, and of time, is an ever-present condition of our problem. In calm weather our entire force can raise a hospital tent with its fly; in a moderate gale, the assistance of a strong detachment from the companies will be required, and, even then, without extreme caution, the iron pin that secures the ridge-pole will be so bent or broken as to render the tent unserviceable. In a driving storm, we will not wish to await such a detail, only to be had after the company camps are in order; nor will we wish to gain for our detachment the reputation of being helpless people who require to be taken care of. The common tent is for the cook, and receives the mess-chest, food-chest, cooking apparatus, and his accoutrements. He must habitually sleep in it, to secure his conveniences from the raids of improvident people who have forgotten

to bring along, or have already lost, the articles of prime necessity in camp life. There will be no room in the cook's tent for anything else. Panniers and other property must be unloaded immediately, for the ambulance and wagon must be parked with the other transportation under the one sentinel, and our animals must not be cheated of a single half-hour of their allotted time for grazing and rest.

For daily use on the march, the best outfit of tentage that can be suggested, that will give the greatest amount of shelter with the least weight, with the greatest economy of labor and time, is one conical wall-tent, one wall-tent with fly, and three common (laced corner) tents. The conical wall-tent gives the largest floor space for the weight, and will afford ample room for the property, for the detachment with equipments, and for sick men besides. The wall-tent is for the steward and acting steward, also giving room for the medical and surgical panniers and the field desk. One common tent is for the cook; the two others will be found very convenient luxuries, not absolutely essential, but sufficiently useful to justify the additional weight of about fifty pounds each. In temporary halts the men need not be fatigued by pitching and repacking the larger tents, the two common tents will afford ample shelter from the sun or rain for the hospital corps and the sick; will give space to open panniers and dispense medicines or dress wounds. With a mounted command that frequently leaves the wagons hours behind, two of these common tents may well be packed with the litters under the ambulance seats. Immediately after halting, sick men can then be made comfortable, the dispensary "opened for business," the ambulance sent away, and the mules given equal grazing privileges with the cavalry horses, which will more than compensate for this trifling addition to their load. These two extra common tents will also greatly increase the capacity of our moving hospital in the stress of emergencies. In a storm or after a battle, the property can be packed into one of them, the hospital corps can pitch their shelter-tents, and the conical tent will shelter sixteen wounded men; and there will still remain one wall and one common tent for operating-room and dispensary.

The medical officer's tent goes with the head-quarters baggage, but it is well to draw it with the hospital tentage and see that it is in good condition before starting. All tents should be marked "Medical Department," with name of post, with a stencil, in such place that the brand may be plainly visible when the tent is rolled. This will prevent confusion, if wagons break and the baggage is mixed with that of other organizations.

Tent-pins must be drawn in a free excess of immediate needs—especially if of wood. The extra ones must be packed in a box and well secured by nails. Those in use will habitually be rolled in the tent to which they pertain. A hundred feet of small rope [ordinary clothesline] for additional stays in high winds will complete our outfit of tentage.

After receipt from the quartermaster, each tent should be pitched in the hospital yard—using only those implements that are to be taken along. It can then be seen that the poles are perfect—and of proper size and length; that all guy-ropes are in good condition; that each tent has the required number of pins; if torn, now is the time for mending. After the condition of each tent has been verified, it is taken down and the poles and pins are laid smoothly along its ridge and snugly rolled in. The roll is then bound by the ropes so that no pin can be shaken out; and the tent is ready for the wagon. This preliminary tent-pitching was once advised by a commanding officer, preparatory to a march the next day. One captain said that, after his twenty years' of experience, this was entirely unnecessary; he would forget nothing. They camped eight miles from the post the next day, when this captain approached with crestfallen air and asked permission to send back a messenger—he had forgotten his tent-pins.

Tools and Implements.—From the quartermaster will be obtained three axes, three picks, two hatchets, two spades, one long-handled and one short-handled shovel, two mess-pans, two camp-kettles, and two galvanized iron buckets. On the march, there must always be found in the ambulance one bucket—for watering the animals by the way,—a hatchet, an axe, a spade, and a pick. With a wagon train, others will help to make the road passable; but, the ambulance being the only wheeled vehicle with the command, you will constantly find gullies to be filled, creek crossings with banks to be sloped, and various obstructions to be removed from your road. Upon arrival in camp the cook will require one axe, and tent-pitching will be done more promptly if you have two for that purpose. When you can get one made, a wooden maul is a less destructive implement for driving tent pins; a section from the trunk of a hardwood tree, of suitable size, with ends supported by iron rings and a handle inserted through the centre, is all that is required. The picks and spades will be useful for trenching around tents, making sinks, and for various other purposes. A small coil of strong iron wire will prove frequently useful in repairing tent fixtures, guying up stove-pipes, etc. In a permanent camp, the hospital tool-chest will be a valuable addition to the outfit. A garden rake and a couple of brooms are policing luxuries that may well accompany the hospital tents for a permanent camp.

Mineral Oil, Matches, Etc.—For ordinary illumination in moving camps, candles are most convenient—least troublesome. For surgical operations and clerical work at night there will be needed a supply of mineral oil for the Diamond reflector lamp. It is customary to take this oil, matches, wicks, etc., from the supplies of the post hospital. In a permanent camp these may be obtained by requisition upon the quartermaster, when candles will be no longer issued as a component of the ration, and hand lamps and oil lanterns will be required.

Rations.—The ration return will be prepared for "The Camp Hospital and Detachment of the Hospital Corps in the Field;" the hospital has certain advantages over other organizations, in the sale of savings to the subsistence department, that may be needed. A list will be made of components as shown in Table III. (page 460), with additional columns for bulk saved, price, and amount. The preparation of this list will always be a crucial test of the steward's discretion, judgment, and experience, an ever-varying, always perplexing problem. The climate, the season, the character of the country to be traversed, the probability of making advantageous purchases along the road, the probable demand and market price for unconsumed components of the ration, are all subjects for consideration now. If the route is to be away from railways, away from the competitive commerce of large towns, as little as possible will be sold to the subsistence department—and the higher prices that can be received in barter by the way be awaited. As the channels of commerce become poorer, the prices of the staple articles of the ration will increase, and those of such agricultural products as may be desired will diminish. You must have food enough to surely subsist your men for the period covered by the return; and a little money will be required to pay for eggs, milk, green corn, etc., that the men may have a variety equal to that of their comrades in the line. The companies leave the post with the fund of each organization to give elasticity to their dietaries; our detachment starts with nothing but the bare ration—we must make and expend a fund as we go along—there is no margin for error or misfortune. Life in the open air and increased exercise sharpen the appetites of the men; and the only compensating increase in the ration is in flour, of which each man receives the entire eighteen ounces, there being no deduction for bakery expenses. Four pounds of baking powder is issued with each hundred rations; and there will be obtained from the subsistence department two dutch-ovens in which the cook will bake his own bread; so that we can safely save four ounces of flour from each ration. This and about one-third of the coffee will be the chief sources

of revenue for this incipient field hospital fund. The following sample statement of the first transactions with the subsistence department can only be a general guide, to be modified to accord with each special case :

Field rations from August 5 to September 4, 189–, inclusive. No. 180.

Components.	Due.	Drawn.	Saved.	Bulk drawn.	Bulk saved.	Price.	Amount.
Pork	8	8	..	6 lbs.	.....	.....	....
Bacon	172	124	48	93 lbs.	36 lbs.	0.078	$2.81
Soft bread	18	18	..	.....	.....	.....	....
Hard bread	12	12	..	12 lbs.	.....	.....	....
Flour	150	104	46	117 lbs.	51¾ lbs.	0 022	1.14
Beans	160	100	60	15 lbs.	9 lbs.	0.012	0.38
Rice	20	20	..	2 lbs.	.....	.....	....
Coffee, green	180	120	60	10 lbs.	6 lbs.	0 231	1.39
Sugar	180	180	..	27 lbs.	.....	.....	....
Vinegar	180	100	80	1 gal.	0.4 gal.	0.13	0.05
Candles	180	180		2.7 lbs.	.....	.....	....
Soap	180	180	..	7 2 lbs.	.....	.....	....
Salt	180	180	..	7.2 lbs.	.....	.....	....
Pepper	180	100	80	¼ lb.	0.2 lb.	0 188	0.04
Yeast-powder	150	150		6 lbs.	.....	....	....
Potatoes	144	144		144 lbs.	.....	.....	....
Onions	36	36	..	36 lbs.	.....	.....	....
Total savings							$5.81

Purchased from Subsistence Department:

12 lbs. ham, at 0 093	$1.12
9 lbs. Y. A. cheese, at 0.113	1 02
5 lbs. lard, at .088	0.44
12 lbs. canned corned-beef, at 0.15	1.80
¼ lb. mustard, at 0.422	0.11
Total	$4.49
Balance in cash	1.32

In the above transaction, including lard and cheese, there is no reduction in the weight of animal food. This will always be a safe provision ; the vegetables bought along the road will be starchy foods, substitutes for the flour ration only. The saving of flour is large, but within the limits of prudence when so large a percentage of the pound of vegetables can be drawn in potatoes. The prices are taken from a Commissary Price List current at the time of writing. The relative price of ham, as compared with bacon, is unusually low. Beans are saved instead of rice, because at the unusually high price the fund receives five cents more than would have been received from an equal number of rations of rice at five and one-half cents per pound ; the price of a quart of milk or a half-dozen eggs is an important gain for our fund in its birth struggle. The soft bread is drawn for use during the first few days of the march—as much as will remain fresh until consumed. The hard bread provides for accidents or irregularities of the march which may deprive the cook of the time necessary for baking.

As soon as received, the ham will be boiled and some beans nicely baked—the pork was drawn to bake with them. These things can be more conveniently and better done on the range of the post hospital, and will greatly relieve the cook upon the march. Two slices of bread, a slice of ham, and a little mustard will make a sandwich to nicely fit in each meat-ration can ; and, with a bit of cheese, a little paper of salt, and an onion, will provide the men with a very satisfactory lunch at each mid-day halt. When the ham is gone, the canned corned-beef will replace it in the sandwich. There should be a mess-pan filled with the baked beans, which, served cold with vinegar, will economize time for the cook and prove a useful and popular addition to each early breakfast.

When the rations are drawn, an allowance for five days will be put in the food-chest, and the remainder boxed up so that the cook can only have access to them by application to the steward. In this way waste, and consequent shortage, will be brought to the steward's attention before the matter becomes serious ; the rations will also be preserved in much better condition. The latter is especially true in regard to bacon, which deteriorates in quality and loses weight during wagon transportation.

The uncertainties of the future compel us to draw the meat ration chiefly in bacon ; but, as occasion occurs, the commanding officer will order the purchase and issue of fresh beef, when his order will be required for the camp commissary to take back an equivalent in bacon. Otherwise the detachment will have received double rations, the accounts of the commissary officer will be confused, and, if he attempts to straighten the matter by deductions from future returns, so much time will be required that the detachment may be split up into fragments, and a matter, simple at first, may become too complex for a just settlement.

The five days' allowance of coffee will be roasted in the hospital range, ground, and secured in close cans in the food-chest.

The Field Desk.—The folding desk furnished by the medical department is too small to contain a sufficient supply of blanks and stationery, and must be reserved for current work. In the absence of one specially devised, the ordinary company field desk furnished by the quartermaster's department will answer the requirements. In laying out the blanks to pack in it, we must consider that the post hospital is a camp hospital that circumstances have rendered permanent ; that the only change has been that record books have been substituted for the retained copies of various returns and reports which are still kept in the camp hospital ; and that a correspondingly increased number of blanks will be required. No meteorological observations are required from the moving hospital. We must review the various departments with which we will have to deal, the various kinds of property for which we will have to account. Soldiers will enlist, be transferred to other commands, be discharged, die, be mustered, be paid, as at permanent posts ; sick men will be transferred to other hospitals ; the detachment will be reported monthly ; there may be lists of wounded, and reports of epidemics. Clothing and equipage, quartermaster's stores, and ordnance property, will each require a quarterly return. Changes of accountability will necessitate blank invoices, receipts, and requisitions ; also returns of medical and hospital property. Completed cases and the hospital fund will be reported monthly. We shall need ration returns, requisitions for fuel, memorandum slips, a blank book for orders, letters, and endorsements, a copy of the Epitome of Current Orders and Decisions, corrected to date. With the exception of ink (which must be packed where the damage will be less in case of breakage), the stationery may also be packed in the field desk.

The Ambulance.—We must see that everything is in serviceable condition ; that no nut or brace is loose ; that the water-keg will hold water ; that there is provided an extra tongue, the required number of litters and rollers, a bucket, a lantern, an axe, a hatchet, a wrench, and a box of axle-grease. All bearings are lubricated before starting.

The Army Wagon.—The busy day of preparation may well be closed by having the wagon brought to the hospital and loaded, ready to pull out with the train in the morning. This will obviate confusion and delay at the start ; the proverbial slip upon the threshold not only will bring misfortune, but is one in itself. With the interval of rest after loading, we can review our work, discover omissions, reconsider the relative importance of things taken and things left behind, and make desirable corrections before the hour of departure.

With the average of American roads, thirty-five hundred pounds is the prudent maximum load for a six-mule team. The wagon box has a floor space of three and one-half by ten feet, and can be loaded to a height of somewhat over four feet, allowing for the curve of the bows. In determining the load, bulk as well as weight must be considered. Heavy packages must be placed nearest the ground ; articles required daily must be accessible without removing the entire load ; all must be packed as firmly and compactly as possible. The fol-

lowing list of packages and approximate weights may be of use as a general guide :

	Pounds.
Rations	550
Food-chest, mess-chest, dutch-ovens, mess-pans, and camp-kettles	360
Medical and surgical panniers	250
Medical and surgical reserve chests and hospital stores	500
Field desk, packed	100
Tentage for the road, with fixtures	350
Axes, picks, shovels, spades, guidons, etc.	100
Tool-chest	90
A table and two benches, with folding legs, and four stools	100
Twenty-four blankets, in two cases	100
Twenty bed-sacks and twelve hair pillows	125
Stoves and pipe	125
Twelve folding cots	400
Twelve folding bedside tables	100
Folding dining table	125
Twelve folding chairs	125
Commode set	35
Pack saddle and fixtures	45
Twelve mattresses	300
Three hospital tents, flies, guys, and pins	600
Total weight	4,440

It will be seen how readily a prudent load is exceeded ; and the space is exhausted long before the maximum of weight is reached. The question is, What can be left behind with least inconvenience ? The twelve mattresses are not essential ; the folding cots are comfortable without them in warm weather, and in cold weather a folded blanket under each patient will insure sufficient warmth. Bed-sacks stuffed with hay or straw make clean, soft beds ; and, with rubber blankets to cover damp ground, the cots may be dispensed with. The ingenuity of the hospital corps will improvise a bunk if one be required. The bedside tables will never be missed. The folding chairs may be reduced to two or three. The dining table is a nearly useless luxury, as the lighter one with folding legs, made by the carpenter for use on the road, is a fair substitute, requiring less space. Pillows are so convenient for steadying an invalid's head, for supporting an inflamed limb, etc., that their exclusion must be a last necessity. The pack-saddle is carried in the wagon for use with expeditions without wagons. The quartermaster will provide an animal when required ; and you need not burden your detachment with another mule until it is needed. With the tentage for the march, you can improvise a very satisfactory camp hospital by attaching the shelter-tents to the common ones for the use of the detachment, and reserving the conical wall-tent for a ward. One hospital tent will be a great convenience—but all three may be left behind if necessary. The medical and surgical panniers are consigned to the wagon as the orderly pouch, the instrument and emergency cases will be sufficient for all accidents on the road ; and the reduction of the ambulance load will be another ever-present and difficult problem of the utmost importance.

Civilian Teamsters.—Army regulations direct that one member of each detachment of the hospital corps shall be designated as ambulance driver, evidently a wise provision in case of long-continued hostilities ; but while the corps remains on a peace footing it will generally be wise to accept the services of the civilian driver employed by the quartermaster, and keep the designated ambulance driver for other duties. The number of privates that can be taken into the field is so small that this increase of force is of great advantage ; and to keep an extra man at every military post throughout the year to provide ambulance drivers for a field service aggregating but a few weeks, would not be an economical policy. The designated ambulance driver may be able to guide the mules safely along the excellent roads about the post, and still be unfit to follow a cavalry command across the country ; without the possibility of testing his skill beforehand, to entrust sick men to his care will involve great risks. Again, the mules cannot be kept for the exclusive use of the medical department—economy requires that they be used for other purposes during a great part of the year ; and the quartermaster does not like to discharge the civilian employee for so short an interval, as a good four-line driver is difficult to secure, and the man will find employment elsewhere.

The quartermaster will send the mules in the harness to which they have been accustomed ; and it is better to leave behind the hospital harness. Your collars may fit the mules, but a new collar is like a new boot—a long march is not the proper time to begin its use ; and if your collars have been moulded by use to fit one team of mules, the next set of animals will surely be of a different size.

At the last moment, there may be another little question to decide. Each organization has its own teams, and there will be no separate mess for the quartermaster's employees ; the teamsters mess with the companies to which they are assigned. The drivers of the ambulance and hospital six-mule team will desire to turn in their rations and mess with the detachment of the hospital corps. These men must live somewhere, and cannot well cook for themselves. A company commander may take them as a favor that will be asked with hesitation ; but that company may be detached the next day and the trouble recur. The messing of outsiders in the hospital is prohibited, but these men are considered as civilian attachés to the hospital corps, who, if they turn in their rations, may properly enjoy the services of our cook. This question has never been the subject of an authoritative decision, but such a ruling by the medical officer is supported by so many good reasons that it is likely to be sanctioned by higher authority if the question is ever raised.

The Start.—At least an hour before the time fixed for starting, the men must be out to feed and groom their horses. Each man must care for his own—for they are strangers yet and prone to misunderstandings, and this early intimacy will beget a useful friendship. After stables the last home breakfast will be taken, each man provided with a mid-day lunch, saddles packed, canteens filled, and accoutrements made ready. The water-keg should be filled from the hospital cooler and wrapped in a wet gunnysack before being placed in the ambulance—to keep it cool by evaporation. The animals must be given an opportunity to drink. We will take a final inventory of the contents of the wagon and ambulance, and see that the emergency case and the instrument case are in the latter. The men will fall in for a final inspection, and, if there are no corrections to be made, may rest at ease until the warning call, "Boots and saddles." The wagon, with the cook on top, will pull out to take the place in the train that may be assigned by the sergeant in charge. The ambulance will follow in rear of the troops. The hospital corps, except the orderly who attends the medical officer, follow close behind the ambulance.

Each start from camp will be a repetition of the above, with the addition of repacking and reloading whatever has been taken out for use. There is an instability about camp life that renders it important that, before sunset, everything about the hospital be so arranged that an order to move in the darkest part of the night can never cause delay, confusion, or loss. Breakfast is a great promoter of cheerfulness ; and, if the cook has done his baking, if he has his fire ready to light, his coffee ground and in the pot, no order to move out will be so sudden as to take the men out of camp without at least a piece of bread and a cup of hot coffee—as well as a suitable lunch in their haversacks.

Habitually the cook must be called a sufficient time before "Reveille" so that the men can take breakfast while the animals are munching their grain ; he can then wash and repack his dishes while the others are grooming, and be ready to assist in striking tents and reloading. It is customary to have all the tents in camp go down at a bugle-note ; but the medical department has not men enough to handle all its tents at once, and it will be necessary to have the smaller ones repacked, and display our military precision upon the circular wall-tent. To have a place for everything and assign to each man his allotted share of the work—so that he may know what to do without orders—is the best means to insure celerity, to avoid confusion. After everything is reloaded, we will move our command a short distance away and go over the ground carefully—with a lantern if necessary—to see that

no tent-pin, knife, fork, spoon, cup, or other article has been overlooked.

THE MARCH.—The detachment will be observed as it moves out. The restless horse is probably uncomfortable; the girth has the nature of a compound pulley—an injudicious man may pinch the back and cause an abscess in a short time; if a horse shakes and tosses his head, the curb strap may be so long as to allow the curb to turn forward and strike the upper incisor teeth. There will be a short halt after the first two miles and at the end of every hour, when the feet of the animals must be examined, girths tightened, if necessary, and saddles readjusted.

Sick men are given a pass from their company commander and fall out to await the ambulance; cavalrymen are generally accompanied by a non-commissioned officer. The surgeon examines each man and endorses his recommendation on the pass. Each man who is excused from any duty by the surgeon must appear on the hospital reports, as in the post; the steward must have a suitably ruled blankbook and enter his name and the other required data at once—as he may never see the man after he leaves the ambulance. Men faint from heat, or suffering from other slight ailments, only need a ride to camp, and may not appear again on the sick report. When admitted to the ambulance, the cavalryman's horse, arms, and accoutrements are taken back to his troop by the non-commissioned officer who accompanied him; the foot-soldier is directed by regulations to turn in his arms and accoutrements before leaving the ranks. In actual war, these provisions are essential, when straggling becomes a considerable evil, and a provost guard arrests all men out of the ranks without written authority; but are generally neglected under the conditions of Indian warfare. The writer has followed marching columns more than twenty-five hundred miles without having seen a company commander's pass or an infantry soldier carrying another's arms or accoutrements. The medical officer will not raise questions of discipline in other organizations until the results seriously affect his immediate command. Common sense and the Golden Rule are useful supplements to army regulations in the face of perplexing conditions. For example, an infantryman is overcome by heat, he feels dizzy and short of breath, he does not know what the matter is, but thinks that if he can rest a moment he will be all right. When the ambulance reaches the spot, we will find him there. His ghastly face bathed in perspiration tells the whole story. There is no question of a pass; we will give him restoratives and load him—and his trappings—into the ambulance. This converts our ambulance into a transport for arms and munitions of war, despite the Articles of the Geneva Convention, in violation of a paragraph of Army Regulations which specifies what may be carried in an ambulance; but any practical board of survey will make us pay for that gun if we throw it away. Of course, in civilized warfare, should we fall in with the enemy, there would be serious incongruity between the cross on the sleeve and the arms in our hands. Truly, circumstances alter cases and demand the exercise of a rational discretion. When sick men start from camp in the ambulance, their arms and accoutrements belong with the baggage of their respective companies, and we must refuse to receive them, for the ambulance would soon become an ordnance depot and be seriously hampered in its legitimate functions.

Each hourly halt will give an opportunity to adjust defects. The ambulance curtains can be raised and lowered to accord with the changed direction of the sun. The animals must be offered water frequently, if the chance occurs. If there be grass, riding animals must be relieved of their bits and allowed to graze. This kindness of his master is appreciated by the horse as highly as the dainty morsels snatched by the wayside; and the friendly relations established between man and beast promote that cheerfulness of spirit so necessary for protracted physical endurance. The man who takes every opportunity to gather a few handfuls of mesquite beans or any other dainty relish, and allows his horse to eat from his hand, will rarely be compelled to abandon a worn-out animal and continue his journey on foot.

TEMPORARY CAMPS.—Each arm of service has its own normal rate of speed. The cavalry, including halts, will average four miles an hour; the infantry, three miles; the mule train, two and one-half miles. The train cannot be hastened; and it is very irksome and fatiguing to hold back a marching column to the slower rate. Without imperative military reasons, the command will not be kept together. Starting together, with a purely cavalry command, we will complete the march of fifteen or sixteen miles and arrive at the camping place a full three hours before the train. With a mixed command, the ambulance is kept in rear of all, and will arrive with the infantry two hours before the train. The cavalry are sometimes held back for morning grazing after the infantry and train have resumed the march; in this case, the ambulance will remain with the cavalry until the infantry are overtaken, when, keeping in rear of the entire command, it will arrive with the infantry as before. The adjutant indicates the location of the hospital, to which the detachment will proceed immediately. Each man will unsaddle and secure his horse with hopples and lariat in the immediate vicinity. In a scorching sun, the backs of animals, moist with perspiration, must be protected until dry by the unfolded blanket secured by the surcingle. The ambulance is now unloaded and sent to the place where the train will be parked when it arrives. All this will take but a few minutes; and the ambulance mules will soon be relieved of their harness and grazing at ease. With helpless sick men, or in stormy weather, the ambulance may be left at the hospital until other provision can be made. The reason for not constantly leaving the ambulance near the hospital is that his wagon is the teamster's only shelter, and it is better that he should lodge near his mules. In threatening or stormy weather, or where artificial shade is required, the shelter tents may now be pitched.

The topography of the site of the future hospital will now receive careful attention. The location for each tent will be marked, briars, weeds, and rubbish removed, trenches dug for the sink and the kitchen fire, fuel and water obtained, and the cook's fire made ready for the match. The location of the tents is a matter of some importance. The general location of the hospital has been fixed by the commanding officer, but the ambulance officer has discretion as to details. High and dry ground will always be selected. A tempting greensward at a lower level is always a dangerous experiment; the place is smooth and green and level, because storm waters concentrate there from every shower. Should our command have been preceded by another, it may be compelled to occupy the old camp; and there will be a temptation to utilize the labor of our predecessors. But man is a mischief-breeding animal, and the old campground has its dangers. It will be more prudent to clear away fresh brambles and pitch our tents to the front or rear, to the right or left. The tents will afford sufficient shade—and it is better to avoid that of trees, for the natural shade is grateful to numerous insects who may resent our intrusion; for, if well apart, the tent and the tree will afford shade, and neither lightning nor high winds need cause anxiety. We will avoid ant-hills, for a ruthless war will result to our disadvantage.

We will have a constant order in the arrangement of our tents and a settled place for everything, so that the men may learn to go into camp almost without orders. The kitchen should be somewhat in rear and on the leeward flank, that neither sparks nor smoke may be carried toward the other tents. If the camp be surrounded by dry grass or weeds, they must be immediately cleared by a belt wide enough to give protection from the spreading fire of some injudicious neighbor; our own kitchen fire must be surrounded by a belt of fresh earth. The sink must be decorously screened by bushes or a common tent.

The water-supply must be examined. If from a spring, a reservoir will be prepared—with gravelled bottom if possible—large enough to allow the water to be dipped

with a camp kettle without roiling. If water is to be obtained from a brook, an approach must be made so that the water may be dipped from the main current, and not from a foul eddy. If from a lake, the water may have a brackish taste from saline ingredients; if so, a pit may be dug on the beach that the fluid may percolate through the soil before being used. This will improve the matter, but the best will be bad enough. The surroundings will be examined carefully, that we may not be drinking the seepage from decaying animal matter. If the troops begin to use the slope above your water-supply as a decorous retiring place to answer the calls of nature, the steward will report the matter at once to the surgeon, that the matter may be stopped before a passing shower can bring down the soluble excreta. Other organizations must prepare sinks, as the hospital has done, and be compelled to use them. The perspiration is now dry on the backs of the animals, and the blankets can be removed, folded, and placed with the other equipments. The animals can be watered and moved to fresh circles of grass.

The experience of a few days will enable all these things to be accomplished speedily, and the men will have a considerable rest before the arrival of the wagon. When this comes, remove only those articles that will be needed. The whole force proceeds to pitch the tents and store the property and equipments within. The cook then unpacks his kitchen, lights his fire, and proceeds to prepare dinner. The other men will now dig a small trench around the tents, banking the earth so that no overflow can reach the interior. These trenches will be of little use without a suitable outlet, a problem in hydraulics so simple as to be sometimes overlooked.

The care of animals in camp is, as yet, a new problem for the hospital corps. Without experience, or definite instructions, the subject can only be discussed in a general way. As a first principle, each man must water, feed, and groom his own horse. This will promote a tie of comradeship between man and beast that will insure a better-cared-for, more serviceable animal. Then, the established hours for stable duties must coincide with those of the rest of the camp, for the trumpet calls will then be a reminder to prevent neglect, and will fix boundaries beyond which punishment will not be deemed unjust. The question of guards is more obscure; no troop commander will accept the responsibility for nine additional animals, and the mingling of these animals with a troop herd will be justly deemed a nuisance. These animals must be sent sufficiently far from camp to secure good grazing, and our four privates cannot furnish a herd guard. The most feasible solution of the difficulty seems to be, to put the horses on the same footing as the ambulance mules with the quartermaster's train. Two or three lariats twisted together and stretched between the wheels of wagons and ambulance will make an improvised picket rope of sufficient length and strength. The end of the ambulance tongue is not a proper place to tie up animals. From overlooking this plain fact, the writer once found himself in the sands of Southwestern Texas, sixty miles from the nearest post, with the only wagon tongue snapped off at the hounds.

Notwithstanding the midday lunch, the men will be ready for their dinner as soon as the cook has it prepared; and, in the uncertainties of field service, a delayed meal may be a lost one. It is impracticable on the march to serve three daily meals as in the post; and this combined dinner and supper, being the heaviest meal of the day, should be served, preferably, two or three hours before sunset. Early hours are observed in camp, and ample time for digestion before retiring should be given. The cook, also, will have ample time, by daylight, to put things in readiness for any unexpected order to move.

Tent ropes vary greatly in length with different degrees of atmospheric moisture; if dry when the tents are pitched, a shower in the night will so shorten them as to loosen or pull out the pins, when a sudden gust of wind may bring down the tents. The men must be instructed to promptly adjust them, as a delay may cause a very unpleasant disaster.

The steward's tent and that of the medical officer should be distinguished by planting a hospital guidon in front of each, for there may be sick calls in the night and the messengers—who will carry lanterns—need not arouse the other staff officers and the entire hospital.

With everything in order, the later afternoon and evening may be spent in idle revery; in watching the lengthening shadows, the twilight deepening into night. The chirping of insects, the murmur of the brook, the rustle of the leaves in the growing stillness, become audible music, a droning lullaby, inviting to repose. This is the dolce far niente of camp life. At an early hour our little world is wrapped in unbroken slumber, the occasional challenge of the sentinel only rousing to a dreamy consciousness that all is well.

Permanent Camp.—The bivouac for a night may sometimes become a resting-place for weeks and months. Sometimes the canvas is gradually replaced by more substantial structures, and the bivouac has passed through all the stages of development to a military post. When it is known beforehand that the position is to be occupied for a considerable period, additional provisions for this more permanent camp can be begun before we dismount at the end of our march. The location will be selected with more care with reference to the convenience of the command, the surface drainage, accessibility to water, and possible meteorological conditions. Sedimentary deposit on one side of a bunch of grass, floodwood or rubbish piled against a tree, a general inclination in one direction of the undergrowth, especially of dead brushwood, are each sufficient to tell you at a glance that the apparently driest of deserts is subject to overflow. That lightning will not strike twice in the same place is a very unreliable proverb. What has happened once is likely to happen again. Like causes have like results, even with the uncertain weather. Year after year a hail-storm will ruin the flowers at one end of the garrison and spare the rest. A belt of fallen timber marks the path of a hurricane; our tents will be safer to the right or the left. Bowlders, or cobblestones, spread out at the foot of the hill, mark the limit of a descending avalanche; it will snow again; there are more stones above. The perpendicular face of the terrace has not crumbled before the slow processes of rain and frost; it has been cut away by a rushing torrent; more floods will come; more land will fall.

Where prevailing winds are dry the grass is greener on the lee side of the hill. We may profit by the same shelter. The cool, refreshing breeze from the mouth of a cañon tells us that is not a good place for a winter camp. Ravines are natural outlets for storm waters; we will avoid the lowest depression. Neither will the exposed divide be selected. Beware of a spot where unusual vegetation indicates moisture; it is the probable outlet of cold springs that no system of drainage will render habitable. In itself, a strong turf is of little importance, for it will soon be worn away, but if the grass is scattered and wiry, or is replaced by reeds or rushes, we will avoid the place; too cold for healthy grass, it cannot be made a sanitary dwelling-place.

As our stay will be protracted, more room will be required, and therefore the increased space may as well be cleared at once. A clear passage must be left between the tents for convenience, and that an accidental fire may not endanger all. The sink will be of greater depth and farther away. The tents should face away from prevailing winds, generally toward the east, or between the east and south. Square tents should present a fly to the hot afternoon sun. Shade trees in our dooryard will give the place a cheerful, homelike appearance, and will be so utilized when practicable.

There is a monotony in life in a permanent camp that is sure to grow irksome; everybody will long for the novelties of the daily march. This is aggravated by absolute idleness, and work must be economized so as to provide the men with a few hours of occupation each

morning for as long a time as possible. After the essentials are provided, diligence is no longer a virtue. It is unwise to do to-day what can be put off till to-morrow, for the time will come when even drills will cease to be a diversion. If carefully planned, a few hours' work each morning after the general police will provide many comforts and luxuries.

The kitchen needs, first of all, a place to store rations where they will be secure, out of the way, and preserved in better condition than they can be in a tent. A pit of suitable size can be dug with a passageway into the tent if practicable. It will be covered first with logs or poles, then with brush, preferably with the leaves on, and then with such a thickness of earth as will render imperceptible all changes in the external temperature. We must be careful to provide ample surface drainage; and if there is danger from ground water, we will carry a narrow trench, somewhat deeper than the cellar, to a proper outlet. If cobblestones are at hand, this drain can be partly filled with them, the sod cut from the top laid on the stones, and the remaining ditch filled with earth. Poles laid longitudinally so as to leave interstices, may take the place of the stones. If necessary, this storeroom can be made above the ground level; but more labor and material will be required, and the same uniformity of temperature will be attained with difficulty.

An oven is a very useful addition to the kitchen. Men grow tired of baking-powder bread, and good baker's bread will be deemed a luxury. If an oven be provided, with a cool cellar where stock yeast can be preserved, your cook will rival the post baker in the quality of his bread; meat can be roasted and beans baked. With brick or stones, lime and sand, but moderate skill is required to construct an oven; but we can do without any of these. I have seen good bread baked in a hole in the face of a bank, where the soil was but moderately cohesive, with a perpendicular shaft sunk for a flue. On a level prairie, a foundation can be raised, or an excavation made for a hearth on which to pull out the coals. An empty barrel will serve as a form around which the clay can be packed; a length of stovepipe will give draught, or a chimney can be built of sticks and mud. The wall must be thick to retain sufficient heat. A piece of sheet iron, or an old oil-can, will do for a door; in the absence of these, stones can he piled in the opening and banked with earth when the oven is used. The first fire will burn out the barrel, but the clay will be hardened and make a very durable oven.

The kitchen fire admits of various improvements. Strips of sheet iron with holes for the kettles may be laid over a trench. This, with a couple of pieces of Sibley pipe or a rude chimney at one end, and a short piece of iron at the other to regulate the draught, will answer nearly all the purposes of a stove. The supply of sheet iron, or tin from old oil cans, is the only limit to the length of this trench, which may be extended across the interior of a tent, which will be sufficiently warmed thereby in the coldest weather. This system of heating may sometimes be conveniently applied to other tents, care being taken to bury the iron cover where it passes under the canvas.

Poles, supported by crotches, can be put up in convenient places, where various articles can be hung when not in use. This preserves the articles in better condition and gives an unobstructed ground space. For lighter articles rope or wire answers the same purpose.

Tent-pins can be replaced by posts firmly planted close to the tents, so as to minimize the hygroscopic variation of the ropes, lessen obstruction between the tents, and give greater security. The tent-pins will be repacked for use when the march is resumed.

In hot weather, arbors can be built over the tents by weaving green bushes into a substantial framework of poles. It is better to make the arbor large enough to shade the tent without lateral walls, as the latter are in the way, and when the leaves get dry increase the danger from fire. With this protection from the sun, the square tents no longer need the flies, which can be used as awnings to increase the dry ground space.

When there is a scarcity of canvas, and at the approach of cold weather, improvised shelters will be constructed. In choosing an architectural design for these, it is well to study the methods of the native population. Their experience is longer than ours, and they have arrived at their present practice after many errors, into which we may fall if we depart from their plans.

On the prairies the scarcity of timber and the prevalence of cold winds render the dug-out a favorite dwelling. But when man burrows in the earth, extra care must be taken to secure dryness of soil, ventilation, and sunlight. Life in a dark cavern will in a short time make men look like jail-birds.

Sods used like brick, make an exceptionally warm dwelling, but involve the expenditure of more labor. With an earth-covered roof a sod building can be made frost-proof and replace the cellar where the nature of the soil forbids an excavation.

The log hut, chinked and plastered with mud, also makes a warm dwelling, but windows are difficult to devise, and sufficient ventilation and light will not be provided without a carefnl supervision.

In milder climates poles planted in the ground, with the interstices plastered with mud, will form the walls, and the combined shelter tents of four men will make the roof of a very serviceable hut.

The tent is a very expensive habitation, and when the camp is to be of considerable duration, the canvas will be replaced by the more economical frame structures, and the conditions of a post hospital will be approximated. The camp hospital is the germ that by development becomes the post hospital; it is the atom that by multiplication produces the field hospital. A ward to shelter patients from the elements, a kitchen where their food can be prepared, a dispensary where medicines can be compounded, an operating-room where wounds can be dressed without disturbing other patients, a storeroom for property not in use, a dormitory for attendants, a place for the dead, and an office where the records can be kept, are the essential elements present in all, and the administration is essentially the same. The ward of the post hospital, with its perfect ventilation, its cleanliness, and its abundant sunlight, is the type, the model toward which we aim. The variations in management are but efforts to obviate the imperfection of our means.

The hospital tent, covering a ground space of 210 feet, and containing a cubic air-space of 1,620 feet, is intended to accommodate six patients. The canvas is practically as impervious as the walls and ceiling of the permanent ward; some air may percolate through it, but the close meshes act as a filter to detain impurities, and the air that passes through from without can no longer be deemed pure. With a floor space and air space hardly sufficient for two patients divided among six, it is evident that the openings for ingress of fresh air and egress of foul air demand more constant attention. In summer, the side walls are raised, the end walls rolled back, and the patients are practically in the open air; but in winter, with the sod-cloth sealed down, with the flaps carefully closed, with a stove consuming oxygen rapidly, to maintain sufficient warmth and keep the air fit for respiration in a hospital tent containing six patients, becomes a very difficult problem. For convenience of administration, the tents are sometimes joined, end to end; but, although the ventilation of each is kept independent of the others, it is unwise to subject more than two tents to a common fate, as the chances for error increase with the number, and the law of diffusion tends to produce a common atmosphere in all.

In the field, the soldier carries his personal effects in his knapsack, and prefers to bring them with him to hospital. As the allowance of transportation limits the amount of hospital bedding, he may as well use his own blanket, leaving the few hospital blankets for emergencies, or supplementary provision. If the case be infectious, the blanket and clothing have been contaminated before admission, and are better kept away from the company baggage. They can also be disinfected before the owner is returned to duty.

Bedsacks stuffed with hay or straw are better than

mattresses for field use. When soiled, the bedsack can be washed and refilled; to rejuvenate a hair mattress is beyond our resources.

Laundresses and matrons are unknown in the field; every soldier washes his own clothes; and the laundry work of the hospital—as well as the clothing of helpless sick men—is a legitimate part of the hospital work to be done by members of the hospital corps. If the articles are pounded in a barrel of hot soapsuds, secured to a rope and allowed to float in a running stream for two hours, and then hung up by the corners to drip and dry without wringing, the matron and her sad-iron will not be missed.

Battle.—Behind the line of battle, the first dressing station, the ambulance station, and the field hospital will each fall under the supervision of a hospital steward, and a previous consideration of the elements of the problem will facilitate the solution. Great battles are generally foreseen, and the location of the field hospital fixed by the medical director; but often the movements of the enemy are unknown, and an unexpected struggle requires immediate action. The medical officer may be searching for a wounded artery, and the selection of suitable locations, and other preliminary arrangements will devolve upon the steward, who must be prepared to act intelligently and promptly. To afford the speediest aid with the least labor, and to keep out of the way, are the chief factors governing our choice of positions. If we obstruct the road with the ambulances and delay the advance of artillery, ammunition, or reserves, we may give the enemy great advantage and ourselves more work.

The Field Hospital.—This must be sufficiently far in rear to insure the wounded from anxiety or further danger; but, with this object attained, as near as possible to the fighting line, for bearers and ambulances may have many round trips to the front, and an extra quarter of a mile will soon amount to a day's journey. From one and one-half to three miles is generally the proper distance from the line of battle. Previous knowledge of the terrain is of great advantage, but if we know what we are looking for, much topography can be learned at a single glance. Water, firm ground, easy access from the main road, and protection from the missiles of the enemy are the main requirements. A farm-house or other buildings that may supplement the tentage in case of need, will be a convenience. These things are generally found together. A belt of timber or a range of hills may allow of a near approach to the scene of operations; an open country, or an unstable front, may render a greater distance necessary. It is well to be a short distance away from the main road, that it may remain unobstructed by waiting ambulances. Then, reserves must use the road in passing to the front, and they will not be cheered by a close inspection of the unpleasant results of war; or, these marching columns may be observed by the enemy, who may experiment with long-range artillery to our discomfort. Strategic positions, clusters of trees, stone walls, and other defensive points will also be avoided, for an ebbing tide of battle may pass that way, and military necessity will ignore our field hospital now anchored there by a multitude of wounded men.

The location being chosen, gates will be thrown open, fences and other obstructions removed, ditch crossings bridged, filled, or graded, so as to give easy access to the front and rear of the proposed hospital. There should be a continuous road for ambulances to pass in and out without backing, turning, or passing one another. Then startled mules can have free headway, and there can be no annoying blockades or distressing accidents.

The operating-room may be a tent-fly stretched as an awning, with a small tent to give further protection to instruments and dressings. These should be to windward of the roads that the dust of passing ambulances may not cause trouble. They should also be screened from observation, as patients awaiting treatment will not be cheered, and those already cared for will be made sick and faint by a view of the operating-table.

The kitchen should be between the operating room and the wards, as it must furnish supplies to each. Boiling water and water boiled and allowed to cool in covered dishes must be constantly on hand in large quantities, for no well or spring will furnish water of sufficient purity for surgical purposes. There must also be a constant supply of hot tea, hot coffee, and hot beef-soup for patients as they are brought in. Hungry men will not do good work; and meals at all hours must be served to drivers, bearers, and other attendants. The field hospital kitchen is a busy place on the day of battle.

There should be two wards—one to receive the wounded from the field, and one to receive them after they have been cared for by the surgeon. The ward for patients awaiting treatment may, in fair weather, be in the open air with such natural or artificial shade as may be required; in stormy weather, tents must be pitched or a convenient building utilized. With a scarcity of canvas, it is better to use the buildings as a receiving-ward and reserve the tents for the more lasting occupation by patients from the operating-room; for the sanitary condition of the tents is under control, and the pathological history of the best of farm-houses is a subject for suspicion.

As the wounded are received from the field, each man will be provided with a card—if he has not been already provided with one—on which is entered his name, rank, company, regiment, hour and day of admission, and any other required data that can now be obtained. This card goes with the man to the operating-room, where is added the diagnosis and treatment, and then to the permanent ward, where entries are made in the register of patients, list of wounded, etc., and the hospital number is added to the card.

As the field hospital is but a temporary halting-place, liable to advance or retreat at short notice, a final disposition of the cases must be made at every opportunity, and, without specific instructions from the surgeon, every case is awaiting transfer to the division hospital at the base of supplies; and the transfer slip may be prepared at once, that transportation need only wait for the entry of date, destination, and surgeon's signature. An entry in the register of the final disposition, as death, transfer to division, or general, hospital, etc., with the date, completes each case so far as the field hospital is concerned.

The receiving-ward may lack the skilled attendance of a surgeon, and the hospital steward must exercise his skill and judgment in therapeutics and minor surgery. Shock must be combated by artificial heat, hot coffee, beef-tea, ammonia, or other stimulants. Pain must be mitigated by morphia, by the mouth or hypodermically; in severe cases by anæsthetics. Hemorrhage must be watched for and promptly checked until the surgeon finds time for its permanent arrest. The order in which patients are sent to the operating-room must be determined. Hemorrhagic cases must go first; cases in shock or collapse must be given time to rally; cases requiring an anæsthetic may alternate with milder ones, to give time for the administration. The anæsthetic will be given in the ward, as a view of the operating-table may unnerve the patient and aggravate the unpleasant effects of the drug.

In the permanent ward, as the cases are received from the operating-room, we aim to place them as we would have them should our hospital become permanent indeed, for wounded men must not be moved about needlessly. Prisoners requiring a guard will be placed together. Severe cases, not admitting of further transportation, will be consolidated, not alone for convenience of nursing, but because they will be disheartened at seeing other cases selected from the same tent to go to the rear; then, should you be compelled to abandon the location, fewer men and fewer tents will need be left behind. Here each man's record must be verified and completed. Everything must be kept well closed up, ready to move at a moment's notice. This constant state of preparation for all contingencies is the proper remedy for the uncertainties of the situation, and will prevent that hurry which soon passes through confusion to panic. For the wounded, the battle is over; and all rumors from the front must be rigorously excluded from the ward, as provocative of excitement and worry.

In a few hours after the battle the last of the wounded will have been brought in, cared for, and sent away to a permanent hospital; instruments will be cleaned, dried, and restored to the cases; dressings and other property repacked; surplus tentage returned to the distributing centre; supernumerary ambulances sent to rejoin the central train; and the field hospital is again a camp hospital, ready to take its place behind the marching column at the trumpet call.

The Ambulance Station.—As soon as the field hospital is located, a steward will go forward with the ambulances and bearers toward the fighting line. The hospital is marked by a flag; guidons must be planted along the roads leading to it. Study by the way all lanes and cross roads, to determine the shortest and best routes for the return of the ambulances. Remove obstructions, repair bridges, fill dangerous ruts, and grade bad crossings, as you go along. Choose a route not likely to be obstructed by troops or trains, screened from the enemy by hills or timber. Note the relation of prominent landmarks to the field hospital, and the roads leading to it, that short and definite directions may be given from afar.

The service of the ambulance mules is very important; and their safety must be considered in locating the ambulance station. The limit of safety is generally fixed at about a thousand yards from the line of battle; but the nearer the approach, the greater will be the effective capacity of the bearers, the more rapidly can the wounded be removed from the field. A wood, a hill, a railway cut, or a ravine, may justify a much nearer approach to the scene of action. These things must be determined in a single topographical glance. The spot chosen must be a little off the main road, which must not be obstructed; must afford space for ambulances to pass in and out without collision, and without short turns, for drivers must have a free headway to bring startled mules under control. Uneven ground must be avoided or remedied; the question is not only of broken vehicles, but of increased suffering for wounded men. A hospital flag must plainly advertise our business to friend and foe, and guidons, so planted as to be visible from the entire field, will help wounded men to find the ambulance station. Shelter here will rarely be required; but should there be delay in the ambulance service, shelter tents or blankets can be hung as awnings to give protection from sun or rain. A fire may be started and preparation made to serve hot soup, tea, and coffee. A supply of good water near at hand is an advantage, but is not essential, as every ambulance keg will come filled from the field hospital.

A medical officer may be on duty at the ambulance station, or all the duties may devolve upon the steward. The name, rank, company, regiment, and probable diagnosis of each case brought by the bearers, or coming in alone, must be entered in a suitably ruled book, and on a card to be attached to the patient. The temporary dressings applied on the field must be inspected and readjusted or others substituted, as may be required. Cases in danger from hemorrhage must receive particular attention and be emphasized by a strip of red cloth. Shock must be palliated by hot drinks, ammonia, or other stimulants, care being exercised to avoid excess, always remembering that whiskey is not a panacea, and that stimulants increase the liability to hemorrhage. Pain may be mitigated by narcotics, the dose to be fixed by the Pharmacopœia, and not by the emphasis of the patient's groans. Narcotics will only be given for present pain, and not in anticipation. Many cases will be able to walk to the field hospital, and severe cases have the first claim upon the ambulances. With a broken arm supported in a sling and bound to the trunk, or with a properly bandaged flesh-wound, with a hospital ticket to show the provost guard, no man will care to linger in a spot affording so little luxury or safety, and small parties may be started on foot for the field hospital. Two privates of the hospital corps will furnish sufficient assistance at the ambulance station; if there be more, they may be held as a reserve, to go to the front with the litters as required.

The First Dressing Station.—The purpose of a hospital corps is to take the unfortunate where they fall on the battlefield, and transport them speedily and safely to the quietude and security of a hospital, far in rear, where they can be put under the most favorable conditions for speedy recovery. As the proverb says, a good beginning is half done, and the first dressing station is the place of beginning. Here, amid the din, the turmoil, and the excitement of battle, the attention of the hospital corps must be concentrated upon its own work. With the speed of systematic order, without disorderly haste, each case must have the benefit of cool judgment and skill from the very beginning. This can only be attained by a careful previous training of the men. A glance will tell that a man is dead, but it must be an educated glance, and without a previous caution the men will waste valuable time and leave men to perish from lack of attention, while they are bringing corpses to the dressing station. They must learn to recognize the presence and know the meaning of jetting arterial blood; a few minutes may make the difference between life and death; and it is clearly useless to start for the dressing station if their charge will be dead when they get there. They must learn to slit the clothing with the knife, and, having exposed the wound, to check the ebbing life-blood by direct pressure or by the tourniquet. They must have in mind the evil potentialities of the sharp fragments of a splintered bone, and learn to confine them within limits by such splint material as they have at hand, to secure immobility of the injured limb by binding it to its uninjured mate or to the trunk. They can protect open wounds from further harm by a fold of antiseptic gauze secured by a bandage. The aim of the first dressing station is to fit men for the journey of two or three miles to the field hospital. With intelligent bearers, under the supervision of acting hospital stewards, this work will be so thoroughly done where the man falls that the duty at intermediate points will be of inspection and verification only. Patients still able to walk, will come direct to the dressing station and receive attention there. Before beginning the thousand-yard journey to the ambulance station, as a rule, every case should be inspected and receive a hospital ticket as evidence that this has been done; otherwise uninjured men might straggle to the rear. No matter how slight the injury, no wounded man will be returned to the ranks. The sight of his own blood unnerves a man; he may be a good soldier to-morrow, he is useless in the line to-day. At the ambulance station or the field hospital he can replace a hospital corps private, who can be sent forward for duty with the litters. After every battle there is a list with the uncertain record "missing;" and anxious friends turn to the records of the medical department, which should begin at the first dressing station.

After a continuous peace of twenty-seven years, it is useless to try to follow the duties of the hospital steward through all the intricacies of field service in war. The survivors from our last great struggle are old men now; and the everyday problems, the little perplexities and vexations of that great period have passed from their memories; like the discordant note in distant music, these things have been left behind. The elements already discussed are raised above the humdrum of life: these seemingly petty details assume a vital importance when we consider that, from this starting-point the younger generation must go forward to meet the great problems of the future. We live not for to-day, but patiently strive to perfect our methods in expectation of the moment when Father Time shall change the slide in his dissolving views, when these minor pictures shall fade away, and we shall stand face to face with the grander panorama of a Nation in Arms. The magnitude of the picture will not appal us; for in it we will recognize—as old friends—familiar elements, combined in familiar atoms, multiplied many fold, but ever the same. The steward's work will be simplified; for in this increase of work there must be a division of labor. If he keep the records, it will be without interruption from kitchen or ward; if in charge of the kitchen, he can give it his en-

tire attention; the perfection of his methods will stand out in bold relief; he will be glad that he learned to avoid errors on a smaller scale, for what he learned to save as pennies will be dollars in the larger transactions; his tables, laden with delicacies, will tell the story of long and careful preparation. In immediate charge of the sick, in a large general hospital, in church or schoolhouse, on cars or steamboats, or in tents on the hillside, the ward of the old post hospital with its annexes will forever remain the unit of measure, the model and the type. Each oscillation of the kaleidoscope will produce a pleasing combination, for the beauty of each picture will be derived from the perfection of the same familiar fragments.

The advent of war will bring higher duties; for the increased work there will be a multitude of willing but untrained hands; with a perfect knowledge of details, with long experience in the study of men, the hospital steward will stand forth as a teacher, with a far-reaching influence for good.

Art is long, and time is fleeting, and no man can hope to say, in one short work, the hundredth part of what might well be said on any subject. The chief object of book or treatise is to make men think; and, if this little work is laid down, not only with a knowledge of what has been said, but with a consciousness of dozens of other things that might have been said in the same connection, if it incites to meditation, to more thorough preparation, it is a success—its highest aim has been accomplished.

George W. Adair.

HOUSE PLUMBING, GENERAL PRINCIPLES OF.

During the last six years considerable progress has been made in the practice of plumbing toward the ideal outlined in the HANDBOOK in 1886. Greater simplicity in piping, and more science in the construction of the fixtures, are the most marked features of this progress. Several cities and towns have modified their plumbing ordinances by striking out the requirement for special trap ventilation called "back venting," and architects, builders, and plumbers generally are becoming more convinced of the uselessness and danger of such a requirement.

The importance of constructing all fixtures on the principle of the "flush tank" is becoming widely recognized, and we rarely find to-day in first-class plumbing work fixtures with the diminutive outlets almost universal ten years ago. The waste pipes are now thoroughly scoured at each discharge of the wide-mouthed fixtures now in use, and ample ventilation is effected throughout the entire drainage system by the discharges, as well as by the thorough ventilation of all the main stacks of piping at both top and bottom. Mechanical seals for trapping are fast disappearing, and are now rarely seen in good work. People have become convinced that balls and valves in traps increase the complication, retard the outflow, and add absolutely nothing to the security of the seal. A sound water seal has been shown to afford perfect safety, and, moreover, no other kind of seal is practicable in water-closet traps. Hence the simple "antisiphonic" water seal trap is becoming exclusively used for all kinds of fixtures.

The sanitary rule of setting all fixtures "open" has become fashionable. Traps and waste pipes are neatly and solidly set, and handsomely polished or nickel-plated. They are becoming each year more frankly recognized by architects as legitimate subjects for artistic treatment. Scientifically constructed and beautifully decorated fixtures, set with highly finished open piping, are among the "show" features of a well-appointed mansion to-day. It is the rule now to admit light and air everywhere under the fixtures, where ten years ago it was the exception.

The quick flushing sink for kitchens and pantries described in the HANDBOOK has been greatly improved within the last few years, and is now entirely automatic in its action. It affords, perhaps, the best illustration of what can be done by plumbing fixtures toward scouring out the waste pipes by powerful water flushing.

Figs. 310 and 311 represent the perfected sink in section and in perspective view. The sink is discharged by means of a self-acting siphon, and a vertical strainer is interposed between the flush-pot and its siphon. The short arm of the siphon is trapped with a seal-retaining

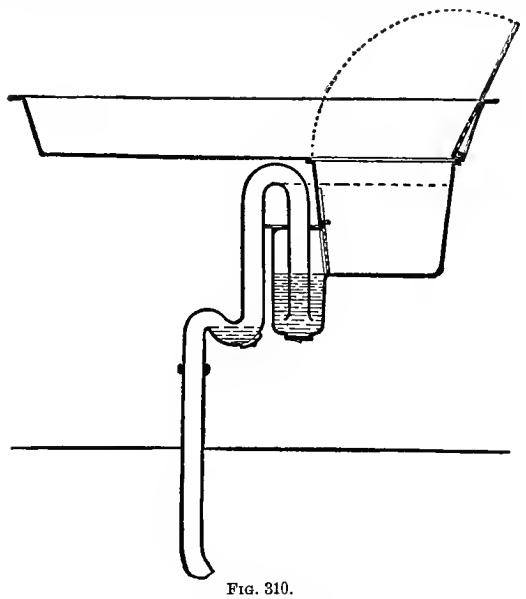

FIG. 310.

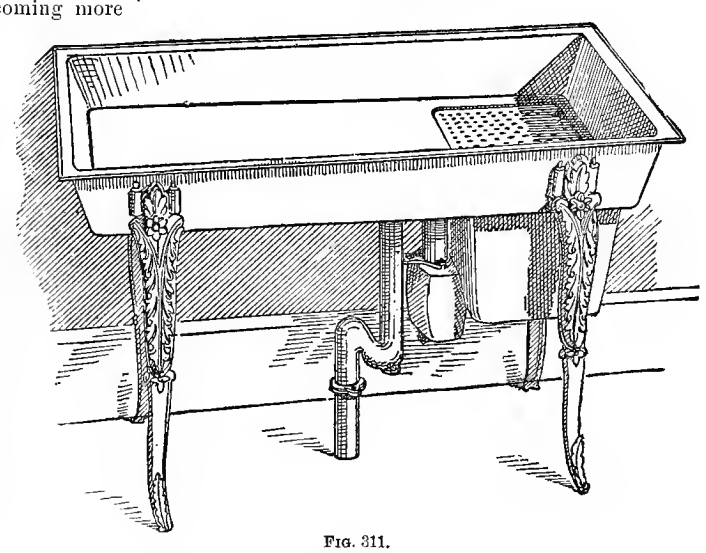

FIG. 311.

trap just behind the vertical strainer. This strainer slides up and down in a groove to give access to the trap when desired, but closes again automatically by its own weight as soon as released. It has been assumed as an indispensable condition in the design of the apparatus, that absolutely nothing should be dependent upon the intelligence or care of the servant, and that by no possibility could the waste passages become clogged, either by accident or by design.

Clean-out openings are provided at the trap and weir-chamber, and give access to every part of the waste sys-

tem. No bones and solid refuse can be scraped into the discharge outlet and dropped into the waste pipe, because this pipe ascends instead of descends at the outlet, and should the top be clogged it will simply cause the water to cease to flow out until the obstruction is removed, which can easily be done by simply raising the lower strainer and lifting out the obstruction by hand.

The operation of this apparatus is as follows: The sink is used in the ordinary manner until the flush-pot fills to the height of the siphon overflow. When this point has been reached the next discharge of a quart or two of water suddenly emptied from the washing-pan or drawn from the faucet, charges the siphon and causes the entire contents of the flush-pot to rush out through the waste passages, filling them "full bore" and scouring them from end to end. The solid matter and large lumps of grease will be left on the bottom of the flush-pot, and must be removed by the servant in the proper manner, inasmuch as they cannot possibly be removed in any other manner.

The simple standpipe overflow basin and bath-tub, and the siphon "jet" water-closet described in the HANDBOOK as lately introduced improvements in plumbing, have now come into very general and constantly increasing use, and in one form or another are recommended by every dealer in plumbing fixtures as embodying the correct principles of construction.

J. Pickering Putnam.

HYDRACETIN (Acetyl-phenyl-hydrazine). A chemical compound of hydrazine, H_2NNH_2, in which two hydrogen atoms are replaced by phenyl and acetyl groups. Its formula is C_6H_5 HNNH CH_3CO. It may be prepared by mixing one part of anhydrous acetic acid with two parts of phenyl hydrazine; the mass becomes hot, and on cooling deposits crystals of hydracetin. *Pyrodin* of commerce is hydracetin mixed with three parts of sugar. It was introduced by Dr. Dreschfield, of Manchester, England, in 1888. Hydracetin is a white crystalline powder, without taste or odor. Soluble in water, 1 part in 50, more so in hot water; very soluble in alcohol. Dose, one-sixth to one-half grain.

It possesses powerful antipyretic properties, and was recommended for typhoid fever, rheumatic fever, and phthisis. The temperature begins to fall in half an hour, and the lowest point is reached in two hours. The effect is not of long duration, and the fever begins to rise again in a few hours. In acute rheumatic fever it appears to have had the best effects, the painful joints being also relieved. It also possesses analgesic properties, and has been used to relieve the pains of locomotor ataxia, neuralgia, and muscular rheumatism, with marked success.

Its employment, however, is negatived by its toxic action. It is a very decided blood-poison, exerting a destructive action on the corpuscles, and hæmoglobinuria is produced. It gives rise to depression, coldness of extremities, sweating, and weakened pulse and respiration. It is generally conceded that it must be used with care, not more than two grains being given during the day, and it should not be continued for more than three days in succession. Guttman, who early reported its value as an antipyretic, and carefully studied its action, advises one and one-half grain a day in divided doses. If the antipyretic action is wanted, the second dose should be given an hour after the first; if for rheumatism or neuralgia, one dose should be given in the morning, the other in the evening.

Hydracetin is also employed as a local remedy for psoriasis, its value in this disease depending upon its reducing power. It is employed as an ointment of pyrodin in the strength of one part in ten. It has failed to meet with approval, as it is not equal to pyrogallol and chrysarobin, and if applied externally may produce toxic symptoms. A case is reported where a ten per cent. ointment, applied to a third of the surface of the body, produced jaundice, hæmoglobinuria, and the usual poisonous symptoms within ten days. *Beaumont Small.*

HYDRASTIS CANADENSIS (Golden Seal). Although not at all a new remedy, its hæmostatic properties have received a great deal of attention during the past few years, particularly in Europe. Attention was directed to it in Germany in 1883, by Dr. Schatz, at a meeting of the Association of Physicians and Naturalists. He described it as an American remedy of decided value, and reported strongly in its favor for the treatment of chronic hyperæmia, and chronic inflammation of the internal genital organs attended by losses of blood. Since this introduction it has been extensively employed with very general satisfaction. In menorrhagia and metrorrhagia without organic disease, as well as in hemorrhages associated with metritis, endometritis, and other structural changes, it is said to check the flow more rapidly than any other remedy. In the hemorrhages occurring at the menopause, and the excessive menstruation of young girls in which the tissues are relaxed and congested, it has proved itself particularly useful. It also relieves all conditions of congestion of the pelvic organs, ovarian pain, dysmenorrhœa, and other distressing symptoms arising from this cause. Its action when the flow is due to myomata appears uncertain, some observers claiming for it decided curative powers, while others have failed to secure any benefit. It has been used in obstetric practice without producing any ill effects. Bossi, of Genoa,[1] gives the result of sixty-four cases in which he employed the fluid extract in such cases. He gave from one hundred to two hundred minims daily, in divided doses, and found that it had "a constant, curative, and prophylactic hæmostatic action on the uterus during pregnancy, labor, and the puerperium, without any ecbolic effect or modification of the uterine contractions." He found it more beneficial than ergot in the flooding of labor and in post-partum hemorrhages, and he trusted to it as a prophylactic for hemorrhages at all periods. Notwithstanding this very decided statement regarding its ecbolic properties, it should be administered with great caution during pregnancy. Cases are reported[2] in which it has exerted a very powerful action on the uterine muscular tissue and induced abortion. Dr. Falk[4] in his experiments with hydrastinine was not able to arrive at any conclusion, but thought it probable that it did possess an ecbolic action.

The hæmostatic properties of hydrastis are due to a constricting action on the arterioles, and this effect seems particularly directed to the vessels of the uterine mucous membrane. Numerous experiments have been made to determine the physiological action of the drug, and among the more recent is a very thorough study of the alkaloid made by Dr. Cerna,[3] of Philadelphia. The following are some of his more important conclusions: Hydrastine is poisonous to animals, the minimum lethal dose in dogs being 0.50 gramme for every kilogramme of the body weight; it kills by failure of respiration. In small doses it appears to have a stimulating effect on the muscular tissue; toxic quantities, however, destroy the irritability of the muscular tissue; on the nervous system it resembles strychnine in its action, increasing reflex activity by stimulating the spinal cord; in larger quantities it produces convulsions, and lastly paralysis; on the circulation, its effect is to diminish the number and increase the volume of the cardiac beats, by an action upon the heart-muscle and the intra-cardiac ganglia; in minute, medium, and poisonous doses it invariably causes a fall in the blood-pressure; in lethal doses this continues until death occurs, while in smaller and medium doses the pressure gradually rises again, but never above the normal point. This lowering is due to a direct action on the heart, and through a paralyzing influence exercised on the vaso-motor system, acting through the central nervous ganglia.

Although the active principles obtained from the plant have been extensively employed, the tincture and fluid extract still sustain their reputation and are preferred by many. Twenty or thirty minims of the tincture, or twenty minims of the fluid extract, repeated four or five times a day, will generally secure all the virtues of the plant.

Two alkaloids have long been known, hydrastine and beberine, and a third termed xantho-puccin has recently been described, but it has not been definitely separated, and its identity remains a matter of dispute.

Hydrastine possesses all the hæmostatic properties of the plant. Its salt, the hydrochlorate, is usually employed. It is a crystalline white or faintly-yellow salt, soluble in water and having an extremely bitter taste. It is employed in doses of from half a grain to five grains, in the same conditions and with the same objects in view as when the preparations of the crude drug are given.

The alkaloid *beberine* is not present in large quantities, and is generally obtained from *beberis vulgaris*, in which plant it is present in large quantities. It is devoid of any hæmostatic properties, and is employed as a tonic and alterative. It is a bitter orange-yellow crystalline powder. *Hydrastin* is an eclectic remedy consisting chiefly of beberine and extractive matter. It is used for many of the purposes for which the alkaloid is employed, and as a cholagogue, stomachic, and tonic. It is a bright-yellow powder.

The latest product, and what is looked upon as the final active principle, is *hydrastinine*. It is a product of the oxidation of hydrastine which breaks up into hydrastinine and opianic acid. Hydrastinine hydrochloras, the salt employed, is a pale-yellow crystalline powder, hygroscopic and soluble in its own weight of water. The dose is very much less than that of hydrastine, being from half a grain to one and a half grain. This substance is said to possess all the medicinal properties of the plant, and is used in all the disorders for which the latter has proved beneficial. The reports of its use are very satisfactory. It is said to act very rapidly, producing its effect almost immediately when administered by subcutaneous injection, while the preparation of the root requires several days' administration before any decisive effect is produced. Dr. Falk[4] has used it in all forms of uterine hemorrhage with very great success; in menorrhagia he obtained the best results by commencing the treatment six or eight days before the expected flow. He gives during this time a daily hypodermic injection of three-quarters of a grain of the hydrochlorate of hydrastinine, and when the flow has begun he doubles the dose. He uses a ten per cent. solution in distilled water. No advantage or disadvantage arises from larger doses. Other reports[5] are equally favorable: twenty-six out of forty-eight cases of hemorrhage were checked within twenty-four or thirty-six hours, and of twenty-seven cases it exerted a decidedly beneficial action in twenty-four. It was administered in capsules or pearls, each containing three-fifths of a grain, three or four being given daily. No unfavorable symptoms followed its use.

Its vaso-constrictive action has suggested the use of hydrastinine in epilepsy.[6] Experiment on animals with two-thirds of a grain per kilogramme, distinctly diminished the excitability of the cerebral cortex, and moderated or prevented artificially induced epilepsy. These observations led to its use in six cases of epilepsy, in doses of from one-quarter of a grain to one or two grains per day. In four of the cases the attacks decreased, both in frequency and intensity; in the other two not much benefit was noticed.

In addition to the hæmostatic properties, hydrastis also exerts a beneficial effect on the mucous membrane of the digestive tract. It has been used with success in atonic dyspepsia, and habitual constipation due to torpid liver; and in the debility arising from the drain of the bleedings it acts as a tonic, resembling quinine in its action.

Its local action is also important, its alterative and astringent properties having long been utilized. It is used as a lotion or injection in leucorrhœa, purulent vaginal discharges, erosions of the uterus, and gonorrhœa. Its local application has also been beneficial in pharyngitis. *Beaumont Small.*

[1] British Medical Journal, November, 1891.
[2] The Lancet, May, 1886.
[3] The Therapeutic Gazette, May, 1891.
[4] British Medical Journal, May, 1890.
[5] Merck's Bulletin, March, 1892.
[6] Ibid., October, 1892.

HYDROFLUORIC ACID. The employment of inhalations of this gas has been suggested by Dr. Dujardin-Beaumetz as a means of treating tuberculosis of the lungs. Knowing its very powerful antiseptic and bactericidal properties, and it having been demonstrated that a 1 to 3,000 solution was destructive to the tubercle bacilli, he instituted a series of experiments, and found that animals could live without inconvenience in an atmosphere containing one part of hydrofluoric acid to 1,555 of air. Inquiry among the employees of glass-works also showed that the vapors in no way acted injuriously on the workmen, and those who were afflicted with pulmonary affection were benefited by employment in the works. For the purpose of applying this treatment the patient is placed in an air-tight compartment in which the atmosphere has been impregnated with the gas. One grain of the pure acid may be vaporized in a room of the capacity of twenty-two cubic metres, which gives the proportion of 1 to 25,000; or, the room may be filled with air that has been forced through a solution containing fifty per cent. of the gas. The patient is placed in the room for one hour daily, the period being gradually prolonged. The results of this treatment are varied: in some instances very favorable results were obtained, in others it proved irritating and increased the pulmonary trouble. Experience has shown that asthmatic and emphysematous patients, and those subject to hæmoptysis should not be subjected to the treatment.

Inhalations have also been applied to other zymotic diseases. In diphtheria it has been used, the air of the room being impregnated with the gas obtained by vaporizing the acid, or by the action of sulphuric acid on fluor-spar.

In whooping-cough it is reported to have a very decided effect. One tablespoonful of the acid is put in about one quart of water in an inhaler, and used every second day. Four or five inhalations are said to check the paroxysms, and the cough that remains may be treated as an ordinary catarrhal affection.

The ordinary acid of commerce is impure and requires to be redistilled for medicinal purposes. It is an aqueous solution of about thirty per cent. of the gas, from which copious white suffocating fumes are evolved. It requires to be kept in leaden or gutta-percha vessels, on account of its corroding action on glass.

The salts of hydrofluoric acid have been utilized for their antiseptic properties, the fluoride of sodium being the most suitable. It is quite unirritating, and is recommended for use where bichloride of mercury cannot be employed. Experiments have shown that a 1 to 350 solution prevents the growth of the yeast fungus, and pathogenic and non-pathogenic microbes. Solutions of the strength of 1 to 3,000 may be used for ordinary antiseptic purposes. *Beaumont Small.*

HYDROGEN PEROXIDE. There has been an extraordinary revival of this compound during the past few years. No new method of utilizing its many virtues has been discovered, nothing new has been added to its medicinal properties, and yet, after an interval of more than thirty years, its value is suddenly recognized by the profession and it becomes "the necessary peroxide of hydrogen." It is difficult to trace the cause of this sudden prominence, but in all probability we have to thank the enterprise of the manufacturers for bringing it to the notice of the physician and the surgeon.

Discovered in 1818 by Baron Thénard, it remained almost unknown until Dr. B. W. Richardson instituted a series of experiments, to consider the possibility of utilizing it in the treatment of disease, and communicated the result of his work to the Medical Society of London in 1860 and 1862. These papers formed a very exhaustive treatise and introduced the subject in almost as thorough a manner as we know it at the present day, although the presence of germs and the rôle they play in disease was not known at that time. The following is Dr. Richardson's *résumé* of his papers. In the paper of 1860 he advanced that, (*a*) the peroxide quickens oxidation, increases secretion, arterializes blood, and hastens the decomposi-

tion of decomposing animal tissue; (*b*) in combination with blood it restores the power of muscles just dead to contract, and yet calms muscular irritability; (*c*) that it promises valuable aid in a large number of cases of disease; (*d*) that in instances of poisoning by narcotics and the alkaloids it might with advantage be introduced in the blood by transfusion or injection; (*e*) that in tetanus it affords a most rational treatment, since tetanic rigidity is lost by its presence in muscle; (*f*) that in typhus, in which death takes place from what I designated as asphyxia commencing in the blood, it might be employed with good effect as an oxygenator; (*g*) that it ought to prove useful both as an internal and an external remedy in the treatment of cancer. In the paper of 1862 the following were his conclusions: (*a*) that in diabetes the peroxide reduces the specific gravity of the urine, while it rather increases the quantity; (*b*) that in chronic and subacute rheumatism it affords relief; (*c*) that in valvular disease of the heart with pulmonary congestion it gives relief to the dyspnœa; (*d*) that in mesenteric disease and in jaundice it causes an improvement in the digestion; (*e*) that in pertussis its effect for good is very remarkable, since it cuts short the paroxysms of cough, and seems decidedly to shorten the period of the disease; (*f*) that in chronic bronchitis it lessens the dyspnœa and renders the expectorated matter less tenacious; (*g*) that in chronic laryngitis it gives pain on being swallowed, and does not appear to be useful; (*h*) that in anæmia it does not of itself render a service, but favors the good effect of iron; (*i*) that in the first stage of phthisis it causes improvement in the digestion, and in the later stages gives unquestionable, and even wonderful, relief to breathlessness and oppression, acting, in fact, like an opiate without producing narcotism, and assisting oxidation; (*j*) that it produces a modified salivation, and might be a good substitute for mercury and the iodides in the treatment of syphilis.

In these papers, although noticing the disinfectant properties, the author did not emphasize their importance, but in an address to the British Medical Association, in 1865, the local employment of the remedy and its disinfectant property were particularly dwelt upon. On this occasion he introduced its use as a spray, and recommended it as a disinfectant for sick-rooms in which patients were suffering from infectious disease, for fetid and ulcerated surfaces, and for the treatment of diphtheria, syphilitic ulcerations of the throat, and gangrene.

Until quite recently there appears to have been but little advantage taken of these important communications. From time to time an occasional paper would appear, and with the advance of knowledge in the field of bacteriology its germicidal properties were demonstrated, but the applications of these properties to the treatment of disease were wholly disregarded. The revival of its use may be said to date from a paper by Dr. E. R. Squibb, of Brooklyn, published in Gaillard's *Medical Journal* for March, 1889, in which he pointed out its valuable properties and advocated its use in diphtheria. There had been occasional communications before this, but they had not attracted the attention of the medical authorities, or influenced the profession to any extent. Numerous papers and reports of cases treated with the peroxide followed, but it was not established as a remedy in surgical practice until Dr. R. T. Morris, at the meeting of the American Medical Association, in 1890, described its usefulness wherever there was formation of pus.

Very little is known of the chemical constitution of hydrogen dioxide. It has the formula H_2O_2, and is described as water combined with an additional atom of oxygen, but what this combination is has not been determined. Richardson considered it identical with ozone, and this view is very generally accepted; it responds to the same tests, and it has been found that water saturated with as many volumes of oxygen in no way resembles the solution of the peroxide, and the action of the two is very different. In using the peroxide it is possible to secure either the ozonic action or the action of simple oxygen; if the solution or spray is used ozone is the active ingredient, but if the peroxide is decomposed the gas that is evolved is no longer ozonic but simple oxygen gas.

The therapeutic value of the peroxide depends upon its instability, and the decomposition that takes place when it comes in contact with certain substances. It is compatible with the mineral acids, alcohol, alcoholic solutions of the alkaloids, alcohol combined with ether, amyl nitrite, glycerine, tannin, and is not decomposed by healthy living tissue, or if decomposed by other substances, exerts on it no injurious influence; but in the presence of every form of germ life, decaying organic matter, pus, or abnormal secretion, it is instantly decomposed and the liberated "ozonic" oxygen attacks and destroys such substances. Its action is perfectly simple and uninjurious, it cleanses the part of all impurities, and acts as a mild stimulant to granulation tissue; it does not cause pain, except in a slight degree when applied to the delicate mucous membranes of the nose, conjunctiva and urethra.

Possessed of this bactericidal action and the property of destroying albuminoid discharges and necrosed tissue, its value in many surgical diseases is readily understood. Applied to ulcers, abscesses, or any secreting surface, it destroys all foreign matter and leaves a clean healthy surface ready for immediate repair. A daily application of the fifteen-volume solution, and dressing with borated lint or any simple dressing, will secure a healthy and rapidly healing surface. In abscess cavities the same treatment may be adopted after evacuation, and Morris states that it is possible to open an abscess of the breast, sterilize it, and destroy the pus, and have perfect recovery, under one dressing. Where there is a sinus or where the abscess is deep and burrowing, it is better to inject slowly and gradually, allowing the first portion to cease effervescing before a further injection is made. In some instances, where the sinus is not deep, it may be desirable to inject freely, the distention that follows allowing the fluid to permeate more thoroughly into the numerous recesses that may be present. For sloughing and gangrenous conditions of cancerous disease it is invaluable to the surgeon and to the patient. It rapidly disinfects the part and removes the offensive odor, and its hæmostatic properties check any dangerous hemorrhage that may follow the removal of sloughing tissue.

For inflamed mucous surfaces, where pus is freely secreted, it may be used with much advantage, particularly if the discharges are foul and offensive. In conjunctivitis, ozæna, ear troubles, cystitis, vaginitis, and gonorrhœa, the parts are to be first washed and a solution of fifteen volumes diluted with eight or ten parts of distilled water applied freely. In these cases it will sometimes be found necessary to use cocaine to allay any sensitiveness. In washing out the cavity of the bladder a double catheter should be used to allow the liberated oxygen to escape.

It has lately been used in the treatment of empyema. Cases are reported in which the pleural cavity was washed with the peroxide, followed by a borated solution. The advantage derived from the peroxide in all cases was very decided, recovery being rapid and unaccompanied by any unfavorable symptom. In poisonous snake-bites and the bites of rabid animals, it is recommended as an antidote, and has been used with good effect to counteract the painful effects of rhus poisoning.

Its powerful local action makes it a very valuable application in diphtheria, and this is one of the most important uses of this compound. It proves very efficient in destroying and removing the diphtheritic membrane and counteracting the ptomaïnes that may be formed.

The frequency and strength of the application to a great extent depends on the character of the disease. Two or three applications may be sufficient, but if the membrane is extensive and interferes with respiration, the solution can be used every hour with benefit. Spraying or gargling should always be adopted. The fifteen-volume solution is used in its full strength if the case is urgent, but the solution diluted with three or four parts of water will generally be sufficiently strong. Reports point to its very great service, and it is rapidly becoming the one topical application that is supplanting all others.

In all forms of diphtheritic inflammation it is equally efficient, as either in the nose or in the larynx the spray readily reaches the site of the disease. In addition to its beneficial local action, the inhalation of the liberated oxygen undoubtedly is of benefit, particularly in the severe cases in which the oxidation of the blood has been interfered with, and the patient is in a condition of cyanosis.

The internal administration of the peroxide is as important as its topical use. In giving it we are giving oxygen, and, as in its local application, it is the supply of free oxygen upon which its beneficial action depends. Within the intestinal tract, as well as on the surface of the body, its disinfectant and bactericidal properties are taken advantage of. In thrush, aphthous states of the mucous membrane of the mouth, and all such unhealthy conditions, it acts quickly and beneficially. In chronic gastritis, gastric ulceration, and all catarrhal disorders accompanied by fermentation and flatulent indigestion, its use checks the abnormal fermentation and restores the disturbed function. Under its influence the general acidity of the gastric juice and the proportion of free hydrochloric acid are increased, and the digestive power markedly improved. In the forms of dyspepsia accompanied by hyperacidity the administration of the peroxide causes an aggravation of all the symptoms. One drachm of the fifteen-volume solution, diluted, three times a day before meals, has proved a sufficient dose. For disturbances of the lower bowel and rectum it may be administered as an enema. Richardson used one ounce to a pint of water and injected it through an O'Beirne tube. In typhoid fever it has been used in this way and administered by the mouth. One ounce may be diluted with one pint of water and taken during the day as a beverage. Richardson used it with favorable results, and Dr. H. F. Wiggin, in the New York *Medical Record*, November 28, 1891, reports a case in which he believed that the peroxide proved of great value. In addition to the above conditions, in which it exerts a local disinfectant action, its power of oxidizing the blood opens up a train of diseases in which it may prove of very decided service. Whether administered by the mouth or inhaled into the lungs, it affords rapid relief in asthma, emphysema, chronic bronchitis, phthisis, heart disease, and in acute pneumonia. Also in poisoning by hydrocyanic acid and the numerous new aniline compounds it should prove of benefit. In pulmonary phthisis it not only relieves dyspnœa and shortness of breath by improving the blood, but also counteracts the night-sweats and fever by neutralizing the ptomaïnes. It is also supposed to act favorably by destroying the bacilli and the purulent infiltrated tissue. In the first stages it possesses a decided remedial action, and Richardson states that it is, of all medicines, the most valuable. This observer also suggested that it might be administered by subpulmonary injection, throwing the solution directly into the lung tissue. He considers that no harm should follow this method, and the oxygen would rapidly diffuse and destroy the tuberculous exudation. In whooping-cough it is said to act almost as a specific, given internally and inhaled. Dose: from ten to eighty minims, three times a day, diluted. Its beneficial action here is due not only to its antiseptic properties, but also to its power of relaxing muscular spasms. Its action is the same in asthma and angina pectoris, and other spasmodic affections. This action described by Richardson leads him to suggest its use in hydrophobia and tetanus. He proposes to inject groups of muscles with the ten-volume solution, using amyl nitrite in combination if necessary.

The property of promoting oxidation in the system has led to its use in diabetes, with beneficial results. The sugar is rapidly diminished, but the amount of urine is increased, this latter effect being characteristic of the peroxide, which increases all the glandular secretions. To overcome this excessive secretion the following combination is used by Dr. Richardson: Codeine, 3 grains; alcohol, 2 drachms; peroxide of hydrogen (10 vols.), 2 fluid ounces; distilled water to make 12 fluid ounces; a tablespoonful to be taken three times a day in a wineglassful of water. Many other observers have obtained the same satisfactory results in this disease.

On account of its stimulating effect on the excreting glands, it is highly extolled by Richardson in the treatment of syphilitic disease, especially in the secondary and tertiary stages. For indolent ulcers, skin lesions, and tertiary deposits its internal administration is very beneficial, particularly if the cachexia is marked. He recommends that it be given in two- to four-drachm doses, three times a day, with infusion of cinchona. The only unfavorable action is a mild form of salivation, which is readily overcome by stopping the medicine. It also increases the action of mercury when given at the same time, much smaller doses of the mercurial salt proving effective.

The evolution of the oxygen and the great expansion that accompanies this physical change, furnish what may be termed its mechanical use. This may be taken advantage of in invagination of the bowel, and may also prove serviceable when sounding the bladder for stone, a small quantity causing a sufficient distention for the purpose. It is also recommended to inject it into a part in which suppuration is suspected. If pus is present the usual reaction occurs and distention follows, into which an incision may be made with facility.

The freedom from toxic action and its unirritating qualities render it a very simple remedy to use. One to two drachms of the fifteen-volume solution, three or four times a day, can be administered, without the fear of any unfavorable symptoms, and will generally prove sufficient to secure all its peculiar effects. It should be freely diluted with water free from any organic matter, and mixed as required. For enemata and for hypodermic injection the solution should always be neutralized with soda.

For sick-rooms its disinfectant and deodorizing properties are best secured by diffusing it as a spray, and hard rubber or glass appliances only should be used. For spraying the throat the solution may be medicated with tannin, quinine, morphine, or any of the alkaloids soluble in alcohol.

The subcutaneous injection is indicated only when an immediate and rapid supply of oxygen to the tissues is wished for, as in asphyxia from drowning, hanging, or in chloroform poisoning, or poisoning from any narcotic. In extreme cases of chloroform poisoning Dr. Richardson suggests that deep subpulmonary injections might be made, throwing the peroxide directly into the pulmonary tissue of each lung. The solutions should be diluted and free from any acid, and of the temperature of the body. No ill effects should follow, as the oxygen is rapidly absorbed, and the small amount of water that remains is harmless.

For inhalation the oxygen is very readily eliminated from the solution, by the aid of permanganate of potash, which also supplies its share of oxygen. A ten per cent. solution of the permanganate added to the peroxide at once decomposes the solution thoroughly. This reaction may be produced in an inhaler and the gas at once utilized, or it may be preserved in balloons and used as required.

The peroxide of commerce is a two or three per cent. solution of true peroxide of hydrogen. Pure anhydrous peroxide of hydrogen is known only as a chemical curiosity, and is described as a colorless, transparent, inodorous liquid, specific gravity 1.45, extremely unstable. When decomposed it yields four hundred and seventy-five times its own bulk of oxygen, leaving behind a little less than one volume of water. The solutions of commerce are designated by the numbers of volumes of the gas that they supply, being five-, ten-, or fifteen-volume solutions, according as they contain a little over one, two, or three per cent. of peroxide of hydrogen. To be exact, a one per cent. solution should supply 4.75 per cent. of oxygen, and a fifteen-volume solution should contain a little more than three per cent. of the peroxide. The pure peroxide is of course undesirable, not only is it not manageable, but it is altogether too strong for any practical use.

The preparation is still the same as that proposed by its discoverer. It may be formed from the peroxides of any of the alkaline earths, but barium is the most suitable. The barium oxide is formed by exposing baryta, heated to redness, to a current of oxygen gas; the resulting salt is then acted upon by hydrochloric acid which releases the oxygen, and this combines with the water to form the peroxide of hydrogen. Fourteen parts of hydrochloric acid are diluted with nine hundred and sixty parts of distilled water, and to this thirteen parts of powdered barium dioxide are added. This gives about a one per cent. solution of the hydrogen dioxide. The barium chloride, which is still in solution, is removed by treating with dilute sulphuric acid, and the chlorine, which remains as hydrochloric acid, is precipitated by sulphate of silver and baryta water. The presence of a small amount of hydrochloric acid is useful in maintaining the stability of the solution, and it is generally present in a slight degree; the amount, however, should be very small. Richardson preferred the addition of dilute phosphoric acid, but the acid produced during its manufacture is the one usually present.

The instability of the peroxide renders the article of commerce of a very indefinite strength. Numerous analyses show that the solutions are far below their nominal strength. Of nine specimens examined by Dr. S. S. Wallian,[1] only two were found to be of the proper strength, and one sample of a ten-volume solution contained one and a half volume only. Dr. H. E. Smith[2] analyzed fifty samples, and found that the highest volumetric strength was only 8.86; eight per cent. of the samples did not contain any hydrogen peroxide whatever, and thirty-six per cent. were decidedly deficient in strength. Dr. E. R. Squibb[3] examined nine samples of the five leading manufacturers' products, and found that only one reached two-thirds of the proper strength, and two samples were less than one-half the stated strength. These results speak for themselves, and when it is remembered that many of the articles that are supplied to the physician have been in the chemist's shop for a prolonged period, with very little care to preserve their properties, there is little wonder that the results obtained from its use are not as favorable as expected.

It is desirable to keep the bottle away from the light and in a cool place, but the decomposition that goes on within the bottle is due to organic matter and other impurities in the solution. A good preparation should remain fairly stable, even when of a high strength. Squibb states that, even when exposed to a summer temperature, it should grow stronger rather than weaker, as the water should evaporate more rapidly than the peroxide decomposes. A solution of peroxide should be bright and clear and free from any deposit or cloudiness, this arising from the oxidized matter thrown down by the decomposition of the peroxide. To prevent this decomposition, free acids are added, but if impurities are present the loss of oxygen still continues.

The strength of the solution may be tested with a standard solution of permanganate of potash. Dissolve 2.832 grammes of potassium permanganate in distilled water sufficient to make 500 c.c. of the solution. Ten c.c. of hydrogen peroxide is then diluted with water to make 100 c.c., and ten c.c. of this is to be tested. A few drops of sulphuric acid are added to acidify the solution, and into it the permanganate solution is to be added, drop by drop, until it begins to color the solution. The number of c.c. used indicates the number of volumes of oxygen present. Another method of testing is to decompose the solution and collect and measure the oxygen evolved.

Ozonic Ether.—At the British Medical Association, in 1865, Dr. Richardson introduced this combination of ether and peroxide of hydrogen. He produced it by agitating a thirty-volume solution of the peroxide with anhydrous ether and adding five per cent. of alcohol. It is soluble in water, is more stable than the solution of peroxide, and may be administered in all the conditions in which the latter is used. The dose is from half to two drachms. As a spray for topical use and to disinfect the atmosphere it is particularly serviceable. In whooping-cough it is very highly praised, as almost a specific remedy; it is used as a spray and the following mixture given: Ozonic ether, three drachms; syrup of Tolu, six drachms; glycerine, four drachms; distilled water, to make six ounces; one-half to two tablespoonfuls for a dose. The ethereal compound also permits of its union with fatty bases for inunction. This is employed in scarlet fever as a disinfecting application, the use of which prevents any poisonous matter from being disseminated, and at the same time is a soothing and emollient application. Richardson also recommends the use of ozonic ether for the production of anæsthesia, the presence of the oxygen preventing any dangers that might arise from partial asphyxia.

Under the name *pyrozone*, there is supplied an ethereal solution of different degrees of strength. In one it is stated that there is as much as one hundred and twenty volumes of oxygen.

Glycozone is another preparation of peroxide of hydrogen, in which glycerine is acted upon by the peroxide under pressure; it is said to supply fifteen volumes of oxygen. The advantage claimed for it is that it is more stable, acts more slowly, and proves more efficient as a dressing for wounds and other surgical purposes.

Beaumont Small.

[1] New York Medical Journal, November 26, 1892.
[2] Ibid., August 6, 1892.
[3] Ibid., August 6, 1892.

HYDROPS ARTICULORUM INTERMITTENS. An extremely rare and obscure disease, characterized by periodically returning attacks of swelling of one or more of the larger joints, unaccompanied by fever or any of the usual signs of inflammation.

But thirty-three cases have so far been reported, and of these but three in this country, the two observed by Fridenberg and the one of my own.

There is a remarkable uniformity as regards the symptoms in all the cases, they forming a clinical picture so characteristic and typical as to leave no doubt of the diagnosis in any well-developed case.

The patient notices a slight swelling in one of the larger joints, usually the knee, and perhaps has his attention drawn to it by a feeling of tension, or of discomfort, uneasiness, insecurity, or wabbling in the affected part. This rapidly increases, so that usually, in from twenty-four to thirty-six hours the joint is so swollen as to seriously interfere with, if not to entirely inhibit, the normal functions. In a short time, usually a day or two, the swelling begins to subside, and in from twenty-four to thirty-six hours more it is entirely gone, leaving the joint to all appearance in as perfect and healthy a condition as before. After an interval of perfect freedom the swelling again appears and the same phenomena are repeated, and so on for an indefinite period of time.

There are no premonitory signs or symptoms indicative of the disturbance; the patient may be, and usually is, in his customary good or bad health, as the case may be. During the attacks there are in most cases no signs of constitutional disturbance; the normal functions of the body remain undisturbed. In two cases, those of Bruns and Pletzer, there was a slight rise in the temperature during the initial attacks, but not afterward, while Perrin reports a case in which each attack was preceded by light chills, followed by slight fever ending in perspiration. Simultaneously with this there was a contraction of all the flexors of the upper extremity, also a painful prickling in all the joints of the same limb. A few hours later the swelling began, and with it the above phenomena gradually disappeared.

In most cases there is no acute pain whatever; in some, however, especially when the hip-joints are affected, the pain is quite acute. In these exceptional cases the diagnosis might be difficult at times, as the swelling would be more apt to be overlooked than when the knee was affected. The subjective sensation is more that of tension, insecurity, and wabbling, than that of pain. Examination during the attack shows the swelling to be an

effusion into the joint. When the knee is affected there is the characteristic bulging at the sides of the patella, which, together with the fluctuation and the well-marked floating of the patella, renders the determination of the cause of the enlargement easy. There is no increase in surface temperature, except in one or two instances (Bylicki, Fridenberg), and no flushing or redness of the skin.

The attacks occur with such regularity that in many cases the patients can tell, not only the day, but even the hour when the seizure will begin. As a rule the interval of freedom varies in different cases from eight to fourteen days; thus in thirty out of thirty-nine recorded observations the intervals fell within these limits. The attacks themselves last in the majority of cases from three to five days. Out of twenty-seven observations twenty did not exceed these limits. The longest interval reported was three months, and the duration of the longest individual attack ten days.

As to age, it may be said to be a disease of middle life, most of the cases occurring in patients from twenty to fifty years of age.

Females are about twice as often affected as males. One or both knees are almost invariably involved at some period of the disease. In three of the cases it is not stated which joints were involved; in one other the elbows alone were affected. In all the others the knees were implicated.

Sometimes there is an alternation in the joints affected, one attack being of the knee, the next of the hip, and the third returning again to the knee, and so on. In two of the cases almost all of the joints in the body were involved, even those of the spine and fingers.

A marked peculiarity of the malady is the strong tendency which it shows to spontaneous cessation of the attacks for periods varying from a month to many years, after which it recommences without any assignable cause.

The disease runs a very chronic course, several of the cases lasting from twenty to twenty-five years. Pregnancy in almost all cases puts a stop to the attacks while it lasts. During only one out of nine recorded pregnancies was the patient afflicted. In several the attacks ceased at once at the beginning, and only one reappeared again a few weeks post partum. In no case is there any marked relation to the catameuia reported, though in a few cases the attacks first began at or about the time when menstruation became established.

As to the nature of the affection, there is nothing definitely known. That it is due to vaso-motor disturbance is admitted by everyone who has been fortunate enough to have observed a case; but whether this disturbance is due to micro-organisms, or is a mere neurosis, is at present undetermined. The evidence is but circumstantial in support of either theory. While it is true that several of the cases have occurred in patients subject to various nervous troubles, yet there are many more in persons having absolutely no hereditary tendencies in that direction. Subjective symptoms, as a rule, are more prominent than objective in neurotic diseases, while here we find the objective far more in the foreground.

Pain, as a rule, is only due to the distention of the joint, and there is none of that hyperæsthesia so characteristic of hysterical joints. The argument that galvanization of the medulla has cured one or two patients is not of much force, as both the patients were taking arsenic at the same time, and one of them had had a period of freedom from attacks for four years, at an earlier stage of the disease, following the administration of Fowler's solution. It is a noteworthy fact that almost every case reported cured or improved had taken either quinine or arsenic, or both combined.

Several of the cases had suffered from malarial poisoning at some previous period, and two others at least were from a malarial region. In two cases the spleen is reported as enlarged, and in one of them the swelling subsided simultaneously with the improvement of the patient under the use of quinine and arsenic.

It would take us beyond the scope of this article to enter into the subject of periodicity in disease. There is no satisfactory explanation of it except in those cases dependent on micro-organisms, yet there is scarcely a disease which does not present more or less well-marked traces of it at times. Innumerable instances might be cited, but as there is a separate article on this subject in a preceding volume, to avoid repetition we may refer to it for a discussion of the various theories advanced and for illustrative cases.

In typical cases there is no difficulty in the diagnosis, except that from its very rarity it is apt to be overlooked. Probably most of the cases are called rheumatism at one time or another, yet a very slight examination would show the swelling to be due to an effusion within the joints, and not extra-capsular.

As regards prognosis, the chronicity and liability to remissions and relapses has been already mentioned. In one case the disease finally ran into chronic dropsy of the joint. In one there was some crackling in the joint, and in two a slight thickening of the capsule, noted. In all others, even after many years' duration, there were no signs of chronic changes in the joints.

As would naturally be expected in so obscure an affection, the most diverse methods of treatment have been employed. The natural tendency of the disease to spontaneous remissions makes the proper estimation of any given method very difficult. However, quinine and arsenic enter into almost all reported cures. In my own case, whereas under the old rheumatic treatment the attacks always ran on through a period of several months, since she has tried arsenic and quinine she has found that she can always stop their recurrence after one, or, at most, two attacks. The tendency to relapse remains.

Of seventeen cases reported cured, relieved, or improved, injections of ergotin, electricity, cauterization and fixation, sulphur baths, and injections of carbolic acid, have each one successful result. In all the others quinine and arsenic were the chief remedies employed, so that in any given case these should have the first trial. After these electricity would probably be more serviceable than any of the other proposed remedies.

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William Barnes.

HYDROXYLAMINE. This compound base exists in the free state only in solution. It is ammonia in which one hydrogen atom is replaced by the hydroxyl group. The formula is NH_2 OH. *Hydroxylamine hydrochloride*, NH_2 OH HCl, forms in colorless crystals resembling chloride of ammonium; it is hygroscopic and very soluble in water, alcohol, and glycerine. It possesses active reducing powers, in consequence of which it has been suggested as a substitute for chrysarobin and other reducing bodies in the treatment of skin diseases. It has been used with success in psoriasis, parasitic affections, and in lupus. It is a powerful poison to all forms of vegetable and animal life, but while proving effective

in destroying the disease for which it is used, it is liable to produce toxic symptoms by its absorption and influence on the hæmoglobin of the blood. The salt should be kept in well-closed bottles in the dark, and when used, a solution of one part in a thousand may be prepared. The diseased part, previously washed with soap, is to be painted from three to five times a day.

Beaumont Small.

HYÈRES AND COSTEBELLE. In addition to the information already given with reference to Hyères (see Vol. III. of the HANDBOOK), the following particulars may be of interest to physicians. The writer's residence at Hyères was too brief to permit personal verification of all that is claimed for this Provençal winter station. But the testimony of Drs. Biden and Cormack, the resident English practitioners, agrees in all principal points. There is certainly no question that the winter at Hyères is very mild, and were it not for the *mistral*, and comparative dulness of the town, Hyères would doubtless be quite as popular as Cannes and Nice. Formerly it was much more so. The table given on the next page is reproduced from the writer's description of Hyères in the *Medical Record*, January 16, 1892, and is due to the courtesy of Dr. Biden, who specially prepared it.

FIG. 312.—View of Hyères Looking North.

SYNOPSIS OF METEOROLOGICAL OBSERVATIONS TAKEN AT HYÈRES.—The shade thermometers are placed in a Stevenson's screen. The screen stands in the open, completely exposed all round, quite away from buildings and walls. If $\frac{1}{100}$ of an inch of rain is measured in the twenty-four hours it is considered a day on which rain has fallen.

In regard to indications and contra-indications, the following opinions will suffice: "The winter climate of Hyères and Costebelle is suitable especially for consumption, chronic bronchitis, asthma, heart disease, and rheumatism: also Bright's disease, gout, incipient paralysis, and the feeble constitution of delicate children. In consumption, obviously, the disease is most amenable in its early stages. Nevertheless, remarkable instances have occurred of relief in advanced cases of a type quite unsuitable to Alpine climates. The occurrence of hemorrhage is not a contra-indication to residence here. For those beyond middle life it is difficult to conceive a more suitable environment than Costebelle offers. The climate of Hyères is less exciting than that of Cannes and Nice" (Dr. Sawtell). "The chief attractions of Hyères are its climate and the beauty of its environs, which render it an agreeable place of winter abode, even for persons in health who do not require the animated movement and recreative resources presented by large towns, and who are in tolerable walking condition. The walks and rides, both on the plain and through the cork-tree woods, by which the hills are for the most part covered, present considerable variety, while from the more elevated positions charming prospects may be enjoyed" (Dr. Edwin Lee). The barometer is high and steady, But on the Riviera, as elsewhere, every winter varies in the rainfall and in the degree of cold; and, therefore, it may happen that the traveller's experience will not agree with stereotyped meteorological tables.

Dr. Cormack says (*The Climatologist*, January 15, 1892) that: "Hyères is admirably suited to cases of phthisis. Should the disease be in its first period when the patient arrives, a complete cure may take place. The same result may be obtained with cases which have arrived at their second period, although the chances are less, but in any case a considerable improvement may be expected. When the disease has passed into the third period, or is too far advanced for any reasonable hopes of recovery to be entertained, life is prolonged for a time.

"All chest complaints and bronchial affections improve under this genial climate. Liver complaints, affections of the kidneys, Bright's disease, diabetes, etc., are all favorably influenced by the warm and equable temperature.

"Gouty and rheumatic cases get on very well here, and generally are much relieved after a winter or two's residence. This is only what would naturally be expected when one bears in mind of what capital importance a dry and warm climate is to such cases, and the great benefit they derive from out-door exercise, for which Hyères offers special facilities, for there is hardly a day upon which an invalid is unable to get out for at least an hour or two, unless the nature of his complaint keeps him confined to his bed.

"Cases of anæmia and asthma also do remarkably well for the same reasons.

"The invalid's day is comprised between the hours of 10 A.M. and 4 P.M. for the warmest months, and 11 A.M. to 3 P.M. when the days are colder. Naturally, special cases have to follow special rules; but no invalids, in any case, should go out until the sun is well risen, nor after sunset, as both before and after sunset the temperature is many degrees below what it marks in the middle of the day; it is specially dangerous for delicate persons and those having weak chests to go out after sunset, for there is invariably a very rapid fall in the thermometer at this time. A most useful precaution for all patients is to be provided with a shawl when passing from the sun into the shade, as the difference of the two temperatures is very considerable. There are certain times, during the mistral, for instance, when invalids do well to keep within doors; more particularly is this the case for those of weak constitution or nervous temperament."

Finally, Drs. Biden and Cormack agreed in assuring the writer that Hyères is a healthy town. There is very little typhoid, no diphtheria or other zymotic diseases, and the foreign colony has nothing to fear, and has had nothing to regret at this delightful winter resort. Anæmia and American neurasthenia should do particularly well there. About the only contra-indication for a winter's residence at Hyères is furnished by recent neuroses, with a tendency to mania.

Month.	Mean shade temperature, Thermometers registering and correcting.		Mean daily shade temperature.	Solar radiation (black bulb in vacuo).	Relative humidity, daily mean. (Per cent.)	Days of sunshine per month.	Days calm.	Days of wind,		Days on which rain has fallen.	Rainfall.
								Light to fresh.	Strong to a gale.		
	Max.	Min		Mean.							In.
Nov...	61.4	45.8	53.6	106.5	76.0	21	16	10	2	7	3.52
Dec...	55.5	40.5	48.0	98.7	73.0	21	15	11	5	6	2.86
Jan...	55.8	39.3	47.5	101.2	76.0	23	18	9	3	6	3.08
Feb...	56.5	40.6	48.5	105.7	75.0	20	13	11	3	6	2.21
March.	59.8	42.3	51.0	112.1	71.0	25	12	15	3	5	2.26
April..	63.3	47.2	55.0	117.6	71.0	23	9	16	4	7	5.11
Mean..	58.7	42.6	50.7	107.0	73.5	135	84	74	22	39	17.04

The water-supply of Hyères and Costebelle is moderately good. The water is very hard, however, and does not agree with everybody. The drainage is quite imperfect, and the cesspools, which are in common use, may become sources of danger.

In the writer's report, already alluded to, Costebelle is thus referred to: From the railway station of Hyères it is but one mile of slightly up-hill wooded road to Costebelle. From the town proper it is two miles in a southerly direction. From Marseilles to Genoa, *i.e.*, along the entire Western Riviera, or "*le littoral*," as the French call it, there are ever-changing and enchanting views. But in all this favored strip of land, so abundantly blessed with blue skies and health-giving sunshine, I have found no prettier views than those which are enjoyed from the Costebelle hill-sides.

Situated on the southern slope of an eminence appropriately named *Mont des Oiseaux*, which effectually protects it from that much-dreaded wind called "mistral," surrounded by forests of aged pines, oaks, and olive-trees, that richly clothe in different shades of green the adjoining hills on the north, east, and west, and with a southerly view over undulating woodlands, stretching out into a picturesque plain that ends abruptly at the Mediterranean Sea a mile below, Costebelle has been happily chosen as a site for a few first-class hotels.

The late Duke of Grafton some years ago found it to be a site without parallel along the whole coast. He built a princely villa and made a road through the pines to serve it. But only within the last ten years has any move been made to provide accommodations for the increasing number of visitors.

In addition to the two older hotels (selected for the Queen of England's residence in the spring of 1892), Costebelle has a third and quite modern hotel, called the Albion, which is in every respect a first-class family residence.

At the Albion good sanitary arrangements were found by the writer, and the other Costebelle hotels have been recently overhauled and made nearly perfect in this respect. *Edmund C. Wendt.*

HYOSCINE. This alkaloid is present in other plants beside *hyoscyamus niger*, having been obtained from *duboisia myoporoides* and *scopola carniolica*. It is supposed to be identical with scopolamine, which is isomeric with cocaine and not with hyoscyamine; it is also identical with duboisine. Hyoscine, $C_{17}H_{23}NO_3$, is a non-crystallizable body, but all its salts form in large, white prismatic crystals, freely soluble in water, insoluble in alcohol and ether. The salts also resemble each other in therapeutic as well as physical properties. The hydrobromate, hydrochlorate, sulphate, and hydriodate are prepared.

As a mydriatic it is rapid, energetic, and brief, but its action is readily maintained. During the administration of the drug its effect on the pupil is an early symptom. Dilatation is said to be more marked with a $\frac{1}{4}$ to $\frac{1}{2}$ per cent. solution than with a one per cent. solution of atropine; it has to be used with caution on account of the readiness with which the system is affected.

Its sedative and hypnotic action has brought it into prominence, during the past few years, as a remedy in cerebral excitement and in the treatment of nervous diseases. In small doses it produces a stimulating action on the nervous centres, but in larger doses it is a powerful sedative. When given until its physiological action is produced, it causes the pupils to dilate, and checks the secretion of the salivary glands and the action of the skin. On the heart it depresses the inhibitory nerves, and causes a weak and accelerated action of the pulse. Some observers have noted in the early stages a slowing of the pulse and an increase in the blood-pressure. It diminishes the irritability of the brain and nerve-centres, lessens to a slight extent the perception of pain, but does not affect tactile sensibility. Its toxic action is shown by the dilated pupil, rapid pulse, relaxed arteries, and redness of the surface, dry, hot skin, rapid breathing, and coma and convulsions.

Hyoscine has largely supplanted morphine in the treatment of acute mania and delirium tremens, in restlessness, and violence in all forms of mental disorders, and in hysteria and epilepsy. Its sedative action is very rapidly produced, and in the majority of cases a calm and refreshing sleep ensues. When pain is the cause of insomnia, it is not of much service. Its action is purely calmative and sedative on the brain, and it should not be administered as a powerful or decided hypnotic; in insomnia it is only applicable in cases in which it arises from central or nervous excitement. In mania, and when there is much excitement, it should be given in full doses of $\frac{1}{60}$ grain by the mouth or $\frac{1}{120}$ to $\frac{1}{100}$ grain hypodermically; a small dose is generally sufficient. When the symptoms are less acute, smaller doses should be given.

Hyoscine has also proved itself very efficient in the treatment of chronic mania and all nervous affections accompanied by mental restlessness; also in nervous diseases characterized by debility and tremors, as in paralysis agitans, disseminated sclerosis, and chronic alcoholism. In these cases the stimulating action of small doses is taken advantage of, and $\frac{1}{200}$ of a grain daily or twice a day is a sufficient dose. Its antispasmodic action is also secured with the same small dose, and it may be used, and with benefit, in chorea, asthma, and other spasmodic troubles of a nervous origin. When cardiac disease is present the use of hyoscine should be avoided or given with great caution, on account of its depressing action on the heart and circulation.

The early physiological effects of the drug are mani-

fested far in advance of dangerous symptoms, but in some cases very severe toxic symptoms have been produced by doses of $\frac{1}{60}$ and $\frac{1}{10}$ grain. Pilocarpine and morphine are physiological antidotes. The former has proved very serviceable and may be administered freely, as much as two grains having been required in a case of delirium tremens in which a comatose condition followed frequent doses of hyoscine.

Beaumont Small.

HYOSCYAMINE. This alkaloid, formerly obtained solely from *hyoscyamus niger*, is now known to be the alkaloid present in many other plants of the order solanaceæ, notably *atropa belladonna*, *datura*, *stramonium*, and *scopola carniolica*. It has recently been obtained from the common lettuce plant, *lactuca sativa*.[1] Professor Ladenburg demonstrated that atropine, daturine, and duboisine are identical with hyoscyamine, both in chemical constitution and physiological action. Any difference is to be found in the molecular arrangement of the constituents, and not in any fundamental change. The terms "atropine" and "hyoscyamine" have been applied to the heavy and light mydriatic alkaloids obtained from the belladonna and henbane plants, the former being the heavy and the latter the light alkaloid. It is now known that both the heavy and light alkaloids may be obtained from either plant, according to the process of manufacture. The light may be converted into the heavy by melting under reduced pressure, or by the addition of caustic soda to its alcoholic solution.[2]

Hyoscyamine, $C_{17}H_{23}NO_3$, occurs in light, silky, snow-white crystals, without odor, soluble in one hundred and twenty parts of water, freely soluble in alcohol, and in acidulated water. There is also an uncrystallized or amorphous hyoscyamine, of a dark-brown extract-like mass, with a strong disagreeable odor. This appears to be a mixture of the various alkaloids and extractive matters. A sulphate, hydrochlorate, hydrobromate, and hydriodate of hyoscyamine are prepared; they are alike in degree of strength and character, forming white, fine crystals very soluble in water. A sulphate and hydrobromate prepared from the amorphous alkaloid are amorphous, deliquescent salts, and less active and certain in their effects.

The therapeutic properties of hyoscyamine resemble those of hyoscine, but since the introduction of the latter alkaloid it has fallen into disfavor. It was found to be less certain in its action, and its use was frequently accompanied by unpleasant symptoms. It is employed as an hypnotic, nerve sedative, and antispasmodic, in mania, restlessness, delirium, insomnia, and all conditions accompanied by mental excitement, also in asthma, chorea, epilepsy, etc.

The dose is somewhat larger than that of hyoscine, $\frac{1}{100}$ to $\frac{1}{10}$ of a grain, which in some cases requires to be increased to $\frac{1}{4}$ grain to obtain the desired action. The presence of the amorphous salts in the market is the source of much of the uncertainty of its action, and the cause of many of the toxic symptoms. The dose of these salts is much larger, being from $\frac{1}{8}$ to 1 grain.

Its mydriatic action is rapid and powerful, but not so manageable as atropine. Cases[3] are reported in which it produced spasms of the ciliary muscle and intense pain and distress; the solution used was $\frac{1}{4}$ grain to the drachm, and relief was obtained by placing in the eye a stronger solution of the same alkaloid. Its toxic action is the same as that of hyoscine, viz., dryness of the throat and mouth, and of the skin, accelerated pulse, dilated vessels, and excitement followed by convulsions and coma.

Beaumont Small.

[1] The Lancet, December 26, 1891.
[2] Extra Pharmacopœia, 1892.
[3] Therapeutic Gazette, March, 1892.

HYPNAL. It is well known that a mixture of antipyrine and chloral results in the production of an oily fluid, which in time again crystallizes. Dr. Bardet (*Répertoire de Pharmacie*, April 10, 1890) made known the fact that when combined in certain proportions the compound possessed the therapeutic properties of its component parts; to this product he gave the name of hypnal. It may be prepared by mixing a solution of 47 grammes of chloral hydrate in 50 c.c. of distilled water, with a solution of 53 grammes of antipyrine in 50 c.c. of distilled water, pouring into a separating funnel, and drawing off, after an hour, the oily-looking fluid from the aqueous layer. At the end of twenty-four hours the liquid will have solidified to a mass of rhombic crystals.* The salt is colorless, odorless, soluble in five or six parts of water, being less soluble than either chloral hydrate or antipyrine.

Bardet found it very useful as an hypnotic and analgesic. He employed it in twenty-two cases, and found it to produce sleep as readily as chloral hydrate, and where pain was present marked relief was at once secured. He also found it act very beneficially in producing sleep when the cause was a spasmodic cough. It has not the bitter taste nor the disagreeable effect on the stomach of its constituents, and secures its desired effect in comparatively small doses. No ill effects have followed its use, but in some instances where it has failed to produce sleep it has given rise to increased restlessness. It is easily taken by children on account of its freedom from taste.

The dose is from seven to fifteen grains for adults. It may also be given hypodermically in the same quantities. As an enema it will also produce its effect in doses of thirty grains.

Beaumont Small.

HYPNONE (Acetophenone). Chemically this compound is methyl-phenyl-ketone, $C_6H_5CO\,CH_3$. It has long been known, but its therapeutic properties were studied and demonstrated by Dr. Dujardin-Beaumetz and Dr. Bardet, in 1885, at which time it was given the shorter name of hypnone. They considered it a very valuable hypnotic, even superior to chloral and paraldehyde, particularly in the insomnia due to alcoholism. Dose, two to four drops. It is a colorless liquid, sp. gr. 1.032. At 57.2° F. it solidifies into a mass which persists to a temperature of 60° F. It is volatile and its odor is very penetrating, recalling that of the oil of bitter almonds. It is not soluble in water nor in glycerine, but is soluble in alcohol, ether, and oil of sweet almonds. It has a sharp, almost caustic taste, and requires to be given well diluted or with the oil of sweet almonds, in capsules.

Further employment of this drug has not supported the views of its discoverers. Its action has proved uncertain, and it is not of any service when the sleeplessness is due to pain. It is only indicated in primary and nervous insomnia, when other soporifics have failed. A further objection to its use is its disturbing effects on the digestive organs and its ill effects on the blood. The following conclusions are formulated by Kamensky: (1) Hypnone enfeebles sensibility and diminishes the reflexes; (2) moderate or large doses produce a slight sleep resembling natural sleep when the drug is introduced directly into the blood; (3) it increases the heart-beat, probably by stimulating the accelerator centre of the heart; (4) in moderate quantities it increases respiration, but large doses paralyze it; (5) it depresses arterial pressure by paralysis of the vaso-motor centre and enfeeblement of the heart's energy; (6) moderate and large doses diminish the excitability of the cerebrum, while all quantities increase the excitability of the spinal cord; (7) it reduces the oxyhæmoglobin of the blood; (8) it diminishes temperature by increasing heat dissipation.

Beaumont Small.

HYPNOTICS. Numerous chemical products have lately been found to produce sleep, and have been tried as hypnotics in cases of insomnia. Most of them proved uncertain and disagreeable in action; a few, however, especially chloralamide, sulphonal, and amylene hydrate, have been found to act with much certainty, and without

* It may also be formed by shaking together concentrated solutions in the above proportions, the crystals being deposited. If the chloral be in excess, the crystals form in prismatic needles.

markedly affecting the functions of circulation and respiration. In some respects they seem to be superior to the old, well-known hypnotics, and hence will probably come into general use, and occupy a prominent place among the standard remedies for insomnia.

CHLORALAMIDE, OR CHLORAL-FORMAMIDE.—Chloralamide was introduced in 1889, by Professor Von Mering, as a substitute for chloral in cases of insomnia in which the influence of chloral on the organs of circulation should be avoided. He supposed that the formamide, contained in chloralamide, would effectually prevent the depressing action of chloral.

Chloralamide is prepared by mixing molecular weights of chloral and formamide, that is, 147 parts of anhydrous chloral and 45 parts of formamide. The liquids combine and form a crystalline solid, as represented by the following equation :

$$\underset{\text{chloral}}{C\,Cl_3\,COH} + \underset{\text{formamide}}{HCONH_2} = \underset{\text{chloral-formamide}}{C\,Cl_3\,CH\,(OH)\,HCONH}$$

Chloralamide is in the form of white, lustrous crystals, having a bitter taste, but no odor. It is slowly soluble in 20 parts of water, and in 1½ part of alcohol. It decomposes in hot water having a higher temperature than 60° C. ; so also in alkaline solutions, but not in dilute acids.

Physiological Action.—Chloralamide does not irritate the mucous membrane of the stomach, and is not affected by the gastric juice. After absorption it is slowly decomposed by the alkaline blood into chloral hydrate and formate of ammonium. The latter is produced as follows : $HCONH_2 + H_2O = NH_4CHO_2$. Consequently, the action of chloralamide is that of chloral hydrate, modified by the rate of its decomposition in the blood, and possibly by the presence of the formate of ammonium.

The experiments made upon animals have yielded somewhat discordant results, not as to the influence of chloralamide on the brain, but as to its action on the organs of circulation and respiration. Von Mering,[1] Kny, and others noticed no fall of blood-pressure in rabbits under the influence of hypnotic doses of chloralamide ; Laanggaard,[2] on the contrary, observed decided lowering of blood-pressure, although this effect supervened more slowly than after chloral hydrate.

Upon man chloralamide acts like chloral, except that it produces sleep less rapidly and less certainly. As a rule, after doses of 2.0 to 3.0 (thirty to forty-five grains) sleep ensues in half an hour, and continues from five to eight hours. During the sleep, the functions of circulation and respiration are performed as vigorously as in normal sleep. After awakening the patient presents no disagreeable after-effects.

Numerous deviations, however, from this ordinary action have been observed, depending chiefly upon the causes of the insomnia. Thus, in cases of intense excitement of the brain, of severe pain, of harassing cough, and of high fever, doses of 2.0 to 3.0 have failed to produce sleep, and sometimes even 4.0 (sixty grains) have been ineffectual. Often, even when the causes of insomnia were not intense, sleep did not supervene before an hour, sometimes two hours, and in rare instances even three hours. In some cases of heart disease,[3] especially in valvular disease with imperfect compensation, a very decided depression of the circulation has been observed. So, too, in typhoid fever a very unfavorable effect upon the pulse was noticed after 2.0 (thirty grains) given in divided doses.

Generally, after-effects do not occur, or they are very trivial, consisting of headache, slight giddiness, a feeling of fatigue, and skin eruptions.

From the above it is evident that chloralamide closely resembles chloral in action, but that it induces sleep more slowly and less certainly, and that it is less apt to depress the circulation. The differences seem to be due to slow and gradual liberation of chloral in the blood, although it is not improbable that the presence of the formate of ammonium may somewhat modify the action of the chloral on the organs of circulation. The variations in the rapidity of action doubtless result from differences in the rate of decomposition in the blood of different persons.

Therapeutic Uses.—Chloralamide is a suitable hypnotic in insomnia not caused by intense excitement of the brain, very severe pain, or extreme dyspnœa. When severe pain causes insomnia, chloralamide alone is not very efficient, but it acts well if given together with a moderate quantity of morphine. In the insomnia associated with mild nervous excitement, with neurasthenia, and with somatic diseases in general, moderate doses, from twenty to thirty grains, are usually effectual. Such moderate doses having frequently failed in cases of intense mental excitement and severe pain, larger doses, as much as one drachm, have been recommended ; but it should be recollected that such large doses may cause dangerous depression. Even moderate doses should not be given in cases of heart disease, if the heart's action be very feeble, or if symptoms of inadequate compensation be present. In no case should the dose be larger than the corresponding dose of chloral hydrate. Chloralamide contains 77 per cent., and chloral hydrate 89 per cent., of anhydrous chloral.

Chloralamide may be prescribed as follows : (1) ℞. Chloralamid., ʒij.-ʒ j. ; Aq. dest., ℥ ijss. ; Acid. hydrochl. dil., gtt. v. ; Syr. rubi idæi, ℥ ss. M. S. : One half to be taken before retiring. (2) ℞. Chloralamid., ʒ j. ; Spir. frumenti, Syr. rubi idæi, āā ℥ ss. M. S. : One tablespoonful shortly before retiring.

SULPHONAL.—The properties of this hypnotic have been described in this HANDBOOK, Vol. VIII., p. 499, and need not be repeated here.

Sulphonal has been extensively used in the last four years. The results obtained by clinicians, who have had ample opportunities for observing its effects, may be summed up as follows :

1. In doses of 1.0 to 2.0 (fifteen to thirty grains) sulphonal is a very reliable hypnotic in simple nervous insomnia ; but in such doses it often fails in the insomnia caused by cough, pain, and dyspnœa. Large doses,[4] however, will generally produce satisfactory sleep ; but their action is often followed by disagreeable effects, and in heart disease by serious depression of the circulation.

2. Sulphonal continues to act in the same dose for a long time. In some cases it has been found that, after one dose had acted well, sleep would take place spontaneously on the subsequent night. It has frequently been observed that a moderate dose, 1.3 (twenty grains), would on the first night act only for a short time, but, when repeated on the following night, cause prolonged, refreshing sleep. Cases[5] have been reported in which moderate doses had been taken for months, at first nightly, and afterward several times a week, with a satisfactory result, and without any apparent injury.

3. Some observers have noticed cumulative effects ; moderate doses, repeated once in twenty-four hours for some weeks without ill effects, suddenly produced very grave phenomena, such as vomiting, prostration, and ataxia. Doses of 1.0 to 2.0 (fifteen to thirty grains) given repeatedly for several days, have in a few instances caused weakness, staggering, grinding of the teeth, difficult articulation, and severe giddiness. In one case 20.0 (three hundred grains) taken within a week, caused severe vertigo, great restlessness, confusion of mind, loss of memory, and clonic spasms.[6]

4. The prolonged use has in some instances been followed by serious disease of the kidneys, and changes of the blood.[7] The urine had a dark-red color, and contained much coloring matter, albumin, and tube-casts. Some of the patients died from heart-failure. The doses were moderate, usually from 1.0 to 2.0 daily.

AMYLENE HYDRATE,—$C_5H_{12}O$.—Dimethyl-ethyl-carbinol $(CH_3)_2C_2H_5COH$. Amylene hydrate is a limpid, volatile, neutral liquid, having a peculiar, spicy odor, and a pungent taste. It is soluble in eight parts of water, and readily mixes with alcohol, ether, chloroform, glycerine, and fixed oils. It boils at 99° to 103° C. Its sp. gr. is 0.815 to 0.820.

Physiological Action.—Professor Von Mering[8] investigated the action of amylene hydrate in experiments upon

animals. In rabbits, doses of two to three grammes in ten to twenty minutes produced sound sleep, which continued from six to eighteen hours. In dogs, proportionate doses were followed in half an hour by sleep, which lasted from ten to eighteen hours. During the sleep no notable change took place either in respiration or in circulation. No lowering of blood-pressure was found when the narcosis was so deep that all the reflexes had disappeared. Moderate doses acted chiefly upon the cerebrum; but large and toxic doses affected also the spinal cord and the medulla oblongata; first the reflexes ceased, then the breathing stopped, and finally the heart stood still.

In man moderate doses cause prolonged refreshing sleep, without affecting the heart, the respiratory apparatus, or the alimentary canal. Poisonous doses produce symptoms resembling those of alcoholic intoxication—deep, long-continued sleep, with complete suspension of motility, sensibility, and reflex action; dilatation of the pupils; slow, irregular, superficial breathing; slow, small pulse, and lowered temperature. No cases of death from amylene hydrate have been reported.

Therapeutic Uses.—Having observed the genial action of amylene hydrate upon animals, Von Mering tried it clinically in cases of insomnia. To 60 patients affected with sleeplessness he gave 350 doses. After doses of 3.0 to 5.0 (forty-five to seventy-five minims), sleep ensued within half an hour, and continued from six to twelve hours. Only four times was the hypnotic action unsatisfactory. No disagreeable incidental effects occurred, and only one patient complained on the following morning of slight headache. When the sleeplessness was due to pain, amylene hydrate did not act well; but the simultaneous administration of a small quantity of morphine rendered the action satisfactory. No deviation from the normal condition took place in the functions of respiration and circulation, and in several cases of heart disease with insomnia, quiet sleep resulted without any disagreeable effects. Von Mering supposed that 2.0 of amylene hydrate act as strongly as 1.0 of chloral hydrate, and 3.0 of paraldehyde.

A very thorough trial of amylene hydrate was made at Professor Jolly's psychiatric clinic in Strasburg.[9] To 80 patients 1,050 doses were given. Small doses, 1.6 to 2.6, were at first used in all cases; if a satisfactory result was not obtained, the dose was increased until the maximum, 4.8 to 5.0, was reached. Generally sleep ensued in from five to twenty minutes; in excited and restless patients, in twenty to thirty minutes; and in the maniacal, in one-half to one hour. During the sleep the pulse and breathing were normal in all cases. The sleep was less sound and protracted after small than after large doses, and the patients were awakened by the slightest touch, as when the pulse was counted; but this rarely occurred after large doses. No injurious incidental effects were observed. The digestive tract was never disordered, and only two or three times did nausea or vomiting occur. The appetite was not diminished, and the action of the bowels not disturbed. In very rare instances patients complained on the following morning of slight headache or throbbing in the head; but in those cases the general condition was disturbed by the primary psychical disease. Free perspiration at the beginning of the hypnotic action occurred in a few patients.

Amylene hydrate has been used to a considerable extent as a hypnotic in hospitals and insane asylums. The reports from these institutions have in general fully corroborated the observations of Von Mering, and of Jolly, of Strasburg.

The dose of amylene hydrate is 2.0 to 4.0 (thirty to sixty minims), preferably in aqueous solution, with extract of glycyrrhiza, syrup of orange, or syrup of raspberry as corrigents. The maximum dose of the Ph. G. is pro dosi 4.0, and pro die 8.0.

It may be prescribed as follows: (1) ℞. Amyleni hydrat., ʒ jss.; Aq. dest. ℥ ij.; Extr. glycyrrh., ʒ ij. M. S.. One-half to be taken at bedtime. (2) ℞. Amyleni hydrat., ʒ jss.; Aq. dest. ℥ jss.; Syrup. rubi idæi., ℥ ss. M. S.. One-half to be taken at bedtime.

Samuel Nickles.

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[2] Ueber einige neue Schlafmittel, von Dr. A. Laanggaard, Ther. Monatsch., 1889, p. 461.
[3] Zur klinischen Wuerdigung des Chloralamids, von Dr. A. Robinson, Deutsch. med. Wochenschrift, 1889, No. 49.
[4] Beitrag zur Sulfonalwirkung, von Dr. Joachim, Ther. Monatsch., 1889, p. 226.
[5] Ueber Sulfonal, von Dr. M. Steiner, Therap. Monatsch., 1889, p. 459.
[6] Ein Fall von Sulfonalintoxication, von Dr. Joachim Rattenberg, Therap. Monatsch., 1891. p. 648.
[7] Ueber das chemische Verhalten des Harns nach Sulfonalintoxication, Therap. Monatsch., 1892, p. 39.
[8] Das Amylenhydrat, ein neues Schlafmittel und dessen Anwendung in der Medicin, Therap. Monatsch., 1887, p. 249.
[9] Ueber die Verwendbarkeit des Amylenhydrat als Schlafmittel, ins besondere bei Geisteskranken, Therap. Monatsch., 1887, p. 329.

HYSTERIONICA BAYLAHUEN, H. B. A perennial plant belonging to the order of Compositæ-Synantherеæ, and closely allied to Grindelia robusta. It is indigenous to Chili and is remarkable for the resinous exudation with which all its parts are covered. It contains a brown, odorous, acrid resin, and an essential oil. No alkaloids have yet been separated. It has a local reputation as an anti-diarrhœic remedy, and has been used with success in chronic dysentery and the diarrhœa of phthisis. The action of this plant has been studied by G. Baillé (*Bull. Gén. de Thérap.*, February, 1889). He found it very serviceable in all the diarrhœas of wasting diseases, particularly in phthisis. He recommends that an aqueous solution be prepared, 1 part to 150 of water, as the alcoholic preparation is not of any value in these troubles. Dr. H. Gilbert (*Therap. Gazette*, January, 1891) has used the fluid extract in various forms of chronic diarrhœa, and always found it serviceable. He employed the fluid extract in doses of ten minims every six hours, and continued its use for a prolonged period. No bad effect followed its use in any of his cases.

He used the tincture in lung diseases, and found that it lessened the secretion and cough, and did not irritate the stomach. The large quantity of aromatic resin which it contains has led to its use in bladder troubles and diseases of the urinary passages. It lessened the pain of micturition in cystitis and rendered the urine clearer and purer.

Beaumont Small.

ICHTHYOL. This compound is obtained by the distillation of a bituminous mineral deposit of Tyrol, which contains an abundance of the fossil remains of fish and other marine animals. During the dry distillation there passes over, between 100° C. and 225° C., a crude volatile oil. This is treated at 100° C. with an excess of concentrated sulphuric acid, which forms ichthyo-sulphonic acid, and this is precipitated by the addition of concentrated brine. The product contains a certain proportion of the unchanged oil, which cannot be removed without producing decomposition of the whole compound.

Ichthyo-sulphonic acid forms salts with ammonium, sodium, lithium, zinc, and mercury, but the ammonium salt is the one preferred and generally understood by the title of ichthyol. Ammonium ichthyol sulphonate, $C_{28}H_{30}S_3O_6(NH_4)_2$, is a clear, thick, brownish liquid with a smoky bituminous odor and taste. It is soluble in water, in a mixture of alcohol and ether, in glycerine, oils, and fats. Experiments on animals show that it does not possess any toxic properties, and but one instance is recorded where very distressing symptoms followed the application of one part ichthyol to two parts of glycerine, to the enretted surface of the uterus. The patient complained of the taste of the drug, tachycardia and general depression came on, and the patient remained prostrated for twelve hours. The symptoms were supposed to be due to absorption of the ichthyo-sulphonic acid through the abraded surface of the uterus.

The therapeutic value of ichthyol depends upon three

factors: its reducing property, its antiseptic action, and a contractile effect which it exerts on the vascular system. It was introduced by Dr. Unna, of Hamburg, in 1883, as a remedy for the treatment of various forms of skin disease. Its use has since been greatly extended, and it is very generally used, both externally and internally, in a great variety of diseases. Unna described it as the remedy *par excellence* against acne, the pustular as well as the papular form. He advises fifteen drops internally twice a day, and a ten per cent. lotion to be painted on at night; each day the part was to be bathed with hot water and ichthyol soap. In rosacea it was equally beneficial, but in eczema, or in either of the above skin affections approaching eczema, it had to be used cautiously and more mild applications employed. He also recommended it in lichen, urticaria, intertrigo, erythema, furunculus, burns, and innumerable other forms of skin disease. In eczemas he found benefit from the internal use of ichthyol and mild soothing applications. Subsequent experience has confirmed the value of this remedy in nearly all forms of skin diseases, including eczema and all forms of eczematous inflammations. Externally it is employed as a lotion of the strength of ten or twelve per cent., or as an ointment with lanoline or other base. Dr. Unna has recently advised the preparation of varnishes, which he considers the most suitable way of applying the remedy: Ichthyol, 40 parts; starch, 40 parts; solution of albumin, 1 to 1½ part; water, to 100 parts. The starch is first moistened with the water, the ichthyol is then added, and lastly the albumin. For surgical purposes he uses: Ichthyol, 25 parts; carbolic acid, 2.5 parts; starch, 50 parts; water, 22.5 parts; the ichthyol and carbolic are dissolved in the water, warmed, and when cool the starch is added. These varnishes may be applied and remain on the parts until the next application, and are easily removed by water.

A more important addition to the therapeutic value of ichthyol has been its employment in erysipelas. Klein found that in dilute solutions it arrested the development of the bacilli of erysipelas, and when used in the treatment it shortened the attack by one-half. The parts should be carefully washed and an ointment of equal parts of vaseline and ichthyol applied; where the surface affected was extensive a weaker application was used—ichthyol, lanoline, and water in equal parts. The applications should be thoroughly rubbed in two or three times a day, and continued for five or six days, when the redness and inflammation will be found thoroughly removed. In using the application the clothes and bedding should be protected.

This drug has not been employed to any extent in general surgery, although it has been recommended as a dressing for wounds, abscesses, and ulcers, in which it undoubtedly possesses a beneficial action. Unna advises the use of the pure, undiluted ichthyol for such purposes. In gynæcological disorders it is much used, and reports of its success are numerous. In chronic forms of parametritis and perimetritis, with exudations and adhesions, inflammatory conditions of the ovaries and tubes, cervical erosions, vaginal catarrh, it causes a lessening of the congested condition, and promotes absorption of the inflammatory products. In no instance has it produced any unfavorable symptoms, and as a wash and tampon it may be used without danger. It may be used with glycerine, one to twenty, as a tampon, with lanoline in equal parts, or a ten per cent. solution in water may be used as a wash. It is also given internally, which assists the action of the typical application in promoting absorption.

On account of its success in gynæcological practice, it has been employed in inflamed conditions of the prostate, a ten per cent. solution being injected into the anus three or four times a day. It appeared to have a very favorable action on the inflamed gland, and in forty cases in which it was used, no abscess occurred in any case.

It was advised as a remedy in rheumatism, particularly in the form due to gonorrhœal infection, but experience has not proved it a success. An ointment is rubbed in the affected joints, and five to twenty minims are taken internally each day. At the meeting of the Fourth International Congress, Dr. Unna read a paper pointing out the value of ichthyol in the treatment of leprosy. He presented the following conclusions: (1) Lepra tuberosa, even of universal extension and more than one year's standing, can be cured; (2) the cure can be effected in a comparatively short time by the energetic internal and external employment of the reducing remedies; (3) among them may be specially recommended ichthyol, chrysarobin, pyrogallol, and resorcin. Of these ichthyol is the only one that can be administered internally, without danger, for any length of time, and consequently is a remedy of great importance. The application advised is an ointment of ten parts ichthyol, seven parts lard, and oil, three parts. Internally, fifteen to twenty-four minims may be taken daily.

In addition to the diseases enumerated, it may be administered internally in all conditions in which there is hyperæmia and capillary dilatation. It in no way disagrees with the patient, although at first it may give rise to disagreeable eructations of gas; this, however, does not persist. It does not cause any irritation of the mucous membrane, but has been found beneficial in all forms of chronic gastric and intestinal troubles. The dose for a child of two years of age is about two minims daily; for adults, from five to twenty minims daily. It is usually administered in pills or in capsules.

Beaumont Small.

IDIOPATHIC ANÆMIA.—Much study has been given to idiopathic anæmia since the publication of the REFERENCE HANDBOOK. Its clinical characteristics, particularly those of the blood, have been more sharply defined, but there is still a lack of entire agreement as to its pathogeny. The most important papers which have appeared in recent years are those of Hunter, Russell, and Mackenzie.

The blood changes in idiopathic anæmia are, with few exceptions, such as may occur in any grave chronic anæmia, but in the former they are more varied and reach a more intense degree. A very important characteristic is the amount of hæmoglobin present; the whole amount is diminished, but, as compared with the greatly diminished number of red blood-corpuscles present, the hæmoglobin is relatively increased. Again, there is great variation in the size of the red blood-corpuscles, the average size probably being larger than normal. The number of nucleated red blood-corpuscles varies, and as they are found in other anæmic conditions their presence alone is not significant; but the occurrence of a considerable number of nucleated cells of large size (gigantoblasts) is regarded by Ehrlich and his followers as almost diagnostic of idiopathic anæmia.

The leucocytes of idiopathic anæmia are diminished in number, the proportion of small mononuclear cells (lymphocytes) being increased, and that of multinuclear cells diminished.

Minute examination of the blood requires that cover-glass preparations should be made, and the blood stained. For this method we are indebted largely to Ehrlich. The cover-glasses should be perfectly clean, and to avoid soiling or moisture it is advisable to use forceps. A satisfactory solution for staining is the following, suggested by Dr. W. S. Thayer:[1]

Sat. aqueous sol. of orange G.....	2
Sat. aqueous sol. of methyl green....	6.25

To be added, drop by drop, while shaking the solution:

Water.....	15
Alcohol.....	10
Glycerine.....	5

The cover-glass preparations of the blood are first fixed by immersion in equal parts of alcohol and ether, or, what is better, by heating them at a temperature of 212° F. or a little higher; but they should not be kept at that temperature more than an hour. They are then stained in the solution mentioned for from two to five

minutes, washed in water, dried, and mounted in oil or balsam. "The red cells are stained orange or buff, the nuclei of the colorless corpuscles green, the neutrophilic granules violet or lilac, the eosinophilic granules a deep red. The nuclei of the nucleated red blood-cells are stained an intensely deep green, almost black."

As regards the pathology of idiopathic anæmia, Hunter's investigations seem to show conclusively that hæmolysis is at least the largest factor in idiopathic anæmia. He, by the way, looks upon pernicious anæmia as a special disease, and as a distinct variety of idiopathic anæmia.

Hunter found the most constant anatomical change to be a large excess of iron in the liver. He concludes that: "In pernicious anæmia the seat of disintegration is chiefly the portal circulation, more especially that portion of it contained within the spleen and the liver, and the destruction is effected by the action of certain poisonous agents, probably of a cadaveric nature, absorbed from the intestinal tract."

Griffith and Burr[2] reach essentially the same results as Hunter.

W. Russell believes that the blood is defective before it reaches the liver, and that this explains the increased liver hæmolysis.

As regards treatment, it is important to keep the stomach and bowels in a healthy condition. Washing out the stomach is a rational procedure, and is reported to have cured one case (Meyer).

The bowel should also be kept free from putrefactive changes by laxatives and antiseptic agents. Dr. G. A. Gibson,[3] adopting Hunter's suggestion, employed β-naphthol in two-grain doses three times a day in a case of pernicious anæmia. Apparent cure resulted. The β-naphthol is best given with salicylate of bismuth, to prevent intestinal disturbance. Hunter prefers farinaceous and fatty foods to meats. Of internal remedies, arsenic is unquestionably the best. It should be given in as large doses as can be borne; some patients have been able to take as high as twenty to thirty minims of Fowler's solution at a dose. Inhalations of oxygen have also proved helpful.

J. H. Musser.

[1] Boston Medical and Surgical Journal, February 16 and 23, 1893.
[2] Medical News, Philadelphia, 1891, lix., 445–450.
[3] Edinburgh Medical Journal, October, 1892.

ILFRACOMBE. A popular sea-side resort and climatic station in North Devonshire, England. Ilfracombe is situated near the mouth of the British Channel, and is surrounded by peculiar picturesque heights called "tors." The climate is bracing, but not mild and equable. It is less rainy, however, than at Torquay. The sanitation of the place is good. The rate of mortality is only about seventeen per thousand per annum. According to Black ("Watering Places of England"), Ilfracombe is "a good-sized seaport town, formed principally by one main street, about a mile long, running parallel with the sea-shore, and a harbor (formed by an inlet of the Bristol Channel), which is almost encircled by picturesque verdurous heights or tors. It is remarkable for a peculiar form of coast, rarely to be met with elsewhere in England. Beginning with the harbor of Ilfracombe itself, the land and sea together combine in making constant alternations of high, craggy, furze-crowned tors, in some cases almost overhanging the sea below, which precipitately break and give place to little bays or inlets, separating and varying what would otherwise be a continuous line of cliffs—thus allowing glimpses of the inland foliage beyond."

The bathing facilities are good, but there are no sands fit to stroll on. One of the features of the beach is a peculiar vaulted passage leading to two coves, one for ladies, the other for gentleman bathers. Interesting excursions abound in this section of Devon. The height of the season is from July to October. Ilfracombe is about six and a half hours by rail from London.

Edmund C. Wendt.

IMMUNITY, ARTIFICIAL. As will be seen from the article "Artificial Immunity" (p. 51), in Ehrlich's experiments upon the transmission of immunity, this observer found that immunity in the father has no influence upon the offspring: the offspring of a highly immune father are just as susceptible as those of a highly susceptible father. Immunity can only be transmitted by the mother, and this takes place in two ways: by intra-uterine transfer of immunity from the mother to the fœtus, and by extra-uterine transfer with the mother's milk. Moreover, the milk of an immunized animal will not only give immunity to the offspring of the animal herself, but can also be used by feeding or by subcutaneous injection to render other animals immune. Now, since the article above referred to was cast, and consequently after it was too late to make any additions, there have appeared two publications: one on the transmission of immunity by the male, and the other upon the variability in the immunizing power of the milk of an immunized animal. The first of these articles[1] goes to prove that in hydrophobia a male dog does transmit immunity to his offspring; this is in striking contrast to Ehrlich's results. It was shown that in rabies highly protected male dogs in two out of three cases transmitted a high degree of immunity to a part of a litter (two out of five in one case, and two out of four in the other). In the third case, where there were four puppies, there was no evidence of transmission at all. In those cases where immunity was transmitted the puppies resisted the inoculation of the spinal cord from a case of "street-rabies" under the dura mater. Animals died of hydrophobia in the check experiments. The three remaining puppies of the first experiment, and all four of the third, died of hydrophobia on subdural application of spinal cord from a case of street hydrophobia. The two puppies which died in the second experiment took the disease from inoculations under the dura with the "virus fixe," a more powerful virus than that of the street. The fathers of each of the litters of puppies were different, but all three were highly rabies-proof. The mothers were all normal, *i.e.*, not rabies-proof.

The small number of these observations and the conflicting results necessitate substantiation before the transmission of immunity from rabies by the male can be accepted as proven.

The other publication[2] referred to above gives the results of further tests of the power of the milk from the goat, which was given immunity from tetanus during and after gestation (mentioned under "Artificial Immunity" on p. 51). It shows that the power of the milk is subject to considerable fluctuation, depending upon the length of time that may have elapsed between the inoculation of the goat and the making of the tests. Some time after the goat had been inoculated it was found that its milk had 4,000 degrees immunizing power. The goat was then inoculated with 75 c.c. of a virulent tetanus culture, and showed no symptoms; but twenty-four hours after this inoculation the milk showed that its immunizing power had fallen to 1,000, and further tests showed that it remained at 1,000 for a day and then gradually rose, attaining a value of over 8,000 in eighteen days. It then gradually fell to below 4,000 in seventeen days, where it remained stationary.

The explanation given of this behavior is that at first some of the antitoxin contained in the milk had to be used to counteract the poison contained in the virulent culture injected into the animal, and this was followed by an over-production of antitoxin. In other words, it is an analogous process to the over-production of leucocytes following extensive destruction of these. Other processes of a similar nature are often met with in biological investigation.

In testing the value of the milk or blood-serum of a goat made immune from tetanus, it is seen from the above that the test must be made at least four or five weeks after the last inoculation, otherwise the result will not be uniform.

The antitoxin contained in the milk was obtained in a concentrated state by precipitation with ammonium

sulphate, dialysing in running water, and drying in vacuo at 35° C. There resulted a yellowish-white powder possessing powerful antitoxic properties.

Meade Bolton.

[1] Tizzoni und Centanni: Die Vererbung der Immunität gegen Rabies von dem Vater auf das Kind. Centralbl. f. Bakt., etc., Bd. xiii., No. 3.
[2] Brieger und Ehrlich: Beiträge zur Kenntniss der Milch-immunisirter Thiere, Zeitschr. f. Hygiene, etc., Bd. xiii., No. 2.

INFLUENZA. *Influenza* is an acute, self-limited, infectious fever, occurring in widely distributed epidemics, and characterized by catarrhal inflammation of the respiratory and gastro-intestinal mucosa, by profound nervous disturbances, and by extreme debility.

Synonyms.—Febris Catarrhalis; Epidemic Catarrhal Fever; La Grippe; Grip; Tac; Horion; La Dando; Ziep; Epidemischer Husten; Epidemischer Schnupfen; Schafhusten; Blitz Catarrh; Mödefieber; Mal Russe; Snufsjuka (Swedish); Qual-Tong (Chinese).

Many other synonyms, grave and humorous, might be listed which have been suggested by the peculiarities of various epidemics, the national characteristics of the people affected, or some fancied resemblance of the symptoms, but *influenza*, *la grippe*, or the Anglicised *grip*, have practically superseded all other names, in medical as well as lay circles.

Influenza is of Italian origin, and was probably first employed by the Italian savants to indicate the supposed occult influence of the stars over the course of the disease. Wolff states that it was first used by an Italian author, Gagliardi: "Parere sopra l'Influenza catarrale, che presentamente regna in Roma e stato ecclesiastico, Roma, 1733."

Other authorities, however, trace its origin to the English writers Pringle and Huxham, the latter of whom, in describing the epidemic of 1742–43, writes: "Quæ per totam Europam hoc vere sub nomine influenza grassata est."

The derivation of *la grippe* is likewise in doubt. Most authors refer its origin, and probably correctly, to the French, *agripper*—to seize, but others derive it from the Polish, *chrypka*, or *grypka*—hoarse. It came into general use in France during the epidemic of 1732 (Marigné: Description et traitement d'une affection catarrhale epidémique observée en 1732, vulgairement appellée la Grippe, 1776).

Historical Sketch.—Since the appearance of the fourth volume (1887) of this Reference Handbook, containing the brief article on *Influenza*, a series of epidemics has swept over the world, which, for rapidity of movement, extent of distribution, and numbers affected, rival any previous visitations of the disease. This series, which began in the fall of 1889, and which can hardly yet be spoken of as an event of the past, was the first general epidemic of la grippe since 1847–48, and really introduced the present generation of practitioners to a disease known to them only in history, and thus becomes one of the notable medical events of the latter half of the century.

Recurring at a time when the study of the infectious diseases was being pushed so zealously along bacteriological lines, and engaging in its study the ablest clinicians of every nation, it was confidently predicted that the mysterious problem of its nature and etiology would be speedily solved. While this prediction has not been fulfilled, our knowledge of epidemic influenza has been materially increased and necessitates a restatement here.

In this necessarily brief historical sketch we shall not attempt a complete chronological account of the epidemics of all ages but shall only allude to those which, from special incidents, mark an era in the progress of our knowledge, and endeavor to trace somewhat in detail the course of the recent epidemics of 1889–92.

Medical historians have interpreted the vague utterances of Hippocrates and Livy, referring to a disease which assumed epidemic proportions in 412 B.C., as the first written allusion to influenza.

Mention is made of an epidemic which prevailed extensively in the latter part of the sixth century, in which the prominent symptoms were headache, debility, cough, and an irresistible desire to yawn. Sneezing was usually the first symptom of the prevailing distemper, and the custom of calling down "God's blessing" upon one who was heard to sneeze is said to have originated at this time.

It is very probable, as maintained by many authors, that not a few of the general epidemics described in the earlier medical chronicles under various names (catarrhal fever, Italian fever, etc.), were epidemics of true influenza.

Parkes traces the disease back to the ninth century. In 827 and 876 epidemics in which cough was the most prominent symptom, and which also extended to domestic animals and birds, originated in Italy and spread rapidly over all Europe. The epidemic of 876 is said to have sadly discomfited the victorious army of Charlemagne on its return march from Italy.

But one epidemic, and that limited to Germany and France, is known to have occurred in the tenth century, after which the world apparently enjoyed immunity for about two hundred years.

Whatever may have been the nature of these early epidemics, our positive knowledge of influenza, according to Wilson, dates from the great visitation of 1510, which covered the whole of Europe and the British Islands, and was so general that "not a single family and scarce a person escaped it."

The epidemic of 1557, which appeared suddenly in Eastern Asia and spread rapidly to the West, was the first influenza epidemic which is known to have crossed the Atlantic to America. This pandemic was very severe in certain localities and was attended with a high mortality. Five thousand are said to have died in Delft alone within a short period.

During the past four hundred years there have been about seventy epidemics of grippe, one-half of which, from their widespread prevalence, deserve to be called pandemics.

The present century has experienced thirteen visitations; the last important one previous to 1889 was that of 1847, in which were stricken more than one-quarter of the population of London and Geneva, and fully one-half that of Paris.

The course of the later epidemics has been quite uniformly from east to west. It is, of course, only the general trend of the epidemic that can be followed, since every locality invaded becomes at once a new centre from which arms of infection reach out in every direction. With few exceptions, the later pandemics of influenza originated in Eastern Asia, where the disease may almost be said to be endemic. From this nidus they travelled westward across Russia, thence over Continental Europe and the British Isles, over the ocean to America, Australia, East Indies, until, like Puck's girdle, they circled the globe.

The epidemic of 1889–90 followed closely the beaten path. The first cases, of which we have knowledge, occurred in Bokhara, Central Asia, in May, 1889. The disease became quite prevalent in July, and following the lines of the new railways slowly invaded other portions of the Russian Empire.

The epidemic can be easily traced through Western Siberia and the post-towns and stations in Russia in its march toward St. Petersburg, which was reached by the end of October, and two weeks later it had assumed such startling proportions in that city as to attract the attention of the civilized world.

From St. Petersburg the epidemic spread with unprecedented rapidity, and the cities of Western Russia, Central and Northern Germany, Austria, France, and the British Islands became, in turn, the scene of its ravages, until by the end of December it had compassed the whole of Europe. Scattering cases announced the appearance of the disease in New York about the middle of December, and a week later it had assumed epidemic proportions. From the seaboard it extended in every direction, and during January, 1890, was generally diffused over the United States, British North America, the Sandwich Islands, and Central America (Guatemala.)

From its starting-point in Central Asia the epidemic also extended in a southeasterly direction. Malta, Cyprus, and Egypt were successively visited in January and February. It was reported from India in February, became epidemic in March, and prevailed extensively in Upper and Lower Birmah during April and May. It reached Arabia in April, many of the pilgrims arriving from India and the Straits having sickened on the voyage.

In the Southern hemisphere the course was from the south northward. Capetown was the seat of its first appearance in Africa, it having been carried thither by steamers; thence it extended northward, reaching Mauritius in August, the Shire Highlands in September, and Abyssinia in November, 1890.

South America was reached in February. Buenos Ayres was infected presumably by steamer from Bordeaux; thence it travelled up both coasts and prevailed in Brazil, Chili, and other States during April and May. It was notably severe in the province of Pernambuco. It was prevalent in Australia and New Zealand from March to July.

In Iceland it occurred in July, and in some remote places of China and Kashmir during September and December.

Dr. Parsons, in his exhaustive report to the British Medical Association, July, 1891, to which we are largely indebted for the facts above related, writes: "Thus assuming the epidemic to have started from Russia in October, it took about six weeks or two months to spread over Europe and reach North America, rather more than two months to reach the Cape, three months to reach South America, four months to reach India, five months to reach New Zealand and Australia, nine months to reach Iceland, ten months to reach Mauritius, and nearly a year to make some remote places in Africa and Asia."

During the summer and fall of 1890 influenza was "smouldering on," as shown by the numerous local outbreaks, usually of short duration, in different parts of the world.

The second general epidemic—1891—began in January, and was but little less extensive, and probably more fatal, than the one just sketched. It, too, was pandemic, but in the journey around the world the course of its predecessor was reversed, and the general trend was from west to east.

The origin of the epidemic is traced to New Orleans, where influenza prevailed extensively and fatally in January, and from which it radiated in every direction. During February, March, and April it spread over the Northern States and was notably severe in Pittsburg and Chicago (March) and the sea-board (April). It was reported from England in April, from Germany in August, from Scandinavia and Denmark in July, from Russia (St. Petersburg) in September, from France in October, from Italy in December, and thus passed from country to country until almost the whole civilized world had been revisited. This epidemic also ran its course in about one year.

Nature and Etiology.—It has been customary to consider influenza as an epidemic catarrhal fever, but recent *dénouements* have materially strengthened the belief, long entertained by some, that it is really an infectious nervous fever.

Many of the symptoms are most readily explicable upon a neural basis, while its probable bacterial origin, together with the knowledge of the toxæmias that usually attend upon bacterial infection, gives support to such an explanation. Much testimony has accumulated during the recent epidemics to show that the nervous symptoms are primary and are followed by secondary involvement of the respiratory and digestive organs. In a given case the pulmonary, gastro-intestinal, or cerebro-spinal symptoms predominate as the nervous apparatus of one or the other system bears the brunt of the disease.

Nervous symptoms are uniformly present and usually pronounced, even in the mildest forms of grippe, while, on the other hand, in many of the worst cases, catarrh of the mucous membranes and inflammation of the respiratory tract are totally absent.

Again, when catarrh and pneumonia are present, they frequently assume "such a peculiar character as to lead to the suspicion that they might arise from irritation of, or loss of power in, the various nervous mechanisms supplying the affected parts, and would therefore have to be looked upon more as vaso-motor and trophic neuroses than as ordinary catarrh and inflammation."

The histories of the various epidemics prove clearly that the disease is not dependent upon climate, soil, season, meteorological, or electrical conditions. It affects all classes of people, irrespective of nationality, sex, social position, or environment, although infants and young children seem to possess partial immunity. While no season of the year is exempt, late autumn and early winter are the periods of its greatest frequency.

The phenomena of influenza are only comprehensible upon the theory of a specific infecting virus or germ as the exciting cause. Its epidemic occurrence, transmission along lines of travel, rapid diffusion, sweeping over whole continents in a few weeks, and affecting nearly the entire population in a certain district in a few hours after its appearance, indicate some powerful morbific agent in the atmosphere which acts specifically upon the animal economy.

Some authors still cling to the theory that the morbific agent is a miasmatic material, but the most generally accepted doctrine, and the one most in accord with our knowledge of the etiology of other infectious diseases, is that which makes it dependent upon the presence of a micro-organism.

Notwithstanding the diligent search of bacteriologists during the past three years, working under the improved modern technique, but little is positively known about the morphology of the pathogenic bacillus and absolutely nothing about the chemical constitution of its special toxine. These investigations have uniformly disclosed the presence of the pyogenic bacteria and the diplococcus pneumoniæ, but it is not claimed that they bear a causal relation to the disease.

From time to time the discovery of the grippe microbe has been announced. But, like Weichelbaum's lancet-shaped diplococcus, Klebs's flagellatum, Jolly's cossack-shaped coccus, Kirschner's punctiform microbe, and Babes's radiated bacterium, each, in turn, has failed in the crucial test and has been relegated to obscurity, along with Saulsbury's infusoria and Seifert's micrococci.

It is again confidently announced that the true influenza bacillus has been, at last, successfully and independently demonstrated by Staff-Surgeon Richard Pfeiffer and Dr. Canon, of the Moabit Hospital, Berlin. According to these observers, it is a tiny rodlet of about the thickness and half the length of the bacillus of mouse-septicæmia. It is the smallest bacillus yet isolated, and is only recognizable during the first twenty-four hours by means of a lens, so that macroscopically a test-tube containing them can scarcely be distinguished from a sterile one. The bacilli are, however, readily differentiated by the peculiarity of their growth, as the colonies always remain separate and do not, like the colonies of all other species of bacteria, join together and form a continuous row. They have been found in large numbers in the blood, sputum, bronchial, and pleural exudations of influenza patients.

Dr. Kitasato has successfully cultivated the bacillus in glycerine-agar to the sixteenth generation. Inoculation experiments have been negative in some species of animals (guinea-pigs, pigeons, mice), but in others, notably monkeys and rabbits, have caused a disease simulating grippe in its main features. Letzereich, of Wiesbaden, has quite recently published an account of control experiments in fifty cases of infectious diseases, viz., measles, scarlet-fever, diphtheria, pneumonia, and catarrhal affections of the respiratory passages, in which in neither blood nor sputum was the Pfeiffer-Canon bacillus found.

Corroborative testimony comes from others high in authority like Professors Babes and Cornil, and even Koch himself is said to have given a partial endorsement to the claims made. It is premature, in the face of the dis-

appointments of the past, to give a positive opinion, but at present it looks as if the Pfeiffer-Canon-Kitasato bacillus were indeed the true pathogenetic microbe of epidemic influenza. Should this be confirmed it will add another to the brilliant triumphs of the present decade.

It is highly probable that the action of the morbific principle of grippe is not limited to man. Epizoötics, very similar in many respects to the epidemics in the human race, have often prevailed among domesticated and wild animals, especially horses, dogs, and cats.

The attention of the profession was first called to this fact by Huxham in connection with the epidemics of 1732–33. These epizoötics occur independently, but more often happen either simultaneously with, or immediately precede or follow, epidemics of influenza. Bartholow favors the view that the epidemic disease in animals is the parent of that in man, but is so modified by transition that each succeeding epidemic is milder and less aggressive.

The contagiousness of influenza has long been a mooted question. The doctrine that contagion is one method of its propagation has been strengthened by numerous observations made during the recent epidemics and is now fully accepted by most clinicians.

The frequency with which epidemics, both in their general and local distributions, follow the regular lines of travel, the immunity of isolated households and communities, and the frequency with which local outbreaks have been traced to their sources leave, indeed, little room for scepticism. The marvellous rapidity with which influenza sometimes spreads in a community once infected is readily accounted for by its remarkably short period of incubation. It is claimed by many that personal contact with infected individuals or materials is the only method of its propagation. The supporters of this doctrine contend that the dissemination of disease-germs through the air must have its limitations. That they can be carried thousands of miles in air-currents without dispersion or destruction, or the assumption, on the other hand, of a proliferation in the air itself, does violence to our knowledge of the life history of disease-germs. There are, however, too many irregularities in the behavior of grippe epidemics, not necessary to be enumerated here, to permit us to accept personal contact as the only factor in its propagation. Hirsch has pointed out that notwithstanding the modern facilities of inter-communication and rapid transit, epidemics do not travel more rapidly now than under the old regime.

The passengers and crews of ships which have sailed from non-infected ports, and have held no communication with other ships, have been repeatedly attacked in mid-ocean.

The following striking instance is related by Sir Thomas Watson: The frigate Stag anchored at Berry Head, on the Devonshire coast, all on board well, April 3, 1833, the very day on which Watson saw his first two cases of influenza in London. The breeze was off the land, and in half an hour after dropping anchor forty men were down with influenza; six hours later the number was increased to sixty, and soon reached one hundred and sixty.

The period of incubation is very variable, both in individual cases, and in different epidemics. It may develop almost immediately after exposure, from which it has received one of its popular names, *Lightning Catarrh*, *Blitz Catarrh*, but, in other instances, there is an incubation period, lasting from a few hours to several days.

The attack does not confer immunity from subsequent ones, and a few persons even experience a second seizure during the same epidemic. An epidemic, as a rule, lasts from four to eight weeks in a given locality, although many run a shorter course and often end as suddenly as they began. The rate of progress not only varies greatly in different epidemics, but also in the same epidemic as it spreads over different districts.

There is no causative relation between influenza and other epidemic or infectious diseases. The statement that prevalent infectious and contagious diseases abate in frequency and intensity upon the appearance of grippe, is not sustained by facts. Neither is there any ground for the popular belief that cholera follows in the wake of influenza. In some instances, notably in 1831, 1847, and 1856, the two diseases have been closely associated in point of time, but the official report of the French Commission fully endorses the conclusion of Gluge and Smolensky that the association was purely accidental.

Morbid Anatomy.—The anatomical lesions found after death give meagre information as to the pathology of influenza. A fatal termination is almost invariably due to some complication, and the structural changes found *post mortem* are characteristic of the secondary disease, and not of influenza. Death rarely occurs in uncomplicated cases. The lesions peculiar to influenza are almost exclusively localized upon the respiratory mucous membrane. The mucous lining of the larynx, trachea, and bronchial tubes is hyperæmic, swollen, and covered with frothy or viscid muco-pus. The catarrh may extend to the finer bronchi, but is ordinarily limited to the trachea and larger tubes. The bronchial glands are sometimes enlarged and softened. The gastric and intestinal mucous membrane is more or less congested in a considerable portion of the cases.

The solitary and agminate glands of the intestine are not usually implicated.

Kernig, of St. Petersburg, found the spleen enlarged in all cases which came under his care.

Symptoms.—The complexus of symptoms of influenza is exceedingly varied, and this variability extends not only to different epidemics, but also to individual cases of the same epidemic. In many cases the attack closely resembles an ordinary catarrh, with little fever and slight hyperæmia of the naso-pharyngeal mucosa; again, it assumes the form of an intense infectious fever, with profound involvement of the nervous centres, while between these extremes are found cases of almost every grade of severity, and almost every combination of symptoms.

Many attempts have been made to satisfactorily classify the protean forms of the disease. The classification most generally followed by recent writers, and which is a modification of that long ago proposed by Hufeland, is into:

1. The nervous form.
2. The catarrhal or respiratory form.
3. The gastro-intestinal form.

It is estimated that in the recent epidemics about fifty-five per cent. of the cases belonged to the nervous, thirty per cent. to the catarrhal, and fifteen per cent. to the gastro-intestinal form of the disease. These estimates will undoubtedly have to be changed for different localities. According to the observation of the writer, nervous symptoms predominated in about eighty-five per cent. of the cases in the epidemic of 1889–90, while in that of 1891, the catarrhal and gastric forms were more common and severe, but still constituted a small percentage of the cases. The division is, however, purely arbitrary, and finds its chief value in emphasizing the fact that the brunt of the attack may fall upon any one of the three great systems.

Influenza usually begins abruptly, but is occasionally preceded by a feeling of indisposition or malaise of from a few hours' to several days' duration. A distinct chill, or, oftener, a mere chilliness, is at once followed by a rise in temperature and the symptoms of a naso-pharyngeal catarrh, with cough, sore throat, frontal headache, pains in, and general soreness of, the limbs, depression of spirits, and sometimes with gastro-intestinal disturbances.

The fever is remittent in type, variable in intensity, rarely exceeds 104° F. in uncomplicated cases, and subsides by lysis, rather than by crisis. As a rule, the temperature reaches its maximum at the beginning or early in the attack, and often drops below normal during convalescence.

A subnormal temperature has also been noted by many during the progress of the disease, accompanied, usually, by surface coldness, feeble circulation, and other evidences of depression. The recent epidemics were peculiar in the large number of cases in which the fever

took on a continuous type, and persisted for two or three weeks, resembling, in many of its features, a mild typhoid fever.

Anomalous cases were also recorded in which the whole course of the disease was afebrile, and, according to Eichhorst, these were particularly liable to nervous explosions.

The pulse is moderately increased in frequency and changeable in rhythm and quality. The tendency to cardiac asthenia, so pronounced in grave cases, often becomes a serious menace in those of moderate severity. An extraordinary slowing of the pulse is sometimes observed. The pulse may only register in the forties or fifties and naturally excites fears of some cerebral complication. This abnormal retardation belongs to the natural history of the disease, although it is often erroneously attributed to remedies, especially if digitalis or other cardiac sedatives have been administered.

Coincidently with the fever, and sometimes preceding it, the symptoms of an acute catarrh of the upper air-passages are manifested.

There are frequent paroxysms of sneezing, a feeling of stuffiness in the head, the eyes are suffused and watery, and coryza with an abundant secretion of mucus speedily follows. The mucous membrane of the nose, mouth, frontal sinus, pharynx, and larynx is congested. The voice becomes hoarse or reduced to a whisper. Cough is rarely absent, usually severe, and recurs in paroxysms which harass the patient day and night. At first it is harsh and brassy and attended with a scanty muco-serous expectoration, which, as the disease progresses, becomes abundant, muco-purulent, and often blood-streaked.

Sharp pains in the sides and under the sternum, dyspnœa, and suffocative paroxysms are experienced, and, as was long ago pointed out by Graves, of Dublin, often without any recognizable intra-thoracic lesion. The catarrhal process does not, as a rule, extend below the larynx or trachea, but if it should invade the lower air-passages, the deepening of the symptoms at once announces the fact, and the illness assumes a more serious aspect.

Nervous symptoms are uniformly present, but vary greatly in intensity. In some epidemics, notably in 1889–90, they predominated over all other symptoms. Severe headache, usually frontal, and pain in the eyeballs are rarely absent. The head pain comes on suddenly, is nearly continuous, dull, and throbbing, with frequently recurring paroxysms of atrocious severity. It is exaggerated by pressure or movement, and is often associated with hyperæsthesia of the scalp and neck.

With the headache there is stiffness and soreness over the entire body, as if it had been beaten, and a backache which in its intensity is suggestive of dengue or small-pox.

The patient either lies perfectly quiet, to prevent the suffering which the slightest movement causes, or tosses restlessly about in the futile effort to find a position of comfort. Sharp neuralgic pains dart along the principal nerve-trunks, but show a decided preference for the trigeminal, intercostal, lumbo-abdominal, and sciatic nerves. These neuralgias are often intermittent, but do not exhibit the periodicity of ordinary malarial neuralgias.

Persistent insomnia or unrefreshing snatches of sleep filled with painful dreams add to the patient's distress. Delirium of a mild type is usually present, and is often marked when the fever is slight. In exceptional cases it becomes so furious as to overshadow all other symptoms. Coming on late in the disease it often announces the onset of some complication.

Vertigo, especially on rising, and muscular tremor are not uncommon. Convulsions and coma are rare, but may develop with the initial fever or at any subsequent period.

The extreme muscular weakness, amounting, at times, to a serious depression of the vital powers, is a peculiar feature of influenza. The debility is wholly disproportionate to the amount of fever, or the severity of the other symptoms, and generally reaches far into convalescence.

The mental condition harmonizes with the physical depression. When thoroughly under the grippe influence, the patient shrinks from mental as he does from physical exertion, is vacillating, foreboding, and often becomes a veritable "Jacques" in his melancholy.

While restlessness and wakefulness characterize most epidemics, others are equally marked by somnolence. Thus the remarkable epidemic of 1712 is known as the *sleeping sickness*, from the almost universal presence of this symptom.

The disturbances of the digestive organs are generally mild and consist of anorexia, coated tongue, epigastric tenderness, abdominal pains and constipation. Nausea and vomiting sometimes usher in the attack and may continue throughout its course. At times, the force of the disease is expended in the intestinal tract and causes severe colicky pains, tympanites, and obstinate diarrhœa. The stools, at first bilious and fetid, soon take on a dysenteric character or become large and watery, like the discharges of cholera nostras, and are accompanied with vomiting, leg-cramps, and rapid prostration. The digestion remains impaired for some time after the subsidence of the acute symptoms, and not only retards convalescence, but favors a return of the gastro-intestinal derangements upon the slightest indiscretion of diet.

The urine is scanty, high-colored, and contains abundant urates. Albumin with casts, hyaline and epithelial, are present in a limited number of cases not necessarily of the gravest type. The integrity of the kidneys is rarely permanently impaired. Cystitis is sometimes met with, and retention of urine in elderly persons is tolerably common.

The presence of an hemorrhagic tendency has been remarked by many observers.

Epistaxis and menorrhagia are the most, and cerebral hemorrhage the least common of the accidents dependent upon this tendency.

Eruptions are occasionally seen, of which herpes, urticaria, and erythema constitute the chief examples.

The disease attains its height on the second or third day and then rapidly declines, covering a period of from four to seven days in its full evolution; but in the graver cases, or in those disturbed by complications, recovery may be indefinitely delayed.

Convalescence is often announced by the appearance of some critical discharge, such as profuse sweating, a copious secretion of bronchial mucus, a free discharge of sedimentary urine, or a profuse diarrhœa.

After complete apyrexia has ensued, there is not infrequently a temporary return of the fever and other symptoms not dependent upon the presence of a complicating disorder. This new outbreak is usually of brief duration, and should be considered as an exacerbation, rather than a relapse. It is apt to appear on the fifth or seventh day of the disease, and is oftenest seen in those who have committed some error of diet or have undergone some exposure. True, relapses are, however, not uncommon or free from danger.

Complications and Sequelæ.—While there has been, of late, a tendency to exaggerate the frequency and importance of the complications and sequelæ of influenza, the fact remains that there is scarcely another disease so liable to intercurrent disorders or to serious after-effects. The more common of these are divisible into two groups: First, those which are the direct outgrowth of the lesions in the mucous membranes and parenchymatous tissues; and, second, the sensory-motor derangements, which result from the action of the grippe toxine upon the cerebro-spinal centres. Among the rarer affections belonging to the first group may be mentioned circumscribed ulceration of the vocal cords, abscess of the larynx, œdema of the glottis and paralysis of the muscles of the throat.

Otitis media is comparatively common. The inflammation does not, as a rule, proceed to suppuration, but is rebellious to treatment and occasionally ends in mastoiditis.

Bronchitis and pneumonitis are, by far, the most frequent and fatal complications of this group. Authors

have endeavored to show that these affections, when associated with influenza, are peculiar in nature and symptomatology. According to Elliott "the grip-lung has a long and very varying condition of passive blood-stasis unaccompanied by râles. If resolution occurs within three or four days, it is accompanied by large mucous râles, and no time is given for the slow appearance of bronchial breathing or bronchophony; but during the long-continuance of the blood-stasis an exudation occurs, increasing slowly, which will give in time some bronchophony and bronchial breathing, but never so complete as in pneumonia. Resolution never occurs in these cases with the suddenness that characterizes it in acute pneumonia. The condition passes off as gradually as it is formed. The sharp, clear-cut, and sudden phases of the pneumonia attack separate it clearly from the obscure, irregular and slow phases of the grip-lung."

Da Costa, in a recent clinical lecture, describes the characteristic influenza lung as one "in which intense congestion occurs, with patches of collapse and with spots of localized consolidation here and there, if consolidation happen at all. Yet there are instances in which real croupous pneumonia takes place, involving considerable portions of the lungs. But these are comparatively rare, and true lobar pneumonia is not nearly so characteristic of the influenza lung as the other form."

Osler, with whom the writer is in full accord, admits that pneumonitis complicating influenza sometimes runs an atypical and very obscure course, but these cases are exceptional, and all the anomalies mentioned by writers as peculiar to influenza are found in any large series of cases of pneumonia.

It is highly important to bear in mind what has been previously stated, that lung complications are liable to creep on insidiously, and that in the presence of anomalous symptoms, whether referred to the respiratory tract or not, the chest, as a matter of routine, should be carefully interrogated. Pleurisy and empyema are not uncommon complications. Abscess of the lung has been noted. That influenza bears an etiological relation to phthisis pulmonalis, especially in the presence of the disposition, can no longer be doubted. It is furthermore a matter of common observation that consumptives fare badly during the prevalence of the epidemic influence.

Watson and Curtin call attention to the fact that during the recent epidemics many chronic catarrhal cases where the lungs were involved resembled closely, and were often mistaken for, phthisis. There were present night-sweats, cough, diarrhœa, fever, and emaciation, while the physical signs also agreed with those of phthisis in all but dulness on percussion, which was absent. These writers in speaking of the relationship between phthisis and influenza make the following remarkable statements: "The catarrhal condition remains and causes a breaking down of lung-tissue. These cases, while presenting the physical signs of phthisis and terminating finally in death, showed during life, on examination of sputum, no bacilli. In the fall of 1890, in the Philadelphia Hospital, the sputa of fourteen cases of phthisis examined (several times and by different methods) for bacilli showed them abundant in four, few in six, absent in four cases. In the fall of 1891, after most of the old cases of phthisis had died, twelve out of twenty-eight cases were found free from bacilli, and invariably with histories dating from an influenzal attack."

The nervous disturbances which occur during and after grippe are equally important.

Althaus reflects the opinion of neurologists in the statement: "That as a powerful etiological factor of protean forms of nerve-disease influenza stands *facile princeps* among all infectious fevers."

The organic nervous diseases most frequently observed may be enumerated in the order of their frequency, as neuritis, meningitis, myelitis, and cerebritis.

Multiple neuritis is less common than the local forms, of which latter neuritis of the supra-orbital, intercostal, and sciatic nerves are oftenest met. But "isolated neuritis of almost every cranial nerve has been recorded with such resulting conditions as optic atrophy, loss of smell and taste, ophthalmoplegias, both internal and external, oculo-motor, facial, bulbar and pseudo-bulbar palsies of various types, including true pneumogastric paralysis" (Mills).

Lepto-meningitis (pia-arachnoid) and cerebro-spinal meningitis are the commonest types of meningeal inflammations.

Bristowe has reported two cases of cerebral abscess, and has seen others in which the symptoms would justify such a diagnosis.

Convulsions have been repeatedly observed, and, in a few instances, the epileptic habit has been permanently established. Mills has seen two cases.

Polio-myelitis anterior is the form of spinal cord disease most frequently associated with influenza. Temporary paralysis of one or more limbs, evidently of spinal origin, is occasionally seen. Abolition of the patellar reflex has been noted.

Neuralgic attacks, severe, persistent, and involving any of the nerve-trunks are, perhaps, the commonest of the post-influenzal neuroses. The rekindling of old and fading neuralgias during convalescence is another of the curious features of the disease.

Neurasthenia, both cerebral and spinal, hysteria and hystero-epilepsy, with their illimitable repertory of disease mimicries, were frequent sequels in the late epidemics.

Insanity is not rare. It usually takes the form of melancholia, with hypochondriacal or religious delusions and decided suicidal impulses. Leledy, Ladame, and others believe that influenza may act either as an exciting or as a predisposing cause, but that there is always an antecedent acquired or inherited predisposition. The onset is often sudden and bears no relation to the severity of the febrile attack. The insane are less disposed to contract grippe than the sane, and its occurrence is sometimes attended by a remission in the mental symptoms. Althaus also recognizes as a rare post-grippal neurosis a peculiarly rapid—galloping—form of general paralysis of the insane, of which he has seen a few examples.

Biermer, Gottschalk, and others remark upon the frequent occurrence of severe hemorrhagic endometritis. In these cases the uterus is enlarged and sensitive, and the hemorrhage profuse. It has long been known that women sick with influenza were subject to profuse and painful menstruation, and, on the other hand, that the menses were apt to return to those suffering from amenorrhœa. Pregnant women are liable to abort under the same conditions.

Prognosis.—Uncomplicated cases of influenza recover. The prognosis is modified somewhat by the character of the prevailing epidemic and the physical condition of those affected. The extremes of life and those debilitated by disease or vicious habits bear influenza badly. Infants are fortunately less likely than adults to contract the disease. The mortality is largely due to complications or to its development in those suffering from advanced pulmonary, cardiac, or renal affections.

Diagnosis.—Influenza is not likely to be mistaken in its epidemic form. The numbers affected, the fever, the catarrhal phenomena, the prominence of the nervous symptoms, and the rapid course will readily establish the diagnosis. Influenza bears a striking resemblance to non-specific catarrh caused by atmospheric changes, but it is only in those isolated cases which herald the approach of an epidemic that this similarity could mislead.

The only difficulty in diagnosis attaches to those cases occurring during the prevalence of an epidemic of grippe in which coryza is absent and the symptoms are those of a general fever. Some of these cases bear a striking resemblance to typhoid fever. The continued fever, delirium, epistaxis, diarrhœa, and prostration are common to both, but the temperature charts and progress of the diseases are very dissimilar.

In other cases the suddenness and violence of the on-

set, the variety and intensity of the nervous symptoms, and the irregular febrile movement are very like epidemic cerebro-spinal fever.

Dengue and the nervous type of influenza have many symptoms in common, but the former is preëminently a disease of tropical climates. In our own country it is confined to the Gulf States and rarely extends beyond the thirty-second parallel. Only once (1780) has it reached as far north as Philadelphia. It was at that time described by Dr. Rush under the name of bilious remitting fever.

TREATMENT.—Influenza is a self-limited disease of short duration. There is no specific and the treatment is largely symptomatic. In view of the many severe complications and sequelæ which may arise, every case should be regarded as serious enough to necessitate confinement, at least within doors, until the fever has disappeared. The experience of the late epidemics demonstrated that those who remained in bed from the beginning of the illness not only appreciably shortened the attack but made a pleasanter convalescence.

Rest in bed, a mild calomel purge or saline draught, cooling drinks, an occasional Dover's powder to quiet cough, and the employment of such general hygienic and dietetic measures as are indicated in acute infectious diseases will meet every indication in simple, uncomplicated cases.

In the futile search for a specific all of the leading remedies, new and old, received an extensive trial in the recent epidemics. The coal-tar derivatives—acetanilid, antipyrin, and phenacetin—were all extensively used, but phenacetin, from its greater safety and the absence of unpleasant after-effects, deservedly enjoyed the greatest popularity. Given early in the attack, it rarely failed to relieve the headache, lower the temperature, and lessen the muscular soreness and tired feeling. The writer obtained excellent results from its combination with quinine or salol and caffeine.

Salicin is an eligible remedy. It acts as a mild tonic, reduces temperature, excites perspiration, and relieves the gastro-intestinal irritation. Its taste is objectionable. Quinia in medium-sized doses may be advantageously given throughout the sickness but is especially indicated in the later stages and in delayed convalescence. When the head pain and muscular soreness are prominent the salicylate of cinchonidia is preferable to quinia, and is supposed to possess decided prophylactic powers. The insomnia, as a rule, readily yields to the bromides or chloralamid. The singularly depressing effects of grippe on the mental and physical powers strongly contraindicate the use of lowering measures and remedies. Stimulants, preferably some form of ammonia or alcohol, should be resorted to on the first evidence of failing strength. In the presence of great thoracic distress or heart-failure a timely use of the heart tonics, of which digitalis and caffeine are the best representatives, may avert the threatened danger. Strychnine alone, or in combination with tonics, is the most reliable drug with which to tone up the feeble heart so often left by grippe.

Gastro-intestinal irritation is best met with salicin, bismuth, resorcin, and the salicylates.

Local applications to the inflamed mucosa add greatly to the patient's comfort and favorably influence the course of the disease. In the writer's experience nothing gives such grateful relief as the occasional spraying of the throat and nose with a weak solution (one to two per cent.) of cocaine and menthol in benzoinol. A gargle of boracic acid or salicylate of soda in glycerine and water soothes the irritation of the mouth and throat. Dobell's solution in the form of spray, or the inhalation of steam, pure or medicated, with eucalyptus, creasote, or terebene, is of signal benefit in allaying the laryngeal and bronchial irritation. Troublesome cough is readily controlled by the old-fashioned Brown's mixture, or by small doses of codeine in syrup of wild cherry.

In the graver types of influenza, or when the course is anomalous, care must be taken not to overlook complications, which often, especially those of intra-thoracic origin, steal on insidiously. These must be managed according to the principles of treatment laid down on other pages of this HANDBOOK.

Delayed convalescence will call for a prolonged course of tonics, and, in many cases, for a temporary change of climate.

Little has been attempted in the way of prophylaxis. It has, however, been lately proposed, on account of its probable contagiousness, to isolate those suffering from the disease and to close the schools and places of public resort during an epidemic.

But the volatile nature of the pathogenous material and the remarkable rapidity with which influenza spreads—its whole career from inoculation to full development being only a matter of hours—will doubtless render abortive all attempts at quarantine.

It has been abundantly proven that during the prevalence of the epidemic influence those who are overfatigued or much exposed in the open air, especially at night, are more susceptible to the disease. The lesson to be drawn from this fact is obvious and should be heeded by the aged and debilitated.

Considerable testimony has been recently collected to show that vaccination with animal lymph furnishes immunity against influenza. Dr. Goldschmidt, of the Island of Madeira, was the first to call attention to this fact. The island suffered from a double invasion of small-pox and grippe, and in investigating the relationship between the two diseases he ascertained that out of 112 persons successfully revaccinated not one contracted influenza; and of 98 in whom revaccination was attempted but failed, only 15 showed any symptoms of the disease. In an isolated villa there were 27 inhabitants, of whom 12 had been recently vaccinated. These all escaped, but the 15 who had not been vaccinated were affected. Althaus, who strongly advocates the protective power of vaccination, refers to illustrations which came to his knowledge, in which small clusters of recently vaccinated persons remained untouched, although surrounded by and freely mingling with grippe-stricken people. The well-known immunity of children is likewise attributed to the protective influence of vaccination. It is stated that in the German army, where revaccination is systematically enforced, influenza was less prevalent and less fatal than in civil life. While influenza affected forty-two per cent. of the population of Berlin, and about sixty-four per cent. of that of Paris, its prevalence in the German Army amounted to only a little more than eleven per cent. A number of garrisons were entirely spared while the inhabitants of the adjacent towns suffered severely, and it is further stated that no garrison was ever affected with influenza when the civil population escaped. When an outbreak did occur in a military post it was found that those affected were almost exclusively soldiers who had not been recently revaccinated. And, finally, statistics show that the average duration of the disease is shorter, complications less frequent, and the death-rate lower in military than in civil life. Further developments in the prophylaxis of influenza will be awaited with interest.

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INSANITY OF PUBERTY AND ADOLESCENCE.

The only addition of importance to what has already been said in the body of this work upon the developmental insanities, viz., climacteric and senile insanity and the insanity of puberty and adolescence, relates to the latter class. In fact, the pathology of the insanity of puberty has become a favorite study of late years through the growing recognition of the profound influence of the state of growth upon the rise, nature, progress, and future of mental disease in the individual.

Hereditary Influence.—We are largely indebted to Clouston for stimulating inquiry in this direction. He is now prepared to state very strongly, as the result of his experience and careful inquiries into family histories of individual cases in which there was an opportunity of obtaining reliable facts, that practically without exception the typical clinical case of adolescent insanity (of the kind described, for example, on p. 128, Vol. IV., of this HANDBOOK) has in his or her ancestry, immediate or collateral, one of the following neuroses, in the following order of frequency:

1. Insanity.
2. Neurotic instability.
3. Intemperance amounting to dipsomania.
4. Epilepsy.
5. Hereditary tuberculosis.
6. General diseases of the nervous system.
7. Congenital imbecility or idiocy.

He finds such hereditary predisposition in forty-five per cent. among adolescents, while but twenty-three per cent. of other cases are thus handicapped.

Our division of the insanities of puberty and adolescence into several groups, according to the various manifestations of mental disease in this transitional epoch, viz., the genuine hebephrenia of Hecker, stupor, hysterical, and masturbatory insanity, receives support and further development in a comparatively recent investigation of the insanity of puberty by Mairet, particularly in the matter of stupor, which, as we have pointed out, occurs almost exclusively in adolescents.

Stupor.—Clinical observation shows, he finds, that puberty can give rise to insanity, and that the insanity of puberty has not always the same clinical signs. Accordingly this form may be subdivided into insanity of puberty with arrest of intellectual development, and simple insanity of puberty. The latter may appear under several different forms: Melancholic stupor, choreic mania or maniacal chorea, impulsive mania, and hysterical mania.

The form of stupor which he describes as peculiar to puberty is identical with stuporous insanity (so-called acute dementia), as distinguished from true melancholic stupor, and merits more ample description than we have accorded it.[1] In three out of seven cases Mairet found puberty to be the sole predisposing cause, while its action was favored in the remaining four by hereditary predisposition. The sex also plays a conspicuous rôle in the causation, as most of the subjects are females. Onanism and mental overwork are occasional factors. Sometimes there is no apparent cause, the stupor appearing suddenly and unexpectedly. A common exciting cause is a moral one, such as crime or other disgrace.

There is usually a prodromic period marked by a variety of nervous and general symptoms, chiefly chlorosis and irregular menstruation in girls, and by physical fatigue, palpitations, and cerebral hyperæmia in men. The onset of the stupor of puberty is usually sudden, and in most cases is manifested by hallucinations, ideas of fear, and intense maniacal excitement. Sometimes these symptoms are accompanied by fever of an ataxo-dynamic character. Rarely, stupor itself begins the attack. Hysterical manifestations may also appear before or with the excitement. Ideas of grandeur may take the place of those of fear. The early physical symptoms are refusal of food, sordes, dry tongue, and constipation due to rapid exhaustion. The circulation is poor, and sometimes sensation is much diminished. This period lasts but a short time, sometimes only a few days, but generally several weeks, to give way to a new phase which is the essence of the disorder, *stupor*. The change is usually gradual, the hallucinations slowly disappearing, and the stupor growing more profound. The patient stands motionless wherever he may happen to be, the head bent, the arms hanging limp. The saliva escapes from his mouth, and his evacuations are passed involuntarily and unnoticed. All food is refused and there seems to be no sensation of hunger. The patient answers no questions and cannot be aroused. That he feels and even hears is sometimes evidenced, however, by his turning his head to the questioner. The circulation is retarded, the heart-sounds clear but feeble, and the pulse more or less rapid, small, compressible, and excitable. The extremities are cold and, perhaps, œdematous. The temperature is below normal. Menstruation is suspended. Sensation is much diminished, but not abolished. The general and cerebral nutrition is lessened. Although thus plunged in stupor, the patient may suddenly have an attack of excitement. Oftentimes this is limited to violent laughter, lasting ten minutes or a quarter of an hour, without any apparent knowledge on the part of the patient why he does so. At other times the disturbance is more general, and then the patient will cry, repeat monotonously the same words, or more often the same sounds, to dance, etc., while the dull, heavy condition persists. Other patients perform ridiculous acts, such as swimming movements, contortions, etc., or else they suddenly throw themselves upon others and beat them, and soon fall back into stupor. These attacks are produced quickly and are of short duration, from a quarter of an hour to an hour, to reappear after a time. The period of stupor, the principal feature of the disorder, lasts from several weeks to as many months. It is a most favorable form of insanity in respect to recovery, which takes place gradually as a rule. It is impossible to confound this with any other form of mental alienation. It is sometimes distinguished with difficulty from the melancholy, with stupor of older patients, but differs therefrom chiefly in the severity of the onset and the rapidity of the emaciation.

CHOREIC INSANITY (OR "MANIACAL CHOREA.")—The insanity which accompanies acute chorea also belongs to this period of life, is of pubescent or adolescent nature, and belongs exclusively to the group under consideration. All the cases of insanity associated with acute chorea on record have occurred within the pubescent and adolescent period, between the ages of thirteen and twenty-three. Most of them have the mental or nervous predisposition, inherited or acquired, so common in the insanity of puberty, and all of them, as a rule, have manifested one or other of the physical ailments common to this critical period, viz.: anæmia, chlorosis, scanty menstruation, pallor, palpitation of the heart, headache, etc. It is now generally recognized that chorea in some form is almost invariably associated with mental changes varying from simple impairment of memory, unusual and extensive irritability, etc., to acute mania or dementia. It is equally a fact that chorea is in its most developed state at this period, and that the accompanying mental manifestations are most marked and peculiar, the severe, dangerous, and fatal cases occurring then. It is also noticeable that in almost every case the choreic and mental symptoms appear and subside at about the same time, thus giving proof by evolution also of the close alliance of the two diseases. This intimate union can only be explained by community of origin, chorea and insanity being two independent branches from the same trunk. Consequently, when we find chorea, essentially a disease of growth, intimately

united in youth with mental disorder, the pubescent nature of that insanity is evident. As the acute forms of both disorders do not appear *together* at any other time of life, choreic insanity, or maniacal chorea, plainly belongs in the category of insanity of puberty and adolescence.

The choreic form of adolescent insanity is more common in the male sex, and heredity plays a more prominent part than in the other varieties. Of the prodromic period cephalalgia is the most frequent and important symptom. Irritability and mental confusion, or change in disposition and insomnia, are present.

The onset is generally abrupt, following close upon the exciting cause. Usually the choreic and mental symptoms appear at about the same time—either the chorea precedes the psychical trouble, as in a case reported by Thore, or the psychical change takes precedence, of which the case to be described later is an example. With the onset may appear delusions or hallucinations which may later dominate the scene. In our case the peculiar nature of the initiatory excitement shows their presence, although none were expressed. Insomnia and nightmare are common. Fever is not an uncommon accompaniment at this stage. The chorea, whether general or localized, reaches its height early in the attack, which is usually not the case with the insanity. The choreic movements also are almost invariably increased during the mental agitation.

The next and principal stage is that of choreic mania, which may be either simple or hallucinatory. The maniacal condition is the same, as a rule, as that of ordinary mania, except perhaps for its marked irritability. The patient may become readily aggressive even when not excited, or, as in our case, he may present a marked condition of hebetude and mental incoherence. These patients are at times, like others of the adolescent class, poetical and dramatic in speech and writing, as well as vain and declamatory. The attacks of agitation in the more marked and characteristic cases consist in running, jumping, leaping, shouting, nightmares, etc. They are also apt to be especially destructive and homicidal. These attacks are almost always spasmodic and impulsive, and are sometimes followed by a state of mental and bodily weakness. Sometimes the attacks are not prompted by hallucinations, as is evidenced by the accounts given by recovered patients; but as a rule they spring from hallucinations and delusions chiefly of the nature of fear.

The duration of acute choreic insanity is very variable, usually several months, but occasionally it lasts as many years. One of Mairet's cases recovered in four years.

The prognosis is comparatively good, but less so than that of the stupor of this period, perhaps because the hereditary predisposition is greater in this form. The following case presents most of the usual features of the disorder, but the severe motor symptoms so far predominated as to mask the mental manifestations, and perhaps even to take the place of, or prevent, the characteristic maniacal outbursts. It properly belongs, as we have said, to the other class, represented by the cases whose condition is that of hebetude and mental incoherence.

W. W——, married, twenty-three years of age, was admitted to the West Riding Asylum February 18, 1882. The certifying physicians stated that the patient was a violent lunatic and gave the following facts: 1. "Talks incoherently, taking no notice of any questions put to him." 2. Relatives report that, "he will sit for hours without speaking." The family physician stated: "He is by nature eccentric in his habits and inclined to be self-willed. Just before the attack he became depressed in spirits, irritable and suspicious of those about him. During the attack he was sometimes violent, sometimes depressed, but had lucid intervals; raved indifferently on various subjects, and would strike with great violence indiscriminately." The patient was brought to the asylum securely bound in a strait-waistcoat which was reinforced by heavy leathern straps. As soon as he was freed from restraint he was seen to be suffering from severe chorea. He was placed in a padded room and became much quieter.

Previous History.—Nothing satisfactory to be learned as to hereditary predisposition. No personal history of convulsions or rheumatism. Had been rather delicate, and had an attack of pleurisy with inflammation of the lungs several years before. His domestic circumstances had been satisfactory. Just before and ever since his marriage, six months before admission, he had worked very hard at his trade, carving and gilding. About four weeks before admission he was obliged to leave his work on account of severe continuous and general cephalalgia, which confined him to bed for two weeks. At this time alteration in his manner and conduct became for the first time noticeable. He was dull, preoccupied, and reticent, appeared dazed and indifferent to his condition and surroundings. Later he returned to his work and seemed "like himself" in every way. A week later he returned home in a confused state of mind and soon became delirious. For the next two days he was much excited, refusing to go to bed or to take food, threatening to throw himself out of the window, and weeping at trifles. No hallucinations or delusions appear to have been expressed. Just after the excitement became pronounced he began to wriggle about, contort his face, protrude his tongue, etc. This disturbance subsided in a day or two. He then conversed freely and naturally, and said that he had fallen in attempting to board a horse-car just before his attack came on, but did not meet with any injury; that he then became confused and wandered about the town a long time before he could find his home. Three days before his admission, when supposed to be rapidly convalescing, his former condition returned with renewed intensity, being ushered in by rapid and disconnected talk. From this time he became very unmanageable and his movements so energetic that he was with difficulty prevented from falling out of bed. His knuckles and elbows were also abraded from contact with the wall. He showed at this time no disposition to violence.

Physical Appearance.—Pale and emaciated. Pupils dilated, the right excessively so and only slightly responsive to light. All his voluntary muscles appear to be affected with chorea. He incessantly writhes and plunges about the bed, tosses his arms, clinches his fists, contorts the face, etc. Abrasions on knuckles and elbows. Skin over sacrum reddened, and on the tongue an ulcer, a quarter of an inch in diameter, caused by biting. Pulse, 140, and of fair strength. Heart and lungs normal; appetite fair. He passes his evacuations in bed.

Mental Condition.—Though questioned in an interval of comparative calmness, the patient can evidently make nothing of what is said to him. He is ignorant of where he is, why he is here, how long he has been here. He makes incoherent, nonsensical replies to the simplest questions, but protrudes his tongue when asked. Expression lost and wondering. During sleep there have been slight movements of the upper extremities and head occasionally.

February 23d to 26th.—Distinct improvement on the whole. The choreic movements are now absent during sleep. By day he is occasionally quite still, and although there is at present much movement of the head and facial muscles, he has been quite free from spasm. A small eschar has formed over the sacrum, and the abrasions on the elbows and hands are inflamed. Is fed by the attendant with soft food, but has great difficulty in properly masticating it. Still irrational and incoherent. He talks in a whisper as if conversing with someone, and most disconnectedly. Says he is in "Fletcher's Mills."

March 4th.—He is not still a minute at a time, but the movements are now confined to the face and upper extremities. He talks in a low tone most of the time. Occasionally he jerks out a sensible reply after evidently trying to collect his thoughts, but soon wanders off onto a variety of subjects.

March 8th.—He is quieter, but still scowls and rolls about somewhat. Touching any part seems to excite muscular contraction. Still unable to concentrate his thoughts or to keep them in the right channel, just as he fails to direct his muscular movements properly after

making a good beginning. He can tell the time and answer simple questions, when roused and made to apply his mind. Still passes his evacuations in bed. Bedsore deep.

March 11th to 19th.—There is but little mental improvement, although the patient is generally free from morbid movements. He often starts up and looks about him, muttering disconnectedly. He replies to a simple question: "They were laughing at me—either jump over here or over there." Allows the medicine to drool from his mouth without attempting to swallow. Gives an occasional rational answer after much pressing. Still unclean in his habits.

March 26th.—The patient has been for some time entirely free from choreic movement. Sits up most of the day. Has become clean in his habits. Whole expression brighter. Answers simple questions correctly, but not readily. Still starts wonderingly when addressed, and makes strenuous but vain attempts to understand and reply. A fortnight later the patient had, in great measure, recovered his intelligence. He recognized his surroundings and that his mind had been deranged. His memory had become nearly restored, but he was still confused and wandering in manner, and his ideas were not perfectly coherent. Expression rather perplexed and vacant. Was still pale and thin. Appetite and sleep, excellent. Gait fairly steady. Bedsore healed. Three weeks later, he was discharged, recovered. There was some elevation of temperature during the three weeks immediately following his admission, but never rising above 101.3° F.

It is well in conclusion to re-group the insanities of this period, giving precedence to more characteristic varieties, as follows:

INSANITIES OF PUBERTY AND ADOLESCENCE.

Pure Forms.

Occurring only in youth and essentially of the adolescent type.	Hebephrenia. Acute Choreic Insanity. Stupor.

Mixed Forms.

Occurring usually but not exclusively in young people.	Hysterical Insanity. Masturbatory Insanity.

The reader is referred to the contributions of Mairet[2] to this subject, from which we have quoted in this article, as well as Clouston's exhaustive lectures on the "Neuroses of Development," for further study of this subject.

Henry R. Stedman.

[1] REFERENCE HANDBOOK MEDICAL SCIENCES, Vol. IV., p. 127.
[2] Annales Médico-psychologiques, vol. viii., 1888, and vols. ix. and x. of 1889.

INSANITY, THE PHYSICAL EXPRESSION OF.

I. INTRODUCTORY AND RETROSPECTIVE.

Francis Warner has defined expression to be "the outward indication of some inherent property or function." All outward muscular movements, whether of the face, trunk, or extremities, succeed definite functional activity of some portion of the central nervous system. This larger use of the word expression is comparatively recent. Muscular movement as an index of cell activity within the encephalon is the latest advancement that physiognomical science has made. Viewed in this light, physical expression deserves serious study. Particularly does the physical expression of the insane merit investigation, for it must be presupposed that any disturbance of function in the central nervous mechanism would be quite likely to be reflected in perverted muscular movement at the periphery.

Previous to the present century study of physical expression was limited to the face. Now, while it is true that the expression of the emotions receives its most perfect and frequent demonstration in the facial region, it must not be forgotten that the entire muscular periphery is likewise a participant. The same physiological processes underlie the manifold, subtle, and delicate movements of the facial muscles as well as the more palpable movements of the muscles of the trunk and extremities. The physiological basis of the gesticulations accompanying ordinary conversation, as well as the more finished gestures of the orator, is undoubtedly the same. All explorers among barbarous tribes give interesting reports of this language of signs. Stanley's observation of the gesticulations of the tribes in Central Africa, as well as the statements of the early discoverers and settlers of America, confirm this idea that there is a sign language common to all races of men. This in turn implies that the functional activities of the central nerve-mechanism are the same, both in savage and civilized races, and affords interesting proof of the unity of the human race.

Correct physiognomical knowledge, therefore, depends on a proper understanding of the physiology of the central nervous mechanism. Ignorance as to the functions of the brain and cord led the earlier writers into the most absurd interpretations. Even so shrewd an observer as Aristotle attempted to explain the physiognomy of man by a system of meaningless analogies. Fancied resemblances to wild animals, such as a broad expanse of chest and shoulders, and certain conditions of the hair and beard were supposed to indicate the possession of certain qualities of mind, such as bravery, energy, and the like.

It is not to be wondered at that the ancients, with their limited knowledge of physiology, should have entertained crude notions concerning the meaning of facial expression. Undoubtedly they were familiar with anatomy, but the subtle connection between the central innervating organ and the external muscular apparatus was entirely unknown to them. To have perceived in a general way that a certain cast of countenance was associated with a peculiar mental development was the utmost advance that their limited knowledge of animal physiology would allow. Hence, though they excelled in copying, they singularly failed in explaining nature. And, as is often the case, the domain that properly belongs to science was, through ignorance, relegated to charlatanism. Analysis of the human countenance was given over chiefly to soothsayers and magicians, who attempted no rational explanation of the various muscular movements of the face, but who pretended to read therein certain prognostications for the future.

It is interesting to trace the gradual development of physiognomic science from the earliest times to the present, and to notice how gradually correct physiological knowledge was attended by broader and more intelligent views as to the real meaning of physical expression. Nothing could be more absurd and childish than the vagaries of the ancient writers upon this subject, nearly all of whom either thought that expression was due to the mysterious influence upon the brain of certain abdominal vapors, or that the Aristotleian doctrine of resemblances gave the correct clue to the expression of the emotions.

Throughout the Middle Ages the study of the physiognomy became so identified with astrology and chirology as to lose even what loose scientific value it had previously attained. Mantegazza calls the seventeenth century the golden age of astrological physiognomy. "Then more than ever," he says, "did men have a passion for mysterious things, for mysteries which have a scientific appearance." The countenance and the heavens were mapped out, and not only character, but future events in the life of the individual were supposed to be prognosticated from a comparison between the lines of the face and the position of the stars in the sky.

G. B. Porta, of Naples, whose work "Della fisonomia dell'uomo" was published in 1627, did much toward severing the absurd connection between physiognomy and astrology that had arisen during the Middle Ages. He was nevertheless a strong believer in the doctrine of resemblances, and his comparisons of the heads of men with those of birds and lower animals are amusing illustrations of the extent to which a blind subservience to a theory may lead one. Notwithstanding the absurdity of many of his comparisons, he still deserves great credit as

being one of the first writers that attempted to trace a tangible relationship between the countenance and the mental and moral development of the individual. De la Chambre followed Porta in 1660, with his "L'Art de connaitre les Hommes," in which he showed a tendency to explain the countenance and its changes in a more rational way.

In 1747 James Parsons, M.D., delivered a short course in the Croonian Lectures on Muscular Motion. These were published in the Philosophical Transactions under the title, "Human Physiognomy Explained." This work, though quite short, is deserving of great praise, for it was a very sincere attempt at explaining facial expression in a more intelligent manner. He endeavored to refer the expression of the countenance to muscular movements in that locality, and by a series of plates sought to establish a relationship between the movements of certain facial muscles and specific states of mind. "The muscles," he says, "are the true agents of every passion of the mind, and the basis upon which our doctrine is founded." The soundness of his views is quite remarkable, and his essay is a prominent landmark in the progress of physiognomic science. The following quotation from his Lectures will meet with the approval of modern physiology: "First, every person has a particular bent or disposition of mind, which oftener reigns in him than any other; secondly, that this habitual disposition, causing the muscles of the face that are destined to express it frequently to act in obedience to that bent of mind, brings on at length an habitual appearance of that passion in the face, and moulds it into a constant consent with the mind. In the course of my own acquaintance, I know some persons who wear on their countenances a constant cheerfulness, complacency, and openness; and by experience I know it to be their continual disposition of mind; and on the other hand, I do know of some on whose faces a settled moroseness always strikes the beholder, and know it to be their own constant plague and that of those among whom they come."

After the appearance of Parsons's Lectures nothing of any especial worth was published until the year 1783, when Lavater, a Swiss clergyman, published his "Essays on Physiognomy Destined to Promote the Love and the Knowledge of Mankind." Lavater was an enthusiast on his subject, and it is remarkable that, being neither a physician nor an anatomist, he should have advanced views at once so much in accord with modern physiological and anatomical knowledge. He struck the keynote of a sound physiognomic science when he declared that outward expression was but the reflection of what was within, that it was the outward effect of an inner cause. He says: "There is not a living being which does not, at least after its manner, draw some inferences from the external to the internal; which does not judge concerning that which is not by that which is apparent to the senses. This universal though tacit confession that the exterior, the visible, the superficies of objects indicate their nature, their properties, and that every outward sign is the symbol of some inherent quality, I hold to be equally certain and important to the science of physiognomy."

Lavater, being a shrewd and acute observer, was not misled by mere resemblances to infer similarity of disposition and character. He recognized the incorrectness of the ancient method of comparing resemblances, and says, "What the great Aristotle has written on physiognomy appears to me extremely superficial, useless, and often self-contradictory, especially his general reasoning." Of Porta, the Italian physiognomist, he says: "He might more effectually have examined the excessive dissimilarity than the very small and almost imperceptible resemblances which can exist." And again: "It is singular enough that he has also compared the heads of men and birds. He speaks little concerning the horse, elephant, and monkey, though it is certain that these animals have the most resemblance to man." By recognizing the fact that the cranium bore some relation in size and external configuration to its contents, and that in proportion as one ascends the scale of animal life important modifications are met with in the size and shape of the skull, he tacitly admitted the relation between the cranium and the cerebrum, and the relationship between the development of the latter and facial expression.

In an article on "Medicinal Semiotics," Lavater suggests the influence upon expression of pathological conditions. Many physicians, from Hippocrates to his time, had accurately described the characteristic facies of disease, and yet few of them realized the physiological and pathological import of what they so faithfully described. Lavater, though not a physician, still inferred that the peculiar facies of different diseases suggests certain changed physiological conditions in the patients themselves. Lavater very nearly touched the true explanation of facial expression.

It is an interesting coincidence that while the Swiss clergyman Lavater was writing his views of physiognomy, at nearly the same time, and in another country, the Dutch physician Camper was working out a theory of physiognomy in nearly the same channel. As might be expected, the physician and anatomist, from his knowledge of the different parts of the body and their physiological relation to each other, would be more likely to arrive at a comprehensive and exact theory than a layman. He clearly enunciated the correct physiological theory of physical expression when he said: "As dissecting of human bodies has been my constant occupation, I have had frequent opportunities of examining which of the nerves, communicating with these more active parts, must have been particularly affected; consequently which of the muscles must have been excited to action by these nerves; and from the action of these muscles depending upon their origins and insertions, course and connections, we may easily learn what pleats in the face, what kind of action in the hands, and so forth, they must necessarily occasion."

The next writer connecting the latter part of the last century with the present time is Sir Charles Bell, famous as the discoverer of the motor and sensitive nerves. Bell, by his accurate anatomical knowledge of the nerves, laid the foundation for all that has been written during the present century upon the subject of physiognomy. He first cleared away the confusion which had hitherto surrounded the anatomy of the cerebral and spinal nerves, and traced these nerves definitely to their terminations and origins. He demonstrated clearly the mechanism of facial expression. The physiology of reflex and automatic action, as well as the important functions sustained by the centres of the cerebral cortex, both in the motor and intellectual activities of life, had scarcely come to be understood in his day, otherwise he would have perceived that the causes of expression in man and the lower animals are often the same; that in each nervous energy is liberated from the cells within the central nervous mechanism, and subsequently transmitted along the nerve-channels to their terminations in muscular structure; that the difference between the causes of expression in man and the lower animals is really less than he imagined, being a difference in degree rather than in kind, and due rather to complexity of structure attained in the cerebral cortex of man.

Dr. G. B. Duchenne's "Mechanism of the Human Physiognomy," published in 1862, was an ingenious and interesting attempt to demonstrate the mechanism of facial expression. By the aid of the two poles of a battery Duchenne sought to isolate certain facial muscles, and by causing them to act independently of the others, produce artificially the expressions caused by the natural action of these same muscles. It seems questionable, however, whether the action of the electric fluid upon the nervous filaments in the face is precisely similar to the action of the nervous centres within the brain upon these same nervous and muscular tracts. In fact it is very doubtful whether the action upon the muscular periphery of the feelings, such as grief, joy, disgust, and the like, is of the same quality and intensity as that produced by the cells of a galvanic battery. Again, it is very questionable whether the actual results which he has shown in a series

of photographs are faithful representations of the various states of mind ascribed to them. The field is one in which the author's imagination may very easily lead him astray. Having formed a preconceived idea of what a certain artificially produced expression may mean, it is very easy to recognize that particular expression. But one who has not previously read the author's description of the plate may, as Darwin says, very easily conceive it to mean something else.

Pierre Gratiolet's lectures, delivered at the Sorbonne, and published in 1865, were a valuable addition to the subject, and particularly interesting because they were the first contribution recognizing that physiognomical changes were only a part of a wider series of muscular movements in other parts of the body. Previous to the appearance of these lectures all writers upon the physiognomy limited their studies to the facial region, but Gratiolet saw that muscular movements of other parts than the face entered into expression. In his "De la Physiognomie et des Mouvements d'Expression" he says: "The face is not the only portion of the body capable of expressing the feelings; on the contrary, the hand, the foot of man and animals, the tail of certain carnivora such as dogs and cats, have expressions that cannot be misunderstood. We may add that there is no movement that does not represent expression and follow the laws of expression."

In 1872 was published Darwin's "Expression of the Emotions in Man and Animals." Darwin, with the clear insight of the naturalist, fully recognized the meaning of facial expression, or more properly, physical expression. Both in man and the lower animals he perceived that the various muscular movements of expression, whether occurring in the face or in the extremities, were merely the outward reflection of interior states of the central nervous system. His wonderful acquaintance with animal life, reinforced by the vast amount of material accumulated during his busy life, makes his work an exceedingly interesting and instructive one. As Mantegazza says, "with his large and comprehensive spirit he traced the general laws which govern expression in the entire animal kingdom. His work is one of the most splendid monuments raised by his genius, and one can say without exaggeration that expression, as far as it is a special branch of comparative biology, was established as a new science only in the work published in 1872."

In 1885 was published "La Physionomie et les Sentiments," by Mantegazza, and in 1886 "Physical Expression," by Dr. F. Warner. Both volumes are a fitting conclusion and summary to all that had previously appeared upon this subject, and a pertinent introduction to the various modifications of physical expression in insanity. A clear understanding of the mechanism of physical expression and close observation of the insane, demonstrate the physiological laws of cause and effect underlying the remarkable changes in expression that occur in various stages of insanity.

II. The Mechanism and Physiology of Expression.

In man the central nervous system has reached its highest development. Beginning with the lowest and most rudimentary forms of animal life, a single centre with afferent and efferent nerve-tracts leading to and from the muscular periphery, is typical of nervous structure throughout the animal kingdom. Becoming more and more complex as we ascend the scale of animal life, in man this nervous structure attains vast complexity. In him the central nervous system is composed of intricate series of cells connected with each other, layer upon layer, the areas above being connected with those below, and so specialized that different areas have specific functions, and yet all subject to control of the cortical gray matter.

Three factors enter into the Mechanism of Expression:

I. The storage and discharge of nerve-force from the central nervous system.

II. The power of inhibition possessed by the cerebral cortex.

III. The trophic changes consequent upon the processes of waste and repair that are constantly occurring in the cerebral cells.

I. *The storage and discharge of nerve-force from the central nervous system.* Physiological and anatomical data lead to the conviction that the mysterious property known as *nerve-force* or *energy* is in some way identified with functional activity of the cerebral cortex, and that, after leaving the cortex, its route is downward to the corpora striata and thence onward through the crura, the corpora quadrigemina, the pons varolii, and the medulla to the peripheral muscles. However it may be modified by the structure through which it passes, there is little doubt that this is the route. Exactly what this nerve-force is would be difficult to say. It is undoubtedly a form of energy, and the nervous system is the special region in which its manifestations may be studied. In some respects it is singularly analogous to that mysterious energy which is now being utilized in manifold ways in the daily life of mankind. Like the electrical fluid, it is invisible and realized rather by what it accomplishes than by any recognizable attribute.

The cortex cerebri seems to be the goal to which are referred all sensations received from without through the various channels of sense. Such sensations are gathered up by the different expansions and terminations of innumerable afferent nerve-filaments in the organs of special sense, like the eye and ear, or in the infinitesimal fibres of the nerves of touch in the skin, and are passed on through various afferent nerve-tracts to the ganglia in the optic thalami, where they are in some way modified and transferred to the cortex, there to serve as stimuli, not only to higher intellectual action, but to the generation of nerve-force. The cortex is, therefore, the objective point toward which all sensations received from without are directed. It is undoubtedly the seat of all intellectual processes and the great reservoir of nerve-energy.

However imperfectly we can define this nerve-force, there is no doubt that it conforms to the law of "Conservation of Force or Energy," which is recognizable everywhere in the great natural world about us. In accordance with this well-known law, either the energy, force, or whatever we may choose to call it, will remain stored up as potential energy, or it will be distributed and appear in some more active form as motion. Ganot says: "When the form of a body is changed by the action of forces, either the work done against the internal forces will remain stored up as potential energy, as in a compressed spring, or will have been replaced by the development of an equivalent of heat. Now, this being premised, we see that the energy communicated to any body, or system of bodies, is withdrawn from some fund of energy previously existing; thus, the energy communicated to the piston of a steam-engine is withdrawn from the heat of the steam; we also see that of the energy thus communicated none is destroyed, but is merely distributed, and exists either as potential energy or as motion of the bodies acted upon, or has been replaced by an equivalent of heat. This fact is called the conservation of force, or more properly, the conservation of energy" (Ganot: "Elementary Treatise on Physics," p. 40). In accordance with this same law the actual forces in the world about us, such as the waves of light and sound, and the ponderability and resistance of bodies with which we may come in contact, all these natural forces are transmitted to the cortex through the various channels of sense; there they are not lost but merely transformed into potential energy, which either remains stored up in the delicate nerve-centres of this region, or, on being liberated and distributed along different efferent routes, appears at the periphery as muscular movement. The comparison with the storage of steam within the boiler is not inapt. Such an accumulation of force must be relieved. In the case of the boiler, the steam, which represents the force, must be liberated at the safety-valve or converted into heat or power; and, in the case of the brain, the potential energy received through the various sensory channels must seek relief through the different

efferent outlets which have their termination in the muscles. Hence muscular movement, in other words, physical expression, is the one universal method by which the higher brain-cells are relieved of their stored energy.

Darwin thus admirably describes this generation and liberation of nerve-energy:

"A sensitive nerve when irritated transmits some influence to the nerve-cell whence it proceeds; and this transmits its influence, first to the corresponding nerve-cell on the opposite side of the body, and then upward and downward along the cerebro-spinal column to other nerve-cells, to a greater or less extent, according to the strength of the excitement; so that, ultimately, the whole nervous system may be affected. This involuntary transmission of nerve-force may or may not be accompanied by consciousness. Why the irritation of a nerve-cell should generate or liberate nerve-force is not known; but that this is the case seems to be the conclusion arrived at by all the greatest physiologists, such as Müller, Virchow, Bernard, etc. As Mr. Herbert Spencer remarks, it may be received as an 'unquestionable truth that, at any moment, the existing quantity of liberated nerve-force, which in an inscrutable way produces in us the state we call feeling, *must* expend itself in some direction—*must* generate an equivalent manifestation of force somewhere;' so that, when the cerebro-spinal system is highly excited, and nerve-force is liberated in excess, it may be expended in intense sensations, active thought, violent movements, or increased activity of the glands. Mr. Spencer further maintains that an 'overflow of nerve-force, undirected by any motive, will manifestly take the most habitual routes, and, if these do not suffice, will next overflow into the less habitual ones.' Consequently the facial and respiratory muscles, which are the most used, will be apt to be first brought into action; then those of the upper extremities, next those of the lower, and finally those of the whole body."

The cortex is therefore quite constantly excited by the various stimuli transmitted to it from the ganglia of the optic thalami, and just as constantly is it sending forth activities through innumerable efferent nerve-channels to the ganglia of the corpora striata, there to be newly arranged and organized before being transmitted to the tracts at the base of the brain and thence to the various muscles. The cortex, therefore, plays a most important part in all the motor activities of life. It is the great storehouse of nerve-force, as well as the seat of all intellectual action. In a certain sense the brain is a great reflex organ; it is continually receiving stimuli from without, which act as excitants to its various centres, and these centres, in obedience to the stimulations received from without, are constantly discharging nerve-energy which may be measured and realized in the countless motor activities that go to make up the life of mankind. Nerve-energy is in part, therefore, measured by muscular activity. And thus physical expression becomes one of the important agencies by which we estimate the nerve-force and vitality of the individual. It will be interesting subsequently to observe how normal and healthy physical expression is perverted by the various functional and organic conditions of the brain in insanity.

This discharge of nerve-force from the brain is either voluntary or involuntary. All the muscular movements that enter into the daily life of man come under one class or the other. It is needless to enter into the much-discussed question as to whether independent motor centres exist in the anterior convolutions of the cortex. The important fact to be remembered is that nerve-force passes down from the cortex to the corpus striatum, and whether it is essentially motor in character before or after it leaves the cortex or corpus striatum, the route followed by it from the cortical centres to the peripheral muscle is always downward through the structures mentioned; and another interesting fact is that automatic and habitual movements become retained, or *organized*, as the physiologists say, in the corpora striata. It is now considered that all the ordinary movements of daily life, such as walking and the like, and many muscular movements of complex character which have been acquired by hard and constant application, are at last permanently organized in the corpora striata, so that, by a single effort of the will, their easy and almost unconscious performance may be elicited.

Many purely reflex, as well as acquired, muscular movements are undoubtedly effected through the action of the optic thalami and the corpora striata without once calling upon the higher centres in the cortex. Sensory impressions are received in the centres of the thalamus, and excite into activity certain centres in the corpus striatum, and, as a result, certain muscular movements ensue. Such movements are purely reflex and automatic, and are often independent of volition and consciousness. Undoubtedly this purely automatic action of the basal ganglia, entirely independent of the cortical centres, is of more common occurrence among the lower animals than in man. Still there are many instances on record now to prove that many most complicated acts have been performed by men at a time when their consciousness and volition—in other words, the centres in the cortex—were entirely in abeyance or quiescent.

On this point Ferrier says: "In man, however, the shorter circle through the optic thalami and corpora striata does not appear sufficient, for the interruption of the conscious circle through the hemispheres by lesion of the cortical motor centres produces paralysis of a very complete and enduring character.

"This goes far to show that even the most habitual, or even the most automatic, actions of man require the co-operation of the centres of conscious activity, a view which is taken and strongly argued by Dr. Ireland.

"But though the basal ganglia may not, of themselves, suffice for the execution of the habitual movements of man, there is every reason for believing that they do so to a large extent, from the fact that the performance of habitual actions exercises but little interference with the conscious activity of the hemispheres in other directions.

"We may express it thus, that in actions requiring conscious discrimination and voluntary effort the larger circle of the hemispheres is involved, but that in the actions which have become habitual and automatic the larger circle is greatly relieved by the organic nexus between impression and action which has been established between the sensory and motor basal ganglia. The optic thalami and corpora striata form thus a sensory-motor mechanism, according to the views of Dr. Carpenter. I would use the term, however, only in the generic sense of afferent-efferent, it having been shown that sensation, or consciousness of impressions, is not a function of the optic thalami. Hence the reaction between the optic thalami and the corpora striata, being below the domain of consciousness, is outside the sphere of psychical activity, properly so-called" (Ferrier, "Functions of the Brain," chap. x.).

Just as the ordinary habitual movements of daily life become organized in the corpora striata and only await the proper stimulus for their elicitation, so has Ferrier advanced the theory that the co-ordination of sensory impression with the mechanism of emotional expression is situated in the corpora quadrigemina. He says: "The foregoing considerations on the relations between the phenomena of irritation and destruction of the corpora quadrigemina, though in many respects professedly of a hypothetical nature, tend to support the view that these ganglia are the centres specially concerned in the reflex expressions of feeling or emotion. This is rendered still more probable by the recently demonstrated influence which the corpora quadrigemina, or, more properly, the deeper parts of the corpora quadrigemina, exert on the functions of circulation and respiration, modifications of which are one of the most frequent concomitants of states of feeling or emotion" (Ibid., chap. v., p. 83).

It is worthy of note also that the third and fourth pair of cranial nerves, as well as the sensory roots of the fifth pair, have their origin in the corpora quadrigemina. All these nerves play a certain part in facial expression. The third nerve, both by its action on the muscles of the eye-

ball and by its connection with the iris, exerts a more or less prominent influence on the changes of facial expression. In like manner the fifth nerve, though chiefly sensory, still by its motor distribution to the pterygoid, masseter, and temporal muscles, is in some degree influential in certain pathological states of expression.

Chief among the factors in physical expression, and particularly in facial expression, is what physiologists have called *muscular tonicity*. It is that condition of the muscles by which a continuous, normal tension is maintained, and is undoubtedly due to the constant transmission of nerve-force from the cerebral centres through various efferent paths to the muscular periphery. This particular discharge of nerve-energy is purely involuntary, and is not recognized in the individual consciousness. Duchenne, in his "Mécanisme de la Physionomie humaine," speaking of *tonicité musculaire*, says that this force never sleeps, that it never ceases, except at death, and that by means of it that equipoise and natural equilibrium of the facial muscles is kept up which constitutes the natural and distinctive physiognomy of the individual. "It is thus," he says, "that the physiognomy in repose is established, the individual physiognomy which consequently ought to be the reflection of our habitual sentiments, the facies of our passions." Mantegazza, also, in "La Physionomie et les Sentiments," refers to this constant innervation of the muscles that enters so largely into healthy expression, and contributes to what he calls the *vivacity* of the muscles. "This vivacity of the countenance," he says, "is the signal that the nerve-centres are in the best possible condition." And again, "The good face, or the countenance of health, means that the physiognomy expresses a good general nutrition, an excellent chemical composition of the blood, and a powerful and well-balanced innervation."

Impairment of muscular tonicity is one cause of the changed expression among the insane. Organic and even functional disease of the cortex quite frequently impairs this transmission of nerve-force from the brain to the muscles which, as we have seen in health, should be constant, of uniform strength, and not intermittent. Our meagre knowledge of the pathology of insanity confirms the inference that *normal* muscular tonicity is produced by a certain constant action maintained by the higher cerebral centres upon the terminal muscular expansions; that the nerve-force is stored up in the cortical centres, and that it is undergoing continuous discharge and distribution to the innumerable deep and superficial muscles of the body.

II. *The power of inhibition possessed by the cerebral cortex.* Besides being a repository of nerve-force, the cortex undoubtedly exercises an inhibitory function, not only over its own centres, but more particularly upon those below them. The whole subject of inhibition is of great importance in any discussion of physical expression, and will be considered more in detail in the following chapter on the physical expression of the insane. Briefly, inhibition is the power of restraining nerve-function which one part of the brain or nervous system possesses over some other part. Many physiological and pathological facts suggest the idea that the chief inhibitory centres are located in the cortex. Study of the physical expression of the insane confirms this view.

In some diseased conditions central irritability is so great and the power of healthy inhibition so slight, that all manner of purposeless movements ensue. Chorea and certain states of mania and melancholia illustrate this. The irregular, spasmodic, and useless muscular movements that characterize these and other diseases of the central nervous system are due to the uninhibited discharge of nerve-force from the higher brain-centres. In health the restraining of all such excessive and meaningless discharge seems to be one very important function of the cortex. But even in health it is noticeable that this power of inhibition varies with the growth and development of the individual, being stronger at one time in the life of the same individual than at another, and even varying with the health and strength of the person. This subnormal inhibition is of common occurrence in so-called "nervous" people. Such persons are characterized by excess of muscular movement, quite often by extravagances of speech, though not sufficiently extreme to be called pathological. Finally, this power of healthy inhibition is modified greatly by hereditary influence.

The inhibitory and co ordinating power possessed by the higher nerve-centres in the brain is slight in infancy, and increases with age and development. The infinite random and meaningless movements of the infant's arms, legs, and facial muscles in response to external stimuli, are only so many outlets for nerve-force unchecked by inhibition and co-ordination. They constitute the physical expression of the infant, and illustrate perfectly its automatic and reflex character. Meynert says: "In consequence of irradiation and the lack of cortical inhibition upon the subcortical gray substance, we find in the child imperfect mimical expression; and in its stead we have pronounced spasmodic contractions, which, according to the spirit of the observer, are interpreted either as laughing or crying. The same is true of those afflicted with *dementia paralytica*" ("Psychiatry," Am. Trans., Appendix, p. 273). Defective inhibition, due to organic or functional disease of the cortex, is one of the chief factors of the morbid physical expression of the insane. Excessive and needless movements of the various muscles of the face and body may be due in the child to the imperfect development of the inhibitory centres, or in the adult to pathological conditions of these same centres; or among adults we may find those in whom healthy inhibitory power has never been developed, simply from lack of proper training in childhood.

III. *The trophic changes consequent upon the processes of waste and repair that are constantly occurring in the cerebral cells.* The entire question of cell waste and nutrition is imperfectly understood. There is no doubt that this branch of cerebral dynamics will receive constantly increasing attention from the physiologist and pathologist of the future. This process by which the cell stores up energy, which in some mysterious way it abstracts from the external world and then liberates through efferent tracts to the muscular system, is an admirable illustration of the law of "Convertibility of Forces." Not one of the forces of nature is lost; it is simply transformed and appears in some other form. But while the cell is engaged in this delicate process still another series of changes is taking place within its own structure, the process of waste and repair. No more delicate adjustment exists in the entire natural world than this equilibration that is maintained in the normal cerebral cell. The slightest disturbance in the protoplasm means impairment of function. This impairment of function, due to primary nutritional defect in the cell, may appear at the periphery as imperfect muscular tonicity, or in impaired nutrition of external parts, or in sluggish and irregular muscular movement. As Warner says, "It appears probable that a very distinct analogy may be made between series of movements and series of acts of growth, and that similar laws may govern both" ("Physical Expression," p. 81). Both "trophic action" and "kinetic action" are the expression of cell activity in the central nerve-mechanism.

Concerning the importance of the cerebral cell, Dr. Lewis says: "We may safely exalt the nerve-cell to a position of the very highest importance in our problems of mind. It is on this account highly important that the nerve-cell of the cerebral cortex should be the subject of careful study by all interested in psychological medicine, and that due attention should be paid to the conditioning of its functional activities, and to the results of its nutritional impairment, disease, and death.

"Suspended within a sac in direct connection with the lymph-channels surrounding the blood-vessels, or rather its own special nutrient capillary, the nerve-cell becomes liable to any influence, however trivial, disturbing the blood-stream in its neighborhood. A quickened circulation, a retarded flow, an anæmic state of the cortex must influence the functional activity of these centres of feeling and thought. A vitiated quality of the blood, or the presence of toxic agents introduced from without, or

elaborated within, the economy will affect them in a greater or less degree, while the activity of the lymph connective system in the removal of the effete products of functional wear and tear will play an all-important *rôle* in the same direction" ("Text-Book of Mental Diseases," p. 484. W. Bevan Lewis). Likewise Dr. Edward Cowles, in the Shattuck Lecture for 1891, bears excellent testimony to the train of symptoms following "weakness and toxic irritation of the central mechanism" ("Shattuck Lecture for 1891," p. 52). Thus it happens that nutritional changes hereditarily pre-established in the cerebral cell, or initiated therein by overwork and neglect of the laws of health, become reflected outward in the physical expression of the individual. Clinical illustration is abundant among the insane; but of this more hereafter.

Finally, it may be said that physical expression (and particularly that portion that is circumscribed by the facial region) is largely automatic, for the most part involuntary, and that it is developed in an entirely mechanical way. It belongs to the large class of reflex movements, and is one of the ways in which stimulations initiated within a central organ, or communicated to it from without, are reflected outward along certain nerve-tracts to terminal muscular attachments. The expression of the emotions, for instance, may be referred back to certain broad fundamental principles that obtain in the lowest radiata as well as in man. Physiologists are quite well agreed that the various emotions seek expression in muscular movements that are either defensive or sympathetic in character. Meynert says: "As movements of expression vary with the emotions, these movements must be either of an aggressive or repulsive character. We will find, with regard to the child in particular, that all physiognomic phenomena come under these two heads" (Meynert: "Psychiatry," Appendix). It is in obedience to this fundamental principle that the jelly-fish approaches toward and endeavors to enclose whatever is agreeable in the way of food, and contracts from and repels whatever is disagreeable in character. In like manner man, though in an infinitely more complex way, as might be inferred from his highly complicated and specialized nervous mechanism, draws near or touches whatever is pleasing, and shrinks from or repels whatever is displeasing. The principle in either case is the same, though in man the mechanism through which the feelings are expressed, as well as the feelings themselves, have become so complex that the original physiological principle is nearly lost sight of.

Individual expression, then, is a variable quantity, developing and changing with the growth of the person, and varying with his moods. In infancy physical expression is simple in character, is limited to innumerable reflex movements which, in the main, are sympathetic or defensive. At this age nerve-force is generated and liberated along different efferent routes, with little restraint. Soon after, or even during early infancy, inhibitory power is developed in the cortical centres, and nerve-force is conserved for future use. Undoubtedly, in earliest childhood muscular tonicity is established by the continuous normal discharge of nerve-force from the cerebral cortex over the shortest and easiest, and for that very reason, the most habitual routes to the muscular periphery. This tonic action of the cerebral cells, which gives to each countenance its characteristic expression, unquestionably receives a powerful influence through heredity. This transmission of the cerebral cell-structure to offspring explains the similar expressions so often seen in different members of the same family. Hereditary transmission plus the inhibitory influences that are developed by education, discipline, and the many attritions of civilized life, modify the tonic action of the cerebral cells upon the facial and other muscles, so that when adult life is reached an individual acquires that expression of maturity that is peculiar to him. It is difficult to define just what it is, and how this mature expression of the adult differs from a certain unfinished and undeveloped expression of childhood and early youth: there is, however, a vast difference in the facial expression of an individual in these two periods of his life, and there can be no doubt that the mature expression of adult life depends upon, or corresponds to, a modification of the cell-structure of the cerebrum. Even in early infancy a wonderful change is noticed in the facial expression during the first few weeks and months of infancy, illustrate perfectly the outward nerve-muscular manifestations which correspond to an inner development. Muscular movements, at first only fleeting, by constant repetition become habitual and permanent. In this mechanical way will heredity, the social, intellectual, and moral life of the individual mould the physiognomy.

An explanation is here found for those singular reversions in old age to certain family expressions which have characterized parents, uncles, aunts, or grandparents. Conolly thus refers to this interesting fact: "On the other hand, persons of ardent dispositions, who have worn all through their active years the physiognomy of an excitable mind, sometimes lose by degrees all this muscular agitation, and as they descend into the calm twilight of age, revert in appearance to that of parents or uncles or aunts still remembered by friends of the family. After death the face often exhibits these resemblances; and, above all, the placidity which human events can disturb no more. When there are exceptions to this, and the countenance bears in the latest years of life the stamp of mean or angry sentiments, which sometimes indeed shock our observation even in the coffin, the effect seems to be a result of the habitual impress of such feelings on the muscular part of the physiognomy during the greater part of life, with few or no benign alternations" ("The Physiognomy of Insanity," by John Conolly, M.D., *Med. Times and Gazette*, May 15, 1858, page 498).

Quite striking and interesting is the change that is sometimes witnessed in the faces of the chronic insane after death. In the faces of these cases there seems to be a partial reversion toward former and more natural expression at the time when death puts an end to the diseased action of the brain cells. Such cases will, after life is extinct, look more natural and more like their former selves, so their old friends say, than they have appeared for years. It would seem that in these cases a strong individual expression had been attained through the influences of heredity and early training, which had been modified for many years by the perverted motor action due to slight pathological changes of the brain, but which expression had returned immediately upon the cessation of the diseased action of the cerebral centres. On two or three occasions within my own experience, when I felt regret for the sad change of countenance that the friends must see in the face of some patient about to die, and who, for years, had been afflicted with chronic alienation, I have been singularly surprised to see how much better the face appeared after death. Certain lines of expression, and a peculiarly unpleasant cast of countenance that I had been accustomed to see for years, and to regard as habitual, had entirely vanished with the cessation of life, and a completely different and, to me, new expression (but which the friends recognized as characteristic of a condition of mental health in bygone years), had taken its place. This singular phenomenon was noticed by Dickens in "Little Dorrit." The Father of the Marshalsea says: "Unless my face when I am dead subsides into the long-departed look, they say such things happen, I don't know, my children will never have seen me."

The study of the physical expression of the insane enables one to observe the mechanism of expression from a pathological stand-point, and yields still further confirmatory evidence of the reflex and involuntary character of expression in general.

III. The Physical Expression of Insanity.

Knowledge of the mechanism of facial expression in health suggests the inference that the physiognomy must be variously modified by disease. If individual expression be due to a close functional relationship between

activity of the cell-structure of the encephalon and muscular movement at the periphery, it is evident that diseased conditions of the central nervous system must in some way exert an influence upon the physiognomy.

Gowers, following in the line of Hughlings Jackson's investigation, to the effect "that the whole brain is made up of structures which subserve sensory-motor processes, and that into such processes all its functions may be resolved," adds, "but that every structure of the brain concerned with sensation proper is connected, directly or indirectly, with a part concerned with motion, may be regarded as a proposition scarcely needing proof." According to this theory the motor disturbances in epilepsy are due to morbid functional conditions in the convolutions, thus demonstrating a most intimate relationship between peripheral muscular movement and diseased cell-activity in the cortex.

In epilepsy an illustration is presented of great motor disturbance and marked alteration of the physiognomy, due to some powerful temporary interruption of healthy cell action in the convolutions. In insanity, and many other allied morbid states, additional opportunity is afforded for observing still further physiognomical alterations due to morbid, though more persistent, changes in the nerve-centres of the convolutions.

Indeed, it is interesting to note, in this connection, the remarkable influence that habitual mental and moral conditions exert upon the physiognomy. Certain types of character are apt to be associated with a certain configuration of countenance. So universally has this been observed, and so frequently have certain mental and moral traits been associated with peculiar facial expressions, that artists and dramatic actors have represented their characters with this or that cast of countenance according to the character of the individual they wish to portray. We often say of the person whom we may pass on the crowded street of a city that he has an ugly face, and we feel quite confident that he may be a man of low, brutal instincts; or, meeting another person, we say of him that his countenance is that of a noble, high-minded individual. Note the faces of the convict class in our prisons and penitentiaries; they are nearly all of them unpleasant to look upon, and many are positively repulsive. The photographs of noted criminals present few features that are attractive.

The physiological reason for this individuality of expression undoubtedly lies in the fact that the expressions oftenest repeated in the face are those most likely to remain, and in time these become the predominant expressions which individualize the countenance. Hence the criminal, in quite a mechanical and involuntary way, establishes what we recognize as a criminal countenance; men of high moral sentiments, and noble, generous impulses, acquire a certain permanent facial expression associated with these more ennobling sentiments. Undoubtedly, specific cell changes within the cerebral centres correspond to these variations in personal character, and have their indices in the face.

In this connection it is interesting to notice the methods of great dramatic readers and actors. These attain their marvellous perfection in the portrayal of their assumed characters, not by studying their attitudes and facial expression before a mirror, but by a process of intense abstraction they lose themselves and become identified with the assumed character to the degree which produces in their appropriate brain-centres conditions identical with those which are real in the characters they represent. The difference is this: in the one the expression is the reflex of real character, while in the other imagination and the power of abstraction throw the brain-centres, for the time being, into the same physiological state which, through muscular channels, is reflected in the countenance and attitudes.

Few possess this great gift, and the difference between the common actor and the great histrionic masters is that the former are usually mere mechanical imitators, while the latter absorb, in the way described, the character they seek to portray, and, for the time being, think, breathe, act, and live in the assumed part. Who that has seen Salvini impersonate Othello has not felt, at moments in the progress of the play, that it was the real Othello whom he saw and heard speak, and not Salvini? And in the wondrous play of his features how plainly could the English auditor read the thoughts and feelings of the Moor, and interpret the words of the great tragedian, though unfamiliar with the language in which they were spoken.

The association of a lower grade of physical health with permanent and fixed criminal tendencies is not always imaginary. Many habitual criminals have been born of unhealthy or intemperate parents, and have spent the formative and growing part of their lives amid hygienic surroundings and conditions that were well calculated to stunt all healthy physical development. Stevenson, in the most interesting psychological study, Dr. Jekyll and Mr. Hyde, recognized this association of evil qualities with defective physical organization, and a healthier and more robust constitution with a more noble and generous character. Hyde was stunted, dwarfish, and anæmic; Jekyll larger, well proportioned, and ruddy. The impression which Hyde left upon the lawyer's mind is not an unusual occurrence. "The lawyer stood a while when Mr. Hyde had left him, the picture of disquietude. Then he began slowly to mount the street, pausing every step or two and putting his hand to his brow like a man in mental perplexity. The problem he was thus debating as he walked was one of a class that is rarely solved. Mr. Hyde was pale and dwarfish, he gave an impression of deformity without any namable malformation, he had a displeasing smile, he had borne himself to the lawyer with a sort of murderous mixture of timidity and boldness, and he spoke with a husky, whispering, and somewhat broken voice. All these were points against him, but not all of these together could explain the hitherto unknown disgust, loathing, and fear with which Mr. Utterson regarded him. 'There must be something else,' said the perplexed gentleman. 'There is something more if I could find a name for it. God bless me, the man seems hardly human! Something troglodytic, shall we say? or can it be the old story of Dr. Fell; or is it the mere radiance of a foul soul that thus transpires through and transfigures its clay continent?'"

These various types of countenance have a new interest to the psychologist when he considers them from a physiological point of view. The defective, ill-nurtured brain may not lead the individual into insanity, but may, even in spite of proper early training, develop a criminal tendency and character. In either case, however, the cortex by its intimate connection with the motor centres below it, and through them with the muscular periphery, is quite certain to modify in some way the muscular play of the countenance. We need not wonder, then, at the hardened, coarse features of the criminal, for during his whole lifetime the higher centres in the brain have received but little active development, his entire life has been animal and sensuous; and in the absence of any exercise of the higher mental faculties there have never been implanted in his countenance those more refined and elevated expressions that are the outgrowth of the moral and intellectual life.

Incapable of anatomical demonstration as this may seem to be, there can be but little doubt that the higher mental faculties do seek expression through activity of the cortical centres; and inasmuch as we know that diseased conditions of these cortical centres do very materially modify facial expression, the inference is reasonable that the unpleasant facial expression of criminals has a physiological foundation in certain structural conditions within the cerebrum.

The illustrated volume by Inspector Thomas Byrnes, of New York, entitled "Professional Criminals of America," is quite interesting to the physiognomist. With few exceptions, the portraits represent men of hardened character, and their countenances give strong evidence of entire lack of sympathy with whatever is ennobling and elevating in life. The expression of their eyes is either furtive and treacherous, or suspicious, or else bold

and brazen. Their mouth and lower jaw bespeak the grasping, selfish, animal life they lead. As might be expected, the faces of women malefactors give evidence of the most striking degeneration; there is little left in their bold, coarse features to remind one of the gentler, more sympathetic qualities of their sex.

It is interesting to note how facial expression, among criminals even, is modified by the degree of intelligence of the individual. The shrewd, well-informed, ingenious bank burglar, possesses a very different face from the low-lived, more ignorant river thief. As Inspector Byrnes says, the latter "are as hard-looking brutes as can be found;" while the former may not only be modest and gentlemanly in appearance, but even people of considerable education. It is quite evident that these latter are the exception, and that they owe their finer countenance to their intelligence and intellectual ability, as well as to a certain moral development; for it must be borne in mind that many of these professional burglars live dual lives. Men of this class often have homes and children whom they are educating in good schools. The ties of affection exist as strongly in them as among men of correct life. It is not difficult in their cases, therefore, to account for an improvement in the type of the criminal countenance.

Occasionally there appears one of those strange moral monstrosities in whom much shrewdness and even intellectual ability is associated with an entire absence of conscience. Such individuals, while keeping up a show of moral and social respectability, may all the while be entertaining the most criminal plans. As a rule, the facial expression of such persons is unpleasant, and their features reveal the more purely sensuous life they are living, as well as the character of the impulses which direct their daily thoughts and actions. These unfortunate beings usually manifest a persistent tendency to develop a morbid passion for cruelty or crime of some sort, and this in spite of any careful early training in the right direction which they may have received.

To this class belong such cases as that of William B——, reported by Dr. Clarke in the *Journal of Insanity* for July 1886; and by Dr. Hack Tuke, in the *Journal of Mental Science* for October, 1885.

E. H. Rulloff, executed at Binghamton, N. Y., and whose case was reported in the *Journal of Insanity* for April, 1872, is another illustration of this same class. He possessed certain remarkable intellectual accomplishments, but seemed entirely devoid of any moral sensibility. Unfortunately no photograph of his face during life could be obtained, while those taken of the plaster-cast made after his death are deficient in details. Dr. Burr, of Binghamton, in a paper, on Rulloff, read before the Medico-Legal Society, September 14, 1871, makes some remarks upon this notorious criminal's general appearance which are so pertinent to the subject under discussion that, in lieu of a photograph, I cannot forbear quoting them. He says: "His countenance when in repose was stolid and indifferent; when giving vent to his frequent ebullitions of passion, it was repulsive and forbidding; but when animated by some subject in which he took an interest, like his favorite theme, philology, his features assumed a lively, active, and intelligent expression. In walking he stooped forward, and had a shambling, shuffling gait, such as he would be very likely to acquire during his long confinement in the various prisons in which he had been incarcerated.

"His entire organization, as has been remarked of the cranium, was coarse. It was not without vigor or powers of endurance, but its material was not of the best quality, and was wanting in the fine finish which is now regarded as the best development of the human structure. In some respects his organization resembled that deteriorated condition, or that low type of physique, which has been declared by Mr. Bruce Thompson, to be characteristic of criminals as a class."

The human countenance, therefore, possesses a singular interest for the physician, because in its manifold expression he may read the reflected impress of certain physiological and pathological changes taking place within the cerebral centres. In forming a diagnosis nearly every physician is influenced in large measure, though often in a tacit and almost unconscious manner, by the facial expression of the individual whose case he may have under consideration. The wise and observing general practitioner often makes a correct diagnosis upon first entering the sick-chamber; he takes in at a glance the peculiar *facies* of his patient and sees in it the pathognomonic signs of some disease. The dusky countenance, the sunken cheek, the dilated nostril, the short and almost panting breath, indicate phthisis even before physical examination. The injected eye, the trembling tongue and fingers, the hurried frightened glance over the shoulder, the sudden start and involuntary repelling motion of the hand, with the intent look of fear peering into corners and toward the direction from which any novel sound may proceed, suggest the delirium of alcoholism. And so the psychiatrist is influenced at times, almost more strongly than he can describe, by certain glances of the eye and a certain configuration of the countenance, and is led to infer alienation, although it would be extremely difficult for him to satisfactorily convey this evidence, so convincing to himself, to another person, or to make it satisfactory to a jury. Nevertheless, it is important evidence to him, and in the absence of incoherence, or of any apparent delusion, he is induced to believe that his patient is mentally unsound, and so persist in his examination or demand repeated examinations until he has struck the key-note of his mental weakness. And how frequently is the reverse true! The examining physician feels sure that the individual before him is not insane; the eye, the countenance in its entirety, indicate to him more definitely than he can formulate the same in language, the repose and the equipoise of health.

The words of Dr. Luther V. Bell, written some twenty-five years ago, in a deposition concerning an insane woman, are interesting and quite pertinent to the present subject. He says: "The reasons which convinced me that Mrs. ——— was laboring under a grade of confirmed insanity of long standing, of probable incurability, and to an extent depriving her of responsibility for her actions, may be included under two divisions. The first may be called personal convictions, not capable of being fully conveyed to another mind, such as the expression of countenance, of eye, of manner, of habit of receiving and communicating thought, which a long acquaintance and domiciliation with the mentally diseased compelled me to accept as the truth; outer proofs of an inner morbid condition, yet which can hardly be so depicted or explained to the inexperienced. All profound and grave maladies have their specific physiognomy, more or less clear and capable of being described; some awfully clear and pathognomonic, like the odor of cancer, or the face of advanced phthisis. Insanity has its own delicate characteristics of face, eye, manner, reasoning, feeling, which can be read by the expert, but which would not be appreciable to the merely casual observer. His power in this regard is not capable of being transferred to another mind, but must die with its possessor."

It is just here that instantaneous photography assists the psychiatrist and enables him to transfer to another or to retain for future reference, through the sense of sight, all those delicate characteristics of face, eye, manner, and the like which are caught by the camera and retained on the sensitive plate—a thing that was not practicable at the time Dr. Bell gave his deposition.

In the present essay it is proposed to analyze the physiognomy of different insane persons. As one result of such analysis we shall find that the facial expression of the insane is determined by one or more of several pathological conditions. By studying these conditions separately we gain a clearer view of the significance of physical expression in insanity, and thus confirm the views already expressed concerning the physiology of physical expression.

These pathological conditions may be considered under three heads:

I. The trophic or nutritive disturbances which accompany the disease.

II. Impairment of healthy inhibition which is so frequently associated with insanity, and one result of which is weakening of the faculty of attention.

III. Excessive or defective nerve-muscular activity of an involuntary character, dependent upon morbid irritation or degeneration of the cerebral structure.

To these may be added the different positions and expressions of the eye, which, though possibly dependent upon the foregoing pathological conditions, are still of such significance as to deserve separate mention.

In connection with the third condition, that of varying motor disturbances, a study of various attitudes of the insane, as well as the different positions of the hands and the manner of carrying the head and the entire body, will be found both suggestive and interesting, as affording striking confirmation of the physiological principles previously discussed.

I. *Modifications of the Countenance in Insanity which are Due to the Trophic or Nutritive Disturbance Attendant Upon the Disease.*—In a large majority of cases insanity is itself caused by depreciated physical health. Dr. C. F. Folsom says: "The exhaustion and the disturbed cerebral circulation arising from acute and chronic diseases, profound anæmia, or prolonged mental strain, associated with emotional disturbance from any cause, are among the antecedents of insanity" ("Mental Diseases," p. 117). The association of neurotic and unhealthy physical conditions in different members of the same family is quite common. Of most frequent occurrence is the association, among different individuals of one family, or an alternation in the same person, of phthisis and insanity.

Aside from such causes as hereditary transmission, alcoholic and venereal excesses, traumatism, and with the exception of its occasional appearance as one of the sequelæ of some other disease such as epilepsy or some of the acute infectious diseases as measles, scarlet fever, and the like, insanity in the large majority of cases is caused by depreciated physical health with or without the association of some moral disturbance. The most frequent history given the physician is the following sequence: Overwork, loss of sleep, loss of appetite, indigestion, emaciation, increased worriment of mind, and, finally, actual insanity. The insanity appears as the result of the imperfect nutrition of the brain, which was in its turn produced by disordered health caused by improper attention to rest and digestion.

On the other hand, insanity itself may act as a cause of the deterioration of physical health. Oftentimes it aggravates the profound physical depression which was, in the first instance, the primary cause of the mental disturbance. We readily understand the reason for this secondary action of the brain upon the general health when we consider that this delicate organ presides over the entire nervous system, and that any disturbance in its action is sure to modify the healthy distribution of nervous force in the different parts of the body. Repeated and long-continued congestions of the delicate centres in the cerebral cortex, attendant on nearly all attacks of acute insanity as well as in the exacerbations occurring among the more chronic forms of the disease, lead to imperfect restoration of cell-structure in this organ, or to an unhealthy hyperplasia of the delicate tissues. Such changes in the brain result in its imperfect nutrition. Impaired nutrition of the brain leads to defective bodily health in various ways: either the morbid ideas which are the result of the brain disturbance lead to refusal of food, or the supply of healthy nervous energy to the entire alimentary canal is so interfered with that all the processes of digestion are improperly performed and healthy assimilation is impossible, or the activity of the cells in the cortex may so interfere with normal vaso-motor innervation that the natural circulation of the blood in other parts of the body is disturbed. In either case a depreciated state of bodily health, a decidedly lowered vitality, with diminished resistance, is the result.

This depreciated state of the general health is manifested in the condition of the skin, the hair, and mucous membranes. Every physician who attends upon the insane is familiar with the cold, clammy hands so characteristic of this class of patients; or with the dry, scaly state of the epidermis; the brittle, dry hair; the furred tongue and oftentimes offensive breath; the peculiar flabby condition of the skin of the face, with its pasty, lustreless color. All these characteristics, though not always present, still prevail in the majority of cases, and indicate that the general health has been impaired either by the cerebral disturbance itself, or by the constitutional causes leading to the brain trouble.

Although the photograph cannot preserve all the conditions of ill health above referred to, still the flabby countenance with its lack of healthy tonicity; the "lean and hungry look," and many of the signs of impaired vitality, are well retained and form a striking feature of any collection of portraits of the insane.

In a general way the study of the countenances of the insane leads to the conclusion that nearly all acute, recent, and very active insanity is attended with emaciation, sometimes only slight in degree, at other times quite extreme. This is quite noticeable in acute mania, acute melancholia, in the depressed stage of *folie circulaire*, during the active excitement of paresis, in acute primary dementia, or in dementia secondary to acute or chronic insanity, especially where the progress of the disease has been rapid.

Those forms of insanity in which there is an excessive elimination of nerve-force from the cerebral centres, are always attended by emaciation. In acute mania, some forms of acute melancholia, the maniacal stage of paresis, this constant and extreme elimination of nervous energy is manifested in almost incessant motor activity, and in these cases we always notice emaciation and general physical prostration.

Case XLII (see p. 519), acute mania, illustrates the emaciation attendant upon constant motor excitement in Fig. 337, A; while in Fig. 338, B, the return to health is evidenced as much by change in nutrition as by intelligence of expression.

In other cases the nervous system may be profoundly affected, and, though motor activity is not a symptom, still the trophic disturbances are as pronounced as in those to which we have just referred. In these cases the motor and the ideational centres seem to be overcome by the force and suddenness of the nervous shock, and there ensues an entire absence of activity in these same centres. There is no longer an elimination of healthy nervous energy from the cerebral region, and hence there is not only a cessation of normal functional activity of all the bodily organs such as the stomach, intestines, liver, kidneys, heart, and lungs, but there is also a paralysis of the centres in the cortex. As a result the patient is not only utterly exhausted and physically prostrated, but he is also mentally confused and dazed. An illustration of this condition, with its attendant trophic disturbance, is seen in Case XXXI., A and B (Figs. 313 and 314). This patient came into the asylum in a state of complete mental stupor; she would neither eat nor speak, gave no heed to personal cleanliness, but would void her urine and fæces wherever she might happen to be, whether standing up or lying in bed. She would stand for hours in the attitude seen in A, her eyes fixed and motionless, and no amount of urging could excite her attention. She became exceedingly emaciated, although she was fed daily upon the most nutritious diet. Comparison of pictures A and B with C (Fig. 315), taken at time of discharge and recovery, illustrates the wonderful nutritive disturbances that occurred during her sickness. Undoubtedly, the profound trophic alterations in her case were due primarily to the extent and severity of the diseased action in the cortical centres.

Another fact is worthy of notice.

Whenever a patient, suffering with some form of insanity, after a long period of mental disturbance, begins to regain flesh and weight without making any corresponding mental improvement, we have reason to fear

that the alienation in this patient may become chronic. In such cases it is not at all improbable that the cerebral structure has accommodated itself to the morbid processes which have been disturbing it for so long a time. The cells in the cortical region continue to act in

FIG. 313.—Case XXXI. Melancholia with Stupor. A, showing full-length attitude maintained for hours. Ocular divergence, self-absorption, and emaciation. (From photograph taken by author.)

their newly acquired morbid manner, while those parts which more particularly preside over the functions of nutrition and assimilation and of organic life act automatically and as naturally as ever. Thus, though the individual may have all the symptoms of chronic delu-

FIG. 314.—Case XXXI. B, showing nearer view of head. (From photograph taken by author.)

sional insanity, or of mental weakness in some form, still the processes of nutrition and assimilation are normally performed, and he may attain a good degree of physical though not of mental health.

More frequently, however, increase of flesh and perfect physical health are coincident with mental convalescence and recovery. In nearly all cases of chronic insanity there is that condition of lowered vitality which is generally the inevitable accompaniment of the disease. The flabby skin, lustreless eye, general absence of healthy plumpness, and the drooping head, all indicate deficiency of normal nutrition. All these symptoms are more manifest in the persons themselves than in their photographs; yet the latter plainly signify the trophic disturbances associated with the disease.

Melancholia is almost invariably attended by pronounced trophic disturbances, and photographs of this class always show what marked inroads upon physical health this especial form of mental disease may make. In no case is this more noticeable than in XXXIII. (see page 528). The emaciation was extreme. Every mental faculty seemed paralyzed, and many bodily functions, such as digestion, assimilation, and nutrition appeared to be almost entirely suspended. His gradual return to mental health is marked by corresponding improvement in nutrition, and shows quite plainly in Figs. 346, 347, and 348.

This depreciation of physical health during the height of the attack, its return and perfect establishment at time

FIG. 315.—Case XXXI. C, same person after recovery. (From photograph taken by author.)

of mental recovery, is quite noticeable in the portraits of Case XXXI., A, B, and C. In Case XLII., Fig. 338, B, taken at time of recovery, when compared with A (Fig. 337), presents very marked changes in physical health.

Alternations in loss and increase of flesh are often noticeable in cases of insanity. During the active stage of paresis, when there is very marked cerebral activity, attended with pyrexia and great motor disturbance, there is much tissue waste, and the patient becomes quite emaciated. When the excitement abates, the fever disappears, and motor activity ceases, then the appetite is apt to increase to an excessive degree, assimilation goes on as usual, and the patient sinks into a passive, quiescent state in which flesh is accumulated to an almost unnatural degree. In cases of folie circulaire there is often increase of flesh and strength during the active stage, and during the period of depression there is marked emaciation. All the processes of assimilation seem to be in sympathy with the depression of mind, and when the reaction comes increased appetite and improved assimilation, together with increase of flesh and strength, also reappear.

In other cases, although there is no real improvement in the mind, still a change in the character of the delusions leads to a more hearty ingestion and assimilation, and the patient's physical health improves, although mentally he may still be far from well.

In many of the chronic forms of insanity, where there

is little undue motor activity, and especially in that form known as paranoia, the bodily functions are carried on quite naturally. In a well-regulated hospital there is so little to disturb the lives of these patients, their hours of eating, sleeping, and bathing are so regular, that even though their cerebral condition is in no way improved, their physical health is quite good, and oftentimes the accumulation of flesh in these cases is almost pathological. A removal of such patients to a less favorable situation often results in a rapid deterioration of their physical health, or at least in a loss of their flesh. In all cases of chronic insanity, however, marked improvement in physical health is more apparent than real. There is, as we have seen, an occasional accumulation of adipose tissue; but in such cases there is often a deficiency in that general vitality and energy which we associate with health, and which is so effective in resisting disease.

To briefly recapitulate what has been said concerning the trophic and nutritive modifications of the physiognomy in insanity:

1. In the majority of cases there is impaired general nutrition due either to (*a*) congenital brain deficiency; (*b*) to abnormal or excessive elimination of nervous energy from the brain, thereby weakening and interfering with the functional activity of that organ; or (*c*) to permanent brain weakness acquired as a result of chronic insanity. In these three ways the functional activity of the brain as a distributor of nervous energy to the organs of digestion and assimilation is interfered with, and the general health suffers as a result.

2. Occasional alternations of flesh and emaciation, of improved and impaired physical health in the same individual, and due to fluctuations in the functional activity of the brain.

3. Occasional coexistence of physical health and mental disease—a condition of things which is oftener apparent than real, and dependent largely upon the fortunate environment of the patient.

II. *Modifications in the Physical Expression of the Insane, Due to Impaired Inhibition.*—The inhibitory power is recognized as playing a most important part in the intellectual and physical life of man. Whether inhibition is a purely metaphysical attribute of mind, or a special function having its seat in specific centres of the brain, its importance as a factor in the life of the individual cannot be doubted. Many writers have denied the existence of special inhibitory centres. Many physiological and psychological facts confirm their views.

G. H. Lewes argues with much force against the existence of special centres of inhibition. He attempts to explain the phenomena of inhibition by what he calls the Law of Arrest. "The Law of Arrest is only another aspect of the Law of Discharge, and may be regarded as the conflict of excitations." According to this theory, each nerve tract and centre possesses inherent inhibitory properties of its own. The strongest excitations prevail: "The discharge is only the resultant of the conflict along the line of least resistance; the arrest is the effect of the conflict along the line of greatest resistance" (G. H. Lewes, "Physical Basis of Mind").

Meynert advances the theory that the gray matter of the brain and cord presents a certain resistance to nerve-conduction. Increased irradiation of any irritation is accompanied by increased resistance in nerve-conduction. "It is evident then," he says, "that inhibition resulting from resistances introduced in nerve-tracts accompanies the simplest reflex processes."

Many physiological and pathological data lead us to infer that nerve-tissue, and particularly the gray matter, possesses certain inherent tendencies to resistance to nerve-conduction. Herein man widely differs from the lower animals. For in them, this resistance to nerve-conduction, which we recognize in man as a part of his inhibitory faculty, is incapable of development, but remains stationary through life just as it was transmitted at birth by heredity. In man, on the contrary, this property of resistance may be developed by individual training and experience. Hence the inhibitory power varies with the person: there is no universal inhibitory standard that can be applied to all alike.

The possession of a high degree of inhibition is often due to an active exercise of the will-power; hence, perfect inhibitory capacity is usually associated in the same individual with a strong and active manifestation of the will. Carpenter says: "Now the man in full possession of his volitional power can use it, (1) in giving bodily effect to his mental decision, by either putting in action the muscles which will execute the movements he has determined on, or by restraining them from the action to which they are prompted by some other impulse; and (2) in controlling and directing that succession of mental operations by which the determination is arrived at" (Carpenter, "Mental Physiology," p. 378).

In the gradual evolution of the inhibitory power the will plays a most prominent part. By active and constant exercise of the will an individual may develop marked inhibitory power. Inhibition represents gradual growth, therefore, and varies at different periods in the life of the same individual. At birth, and during early infancy, it scarcely exists. Every act that the infant performs is the impulsive and spasmodic result of sensory stimulation. During childhood the inhibitory power receives its first training and development. The child learns to govern himself. Experience and his parents teach him that the mere impulsive gratification of every whim that may arise, of every appetite that suggests itself, is not only not desirable, but may be fraught with disastrous results, both here and hereafter. In youth and manhood this power of inhibition receives constant education. The experiences of life all tend to develop it, if the will insists upon it.

In the cultivation of man's moral nature the successful development of inhibition receives a good illustration. Man's unbridled animal instincts might lead him into habits of vicious and selfish indulgence, of which the criminal records present abundant illustrations. The teachings, however, of religion, morality, and even the instinct of self-preservation, lead him to place a check upon these mere animal indulgences. At first the conflict may be difficult, as the history not only of individuals but even of entire nations, will testify. Individual persistence succeeds, however, in implanting in the person such power for resistance that these temptations not only cease to have any allurement, but even become loathsome. Such inhibitory resistance is transmitted by heredity.

The inhibitory power, therefore, may vary greatly among races of men as well as among individuals. Education is certainly a prominent factor in its development. Civilized man possesses the inhibitory power to a greater degree than the savage; the educated, in this as in many other respects, are vastly superior to the ignorant. Indeed, success in life may be measured by the degree of healthy inhibition possessed by the individual.

Climatic and hereditary conditions exert a powerful influence in modifying and developing the inhibitory power. And thus we can understand why it is that the people of one nationality and climate differ so materially from those of another in the possession of this faculty.

We may briefly summarize by saying that inhibition seems to be a restraining power which is implanted in the mind, and incorporated as it were in the nervous system of the individual. It is largely a matter of individual growth, and depends for its successful development upon the strong and healthy exercise of the will. There is also evidence that the inhibitory power is modified in various ways by climatic and hereditary influence. It is also evident that, when once this inhibitory and restraining power is implanted within the nervous organization of an individual, its habitual and almost involuntary exercise is elicited by the presentation of the proper stimulus. Thus habits and tendencies which have only been repressed with the greatest difficulty and after the most active exercise of the will, receive frequent and comparatively easy restraint when once a tendency to their inhibition has been fairly established by the individual.

The inhibitory power seems to be intimately associated

with all our higher faculties, and in common with them seeks expression through functional activity of the cerebral cortex. The inference is natural that functional or organic disturbance of this region should be attended by disordered inhibition. Among the earliest manifestations in insanity is impairment of the inhibitory power.

In health the inhibitory function is exercised in a twofold manner: First, in checking irrelevant trains of thought, repressing whatever is impertinent to the subject engaging the attention; and secondly, in checking certain muscular movements which, though they naturally follow the stimulations which have preceded them, still, for the time being and with other objects in view, are undesirable and out of place.

It is not surprising that the inhibitory function, so intimately associated with all the higher activities of the mind, and probably identified with cell-activity in the cerebral cortex, should be among the first to become disordered in insanity. A careful analysis of the symptoms that arise during the premonitory and early stages of mental alienation discloses evidences of weakened inhibition.

Among the higher faculties the attention holds a most prominent position. Active exercise of the inhibitory power is indispensable to a complete awakening of the attention. And the success attained by any individual in the various walks of life may be measured by his power of inhibiting whatever is irrelevant, that is, by his ability to concentrate his attention upon the work before him.

Obersteiner has well said: "We can will that a certain action to which there exists a powerful stimulus should be repressed and carry out another. By inhibition of the former we concentrate our attention on the latter. . . .

"Ideas tend to call up other ideas by association, and naturally along the most easy channels. But we can check the current of ideation along the easiest paths and divert it into paths which are more difficult. We think attentively and inhibit continuously. The more powerful this inhibitory working of the attention, the more intense the thought, the more numerous the paths opened up, and the more productive in its consequences. It appears therefore from these considerations, that in every mental act, whether it be in the domain of sensation, volition, or intellect, there is seen an inhibitory power essentially the same in all cases" ("Experimental Researches on Attention," by H. Obersteiner, in *Brain* for January, 1879).

In the early development of insanity one of the first symptoms to attract the notice of the friends, and to arouse their suspicions of mental disturbance, is a manifest inability on the part of the patient to concentrate his attention. This will declare itself in various ways. The patient becomes inaccurate. If a mechanic he either accomplishes less work or is careless; if in business he makes frequent mistakes and fails to fulfil important obligations. All this inaccuracy and omission of detail is due to varying degrees of self-abstraction. The patient has lost the power of successfully inhibiting the fleeting thoughts or suspicions which crowd his mind and which supplant the ideas that immediately concern his daily work and life.

In health the individual possesses the power to turn his thoughts in the direction of his work or whatever may interest him at the time. Irrelevant ideas and sensations can be inhibited, and only those regarded which will assist the work in hand. But in the earlier stages of insanity, and in the more firmly established conditions of the disease, every morbid idea, and often every communication to the sensorium through the avenues of the special senses, acts as a diversion. The patient's power of attention is so easily distracted, he places such a morbid construction upon every new sight or sound, and his inhibitory power is so weak that healthy concentration upon affairs of real importance is an actual impossibility.

The asylum workshop affords an excellent illustration. Here you may study inhibitory incapacity in every stage of development. A stranger enters the room and probably half of the patients will cease working, some will arise from their seats, and possibly one or more will walk about the new-comer, looking him over inquisitively and either talking to themselves or to the visitor. And in what a scattered and desultory way is much of the work performed! Evidently ideas irrelevant to the occupation in hand absorb and divert the attention of these diseased minds into other channels. In just the proportion that the individual possesses inhibitory capacity, to just that extent does he seem capable of performing successful and intelligent work.

Bearing in mind, then, that weakening of healthy inhibition is one of the first results of insanity, we find this impairment of the inhibitory capacity manifested in the physical, and particularly the facial, expression of the insane in two ways:

1. There is inability to control the movements of the facial muscles. The insane make few attempts at concealing the facial expression of their feelings. With them impaired inhibitory power interferes with that slight volitional control which we possess over those facial movements that habitually follow certain emotions. In the familiar language of daily life the insane *look* very much as they *feel*, and their attempts at concealing their real emotions are few and unsuccessful.

2. For the same reason there is impaired inhibition, there is inability to concentrate the attention, the result of which is an expression of self-absorption quite peculiar and characteristic of the disease.

These two elements in the facial expression of the insane merit more discussion in detail. First, as to inability to control the well-known facial expressions of certain emotions. We must remember that the muscular movements producing facial expression are essentially reflex, and largely involuntary. When displeased we do not will our facial muscles to assume certain positions characteristic of displeasure; neither when amused do we will that they should contract in the way peculiar to the expression of amusement. As has been previously stated, the muscles, without any seemingly volitional effort of our own, assume these positions themselves in obedience to the special force transmitted to them from the cerebral cells along the intermediate conducting nerve-fibres.

Although the ordinary muscular movements concerned in facial expression are involuntary, still man does possess a limited control over them. This inhibitory influence over muscular contractions that are commonly reflex and involuntary is developed by education and experience; and is often carried to a high degree of perfection by persistent self-training in this particular direction. The emotions are more unreservedly expressed in the face of the child than in that of the adult; the ignorant and uneducated betray their feelings in their facial expression more frequently than do the intelligent; indeed, this power of controlling the expression of one's innermost sentiments may be the evidence of a healthy and well-balanced mind. This attempt at concealing these deeper feelings is practised to a certain extent and with varying success by every one. Sometimes a sentiment of pride, again criminal reasons influence an individual to inhibit the ordinary movements of facial expression. Thus a man may be bowed down with grief, and yet when he appears in public will, from a secret feeling of pride that leads him to avoid betraying his emotions to others, conceal every expression of sorrow. He will smooth out the wrinkles of pain on his forehead and appear calm and unmoved until by himself again. Or the criminal, who harbors motives of hatred and revenge, or who has committed some great crime, will conceal, or at least attempt to conceal, the malignant and guilty expression which would otherwise betray him.

To a certain extent, therefore, the normal involuntary and reflex movements of facial expression are inhibited in health. In insanity, however, the inhibitory power is so weakened by the disease that successful control of these movements is difficult.

The insane patient makes few and ineffectual attempts at disguising the feelings which oppress him. The conflicting emotions by which he is disturbed are reflected through the various motor-tracts to the face, and as a result we may often read the character of the delusions which preoccupy the mind. Thus the expression of the

countenance in acute melancholia is generally quite characteristic of a depressed state of the feelings; and what is especially noteworthy is the fact that this diseased expression is far more intense than would be the expression of similar emotions in the same individual in health. Impaired inhibition does not exercise any restraining influence upon the countenance, and, whether alone or in the presence of others, the melancholic presents the furrowed brow, the anxious and distressed expression about the eyes and mouth that are characteristic of these especial emotions, whether they proceed from natural or morbid causes. The only difference is that the normal manifestation of grief is modified by healthy inhibition, while morbid sorrow is persistent, intense, and not subject to outward restraint.

Indeed, the most marked illustrations of impaired inhibition are found among the faces of the melancholic insane. There is oftentimes in these cases a complete abandonment to the predominant emotion—the patient making no effort whatever to control the expression of the feelings. Darwin's remarks upon the facial expression of sorrow are particularly interesting, and, undoubtedly, are physiologically correct. As his explanation of the physical expression of grief is corroborated by the physiognomy of melancholia we will briefly refer to what he says upon the subject.

The muscles which are brought into play during the expression of painful emotions are the corrugators, orbicularis, pyramidalis of the nose, and the frontalis. These are what Darwin has called the "grief muscles" when they are placed in "conjoint yet opposed action," which action he thus describes: "When a person elevates his eyebrows by the contraction of the whole frontal muscle, transverse wrinkles extend across the whole breadth of the forehead; but in the present case (expression of grief) the middle fasciæ are alone contracted; consequently, transverse furrows are formed across the middle part alone of the forehead. The skin over the exterior parts

FIG. 316.—Case XXVII., Chronic Melancholia. Morbid and uninhibited expression of grief. Darwin's "grief muscles" in contraction producing "horseshoe mark." (From photograph taken by author.)

of both eyebrows is at the same time drawn downward and smoothed by the contractions of the outer portions of the orbicular muscles. The eyebrows are likewise brought together through the simultaneous contraction of the corrugators; and this latter action generates vertical furrows, separating the exterior and lower part of the skin of the forehead from the central and raised part. The reunion of these vertical furrows with the central and transverse furrows produces a mark on the forehead which has been compared to a horseshoe; but the furrows more strictly form three sides of a quadrangle. They are often conspicuous on the foreheads of adults, or nearly adult persons, when their eyebrows are made oblique; but with young children, owing to their skin not easily wrinkling,

FIG. 317.—Case LV., Acute Melancholia. Marked and characteristic innervation of Darwin's "grief muscles." Intense motor disturbance. (From photograph taken by author.)

they are rarely seen, or mere traces of them can be detected" ("Expression of the Emotions in Man and Animals," by Charles Darwin, Am. ed., 1873, p. 181).

This peculiar contraction of the "grief muscles" receives its best illustration in states of mental depression, but irregular and morbid activity of the brain-cells in different forms of insanity may produce nearly the same action, even though the state of mind is one of complete confusion or even exhilaration. In Case XXVII., chronic melancholia, we see the action of Darwin's "grief muscles" producing in a striking degree obliquity of the eyebrows and the vertical lines between them which Darwin says is so characteristic of emotions of depression. In this same case the naso-labial furrow, extending from the wing of the nose to the angle of the mouth, and which Darwin says is of so frequent occurrence in blubbering children, is strongly marked. In Case LV. this peculiar action of the corrugators and central fasciæ of the frontalis muscle is strikingly illustrated. The corrugators in their contraction draw the eyebrows inward, producing the vertical furrows seen at the inner edge of each eyebrow; the frontalis in its contraction produces the transverse furrows across the centre of the forehead, while the orbicularis in their contraction smooth out these transverse wrinkles on the outer borders of the forehead. As in the previous case, the naso-labial furrow and the depression of the corners of the mouth, due to the contraction of the *depressores anguli oris*, are very pronounced. Indeed both Cases XXVII. and LV. afford most strik-

ing representations of prolonged concentrated grief and mental suffering. These are typical cases of melancholia, and while it is evident that emotions of depression have produced their normal and legitimate expression in their faces, it is equally plain that no person in a state of mental health would present this remarkable appearance for several consecutive hours, and in the presence of others. Such action as is represented in the photographs of Cases XXVII. and LV. could only proceed from persistent and uninterrupted morbid cell activity. In health, the normal inhibitory action of the cortical centres would render such extreme manifestations impossible. In these cases of melancholia no amount of persuasion or distraction, not even the fact of sitting for a portrait, when most people make an effort to smooth out their features, produces the slightest change in these disturbed and painful countenances. It is quite obvious that healthy inhibition has ceased to be a factor in the facial expressions of these unhappy subjects, and that the various muscular contractions of their faces are so many persistent signals of the psychic pain which fills their minds. The photographs figured in Plate IX. of Kirchoff's work (Figs. 318, 319, and 320 of the present article) illustrate the uninhibited expression of distress in the facial region of a case of paralytic dementia, upon an imperfect attempt to articulate a difficult word, and the smoothing of all the muscular folds when the patient is in repose.

FIG. 318.—Paralytic Dementia. Face in repose. (From Kirchoff's Handbook.)

FIG. 319.—Paralytic Dementia. (Same case.) Uninhibited expression of distress as shown in the contraction of the "grief muscles" upon attempting to articulate a difficult word. (From Kirchoff's Handbook.)

In the portraits of cases of acute mania it is very plain that inhibition exercises no restraining influence whatever over the constant nerve-muscular activity which so transforms the physiognomy. Case XLII. (see p. 519) illustrates how completely has intelligent control over the features been swept away by the storm raging within the cerebral centres.

The faces of the chronic delusional insane show quite clearly the absence of healthy inhibition. Thus the sly, distrustful glance, the bitter, lowering look of hatred and enmity, the self-satisfied air of exaltation, or the dejected countenance of self-abasement, are expressions quite frequently noted among this class of insane, and are another evidence of the inability of the patient, through impaired inhibition, to control the outward manifestation of the inner feelings. These same feelings exist in health, oftentimes with great intensity, and yet how perfectly are they concealed! In this connection it is interesting to note that in the weaker mental conditions of childhood these same feelings and emotions are frequently and as clearly represented in changes of facial expression as are the corresponding emotional states in the faces of the adult insane. The main difference lies in this fact, however, that in childhood inhibition through the will has not been developed, while among the adult insane it has been weakened by disease.

FIG. 320.—Paralytic Dementia. (Same case; conditions the same as in Fig. 319.) (From Kirchoff's Handbook.)

FIG. 321.—Case III., Chronic Delusional Insanity. Persistent, uninhibited ideas of suspicion and hostility. (From photograph taken by author.)

Case III., characterized by chronic delusions of enmity and suspicion, and also homicidal, quite clearly expresses in the countenance the dissatisfaction with, and the opposition to, those about him, as well as fierce determination to gratify his impulses on the first favorable opportunity.

Case XII. quite plainly manifests in his countenance his all-absorbing egotism. In sitting for his portrait he chose his own position, arranging with great care his decorations, consisting of old buttons, bits of glass,

FIG. 322.—Case XII., Paranoia. Morbid egotism and fondness for display. (From photograph taken by author.)

brass wash-bowl chains, tin, etc., which he imagined to possess great value. The violin, which he made himself out of limited materials, and with an old knife and awl, he was anxious to display as a Cremona instrument of rare worth. The inconsistency of his real position (that of confinement for life in an asylum), the utter worthlessness of his jewelry and improvised insignia do not in the least lead to the inhibition of the expressions of morbid vanity and self-importance which pervade his countenance. Indeed, in nearly all forms of acute or chronic insanity, characterized by active persistent ideas, there will be noticed in the facial expression a complete abandonment to the prevailing morbid emotions, with scarcely any attempt at inhibition.

FIG. 323.—Case of Paranoia. Uninhibited expression of opposition and resentment. (From Kirchoff's Handbook.)

Kirchoff's views of insane patients in Fig. 331, Fig. 332, Fig. 325, and Fig. 326 illustrate how completely the insane abandon themselves to the predominant sentiments that characterize their individual cases. Fig. 329 is especially interesting, in that the same individual is shown under more normal conditions. Impaired inhibition explains all this distortion of feature.

A peculiar appearance of self-abstraction is the second way in which weakening of the inhibitory power among the insane manifests itself.

This self-absorption results from inability of the patient to inhibit trains of morbid and irrelevant thought. He looks preoccupied, and often entirely disregards his environment. So absorbed does he become that it is with the greatest difficulty that he concentrates his attention on persons or things about him. Hence results an expression of indifference, a fixed intent gaze, but with no particular object within the range of vision. In discussing the position and condition of the eyes in the countenances of the insane more extended allusion to this subject will be made. At present it is only necessary to call attention to the fact that the peculiar absorbed, absent-minded expression, so frequently met with in the insane, is due to impairment of the faculty of attention caused by weakening of the power of inhibition. In Figs. 333 and 334, taken from Kirchoff's work, this absorbed expression, indicating complete disregard of the environment, is well preserved.

FIG. 324.—Case of Paranoia, Showing Disappearance of all Healthy and Natural Expression, Due to Absence of Cortical Inhibition. (From Kirchoff's Handbook.)

III.—The third manner in which the physical expression of health is modified by insanity is through *excessive, deficient, or automatic nerve-muscular activity of an involuntary character, dependent upon morbid irritation or degeneration of the cerebral cell-structure.* Allusion has been previously made to that regular transmission of nerve-force which, in conditions of health, is constantly passing from the cerebral centres to the muscular periphery. The results of this elimination of nerve energy are seen in that permanent and normal tension of the muscular system called muscular tonicity, and also in the ordinary facial expression of every individual when the features are in repose. It is proposed in the present section to consider how this normal and regular transmission of nerve energy in health is modified by

FIG. 325.—Case of Mania, Showing Uninhibited Muscular Movement. (From Kirchoff's Handbook.)

the functional and organic disturbance of the brain in insanity. In doing this we enter the larger field of Physical Expression, where we study not only the changes observed in the face, but every abnormal manifestation taking place in the entire muscular system, including gesticulations, attitudes, manner of holding the head, carrying the hands, and every possible irregular and abnormal muscular movement.

Fig. 326.—Case of Mania. Uninhibited egotism and exhilaration. (From Kirchoff's Handbook.)

All these movements, which are caused by irregular cell activity of the cerebral centres, have one characteristic distinguishing them from the ordinary changes of facial expression: they are entirely meaningless, subserve no purpose, and do not conform to any of the well-known expressions of the emotions, as grief, joy, etc. In health the expression of these emotions is always recognized by certain well-known muscular contractions which observation has taught us are characteristic of corresponding mental states. We know, for instance, that laughter will be manifested by contraction of the *corrugators*, of the *malaris*, and of the *great zygomatic*; in grief we know that the eyeballs will be rolled a little upward and inward, and that the contraction of the central fibres of the *frontalis* acting upon the *corrugators* will produce a peculiar and very characteristic wrinkling of the forehead above and between the eyes, and that the *depressores anguli oris* will draw down the corners of the mouth. These muscular contractions follow in a certain definite manner their causative mental states. So regularly and constantly do they succeed their antecedent mental conditions, that, given the state of mind, the resulting movements of expression can be foretold even before their appearance. Hence the expressions of the emotions can be easily separated into groups: thus we have the expression of joy, grief, disgust, and all the others.

Fig. 327.—Case of Mania; showing unrepressed expression of exhilaration. (From Kirchoff's Handbook.)

On the other hand, the movements under discussion are not regular, do not indicate any particular state of mind, but represent rather that irregular and interrupted action of the brain-cells which often takes place in acute insanity, and is of very frequent occurrence in the degenerative brain conditions of chronic alienation.

To avoid confusion we may study this phase of the Physical Expression of the insane under three heads:

I. As representing states of excessive nerve-muscular activity due to central irritation.

II. As representing states of deficient nerve-muscular activity due to central degeneration.

III. As representing states of automatic cell-activity in the cerebrum occurring not infrequently in acute insanity, and quite constantly in the chronic form of the disease.

1. *Physical Expression of the Insane Caused by Excessive Nerve-muscular Activity.*—That mysterious property which, for want of a better name, we call nerve-force, is undoubtedly being constantly stored up within the brain-cells, and as regularly discharged from them. The intimate relationship between this elimination of nerve-force and muscular movement has been clearly stated by Dr. Carpenter, in the following paragraph:

Fig. 328.—Case of Mania; showing unrepressed expression of exhilaration. (From Kirchoff's Handbook.)

"We shall hereafter see that each kind of mental activity—sensational, instinctive, emotional, ideational, volitional—may express itself in bodily movement; and it is clear that every such movement is called forth by an active state of a certain part of the brain, which excites a corresponding activity in the motor nerves issuing from it, whereby particular muscles are called into contraction. No physiologist can doubt that the mechanical force exerted by the muscles is the expression of certain chemical changes which take place between their own substance and the oxygenated blood that circulates through them; or that the nerve-force which calls forth those changes is intimately related to electricity and other physical forces.

But this nervous activity has its source in molecular changes in the nerve-centres; the transmission of nerve-force along the motor nerve being just as dependent upon chemical changes taking place between the substance of the ganglionic centre from which it proceeds, and the oxygenated blood that circulates through it, as is the transmission of an electric current along the

Fig. 329.—Folie Circulaire. A, Depressed stage, with expression of uninhibited grief. (From Kirchoff's Handbook.)

telegraph wire upon the chemical changes taking place between the metals and the exciting liquid of the galvanic battery" ("Mental Physiology," Am. Ed., 1874).

The laws which govern this elimination of nerve-force are similar to the laws governing force in general. The great law of conservation of force or energy prevails in the field of cerebral activity as elsewhere. When chemical changes take place within the delicate nerve-centres of the brain as a consequence of external stimulation through the senses, or internal stimulation following mental activity, the result conforms to the requirements of this universal law. Either the force generated by these chemical changes remains stored up in the cerebral cells as potential energy to be called forth at some future time by stimulation, or it is transferred from the cells along the proper tracts to the muscular system, and appears as motion. This is the physiological definition of Physical Expression.

Fig. 330.—Folie Circulaire. *B*, Exhilarated stage, when countenance has returned to a more normal condition. (From Kirchoff's Handbook.)

Now, a certain constant and regular transmission of this nerve-force from the central cells to the muscular periphery is, as we have seen, natural and in accordance with health. Indeed, a state of general good health demands this outward relief for the potential energy constantly accumulating within the brain-cells. Thus the excessive muscular activity of all young and growing animals, the playfulness of young dogs and kittens, the pranks and follies of boyhood, are oftentimes merely the expression of this great natural law. In adult life the potential energy of cerebral cells is manifested in more practical and useful ways, but still in the most tangible results of a successful business, mechanical or professional life, we recognize the outward manifestation of the potential energy which has been stored up within the brain-cells until the proper stimulation called forth its discharge.

Fig. 331.—Case of Periodical Melancholia. (From Kirchoff's Handbook.)

This intimate relationship between muscular movement and central cell-activity within the cerebrum, has been discussed in Dr. Francis Warner's interesting volume on "Physical Expression," and in a recent article by the same author in the *Journal of Mental Science* for April, 1889. This author calls attention to the fact that these outward manifestations of central cell-activity begin at birth, and are witnessed in the countless random and meaningless movements of infancy, to which he has given the name of *mikrokinesis*. Undoubtedly at a very early age healthy inhibition of muscular movement begins. One by one useless and superfluous movements are checked, eliminated, or co-ordinated in such a way that when adult life is reached, the individual, if in health, manifests those muscular activities which subserve the general purposes of the will and intelligence.

Fig. 332.—Case of Periodical Melancholia. (From Kirchoff's Handbook.)

Even at this period of life many movements remain, fulfilling no particular purpose, but representing mere automatic cell-activity which has either been acquired by the individual or transmitted to him by heredity. The various movements of the facial muscles, including the tonic contractions already referred to, and which, in their totality, form the individual physiognomy, belong to this automatic and acquired class.

In diseased conditions of the brain, however, the pathological irritation of these delicate nerve-centres may be so great as to overcome any acquired inhibitory resistance, and thus liberate an excess of nerve-force which will seek an outlet in the usual way by passing along the efferent motor tracts to the muscles, and there appearing as muscular movement. Thus it is that in the functional or organic brain disturbances of insanity, abnormal motor activities are a frequent accompaniment of disturbed states of mind.

Fig. 333.—Case of Dementia. Ocular divergence due to suspension of the attention and lack of ideation. (From Kirchoff's Handbook.)

Pathological motor activity is, as we have seen, spasmodic, irregular, and purposeless. The most striking illustration of this fact is afforded by cases of chorea and epilepsy. There seem to be good reasons for supposing that in these diseases the brain-cells are in an unstable condition, owing to hereditary, traumatic, or nutritive

disturbances, and that, as Gowers says, the discharge of these same cells "may depend on the production of force within being increased in excess of the resistance, or on the resistance being duly lessened" ("Epilepsy and other Chronic Convulsive Diseases," p. 213).

In the active stages of mania and melancholia, in the acute excitement which sometimes occurs in paresis and other organic diseases of the brain, this same discharge of nerve-force takes place. The unceasing jactitation of acute mania, the restlessness of melancholia, are familiar illustrations. Such patients are apt to be in a state of constant muscular activity, pacing the floor, tearing their clothing, and destroying whatever comes in their way.

FIG. 334.—Case of Melancholia. Self-absorption, ocular divergence, and contraction of "grief muscles." (From Kirchoff's Handbook.)

These irregular and motiveless movements of the insane are earliest manifested in the facial muscles. The extreme sensitiveness of this region to cerebral conditions, and the weaker inhibitory control which the brain possesses over these delicately poised muscles, are reasons why the face so often presents the first physical manifestations of the advancing mental disease. Very frequently the muscular disturbance does not extend beyond the face; but it is quite rare that this region does not show some evidence of the morbid irritation of the brain-cells. When the face alone is disturbed in this way, the resulting expression is quite peculiar, and resembles those meaningless contractions that are produced when a mild galvanic current is passed through these muscles. The muscles are gently but continuously contracted, particularly those about the forehead, at the root of the nose, and about the mouth, giving to the patient a peculiar kind of *troubled* or *anxious* expression. It is often noticed by the friends at a very early stage of the disease, and they will tell you that the patient does not look natural, that his countenance has a strained, intense look, quite different from his normal expression, but still very difficult to describe.

FIG. 335.—Case XXXIX. Acute Mania. *A.* As he appeared on arrival at asylum from prison. Morbid innervation of facial muscles. (From photograph taken by author.)

This particular region about the forehead, above and between the eyes, and at the root of the nose, is the first to bear evidence of psychic pain or distress, and, indeed, of mental excitement of any kind. Nearly all writers on physiognomy speak of the important rôle sustained by the frontal region in the development of facial expression. Some attribute this fact to the nearness of the part to the regions of thought and mental activity in the brain, and cite as one evidence of this the fact that we all involuntarily rub or press this space above and between the eyes when we are perplexed. The act of rubbing relieves, in some way, the unpleasant tension which we feel at such times. It is not at all improbable that the nerve-force, liberated by the increased activity of the anterior convolutions of the brain during active thought, is transmitted from the cortical centres to these muscles and occasions that slight feeling of tension, which is undoubtedly relieved by rubbing.

The peculiar action of the "grief-muscles" in melancholia has already been discussed. It is somewhat singular that these same muscles are called into action in other states of mind than those of morbid depression. States of mental confusion, of mania, with exhilaration, often stimulate the grief-muscles into activity. Illustrations of this are afforded by Cases XXXIX. Fig. 335, A) and XLII. (Fig. 337, A). In these last cases

FIG. 336.—Case XXXIX. *B.* Taken at time of discharge and recovery. Disappearance of morbid innervation, improved nutrition. (From photograph taken by author.)

we may believe that the cell irritation of the cortex transmits nerve-force in the direction of the so-called grief-muscles, since, through repeated use, that channel affords the readiest outlet. Or, it may be that this disturbed and anxious look so often seen in different phases of insanity is due to a feeling of displeasure awakened in the mind of the patient by the opposition to his plans and delusions, which he so frequently encounters in those about him; and this sense of displeasure and disappointment has its usual manifestation in the muscles that reflect these emotions. However this may be, the frontal region, including the eyes and space between them, is, through contiguity to the brain, the most expressive part of the face, and the nerve-muscular activity of insanity finds there its earliest and most persistent reflection.

Returning to the illustrations, we find that the portraits of Cases XXXIX. and XLII. illustrate the peculiar muscular contractions already referred to, and which proceed from the brain irritation of *mania* in different degrees of intensity. Case XXXIX. was transferred to the asylum from the prison. Six weeks before his removal to the asylum he began to be careless in his work,

and was supposed to be refractory. He was placed in solitary confinement, but while in this situation he began to develop hallucinations of sight and delusions of exaltation, thinking he was Christ. On his arrival at the asylum he was quite deluded, slightly incoherent, and exhilarated. Fig. 335, A, shows his appearance at this time. The compressed lips, the almost bristling hair, deep furrows in the skin extending from the alæ nasi to the corners of the mouth, the lowered eyebrows, and deep wrinkling between the eyebrows at the root of the nose and on the forehead, illustrate what has been referred to as a "troubled" expression, and show how the centric irritation has been communicated to the muscles of the face. Fig. 336, B, giving the face of the same individual at time of recovery, presents a most marked contrast. The smooth brow and forehead, the clear, open eye, and natural position of the mouth, all indicate, more clearly than words can express, the subsidence of the storm within the cerebral centres.

Fig. 337.—Case XLII., Acute Mania. A. Taken during active stage. Morbid innervation, trophic alterations, neglect of personal appearance. (From photograph taken by author.)

In Case XLII. (Fig. 337), the patient was entirely incoherent, and in a state of constant muscular agitation. He was destructive, and almost too confused to eat his meals, so that frequent feeding with the nasal tube became necessary. The staring eyes, wrinkled forehead, dry, dishevelled hair, and torn coat are in striking contrast with Fig. 338, B, in which the hair has assumed its natural condition, the face is smooth, and the eyes are calm and quiet.

In cases of melancholia with motor disturbance we see the effects of central irritation reflected in muscular agitation. Sometimes the patient will pace the floor wringing the hands, groaning and moaning, or the excitement will become so intense as to lead to an impulse to tear or destroy whatever comes within reach.

In many cases of chronic insanity almost constant tooth-grinding is a noticeable feature, and another illustration of morbid transmission of nerve-force from the central cells to the muscular periphery. Tooth-grinding is not uncommon in nervous children, and is of very frequent occurrence in the insanity proceeding from structural brain disease. It is noticed oftener in connection with paresis than with any other disease. In passing through wards for demented patients it is a familiar sound, and sometimes is made with such force that it can be heard at a distance of thirty or forty feet. Warner thus alludes to this symptom: "Tooth-grinding is produced by the action of the deeply situated pterygoid muscles; champing of the jaws is produced by the masseter and temporal muscles; all these muscles are supplied by the fifth nerve, and it is to their condition that we must look for information as to the condition of the central origin of the nerve." By means of the Casserian ganglion and small nerve-filaments branching from it, the fifth nerve is brought into intimate connection with the dura mater and adjacent membranes. In chronic insanity associated with dementia these membranes are nearly always found to be in a pathological condition. It is quite natural, therefore, that morbid sensations should be transmitted from these diseased membranes, through the sensory branches of this portion of the fifth nerve, back to its origin in the pons varolii and medulla, and thence be reflected outward along its motor tract to the pterygoid and masseter muscles.

In many cases of maniacal excitement attention has been called to the dry, rough, and almost bristling condition of the hair. In those patients who have recovered from mania the hair resumes its normal condition, is softer, and more easily kept in place. Illustrations of this are seen in Cases XXXIX. (Fig. 335) and XLII. (Fig. 337). In chronic, or in recurrent mania the dry and bristling state of the hair is of common occurrence. One case under the writer's observation, a woman, was characterized by exacerbations of excitement, and at these times her hair was exceedingly dry and stood out in a striking way all about her head and face. In two cases the hair was naturally curly but, as one result of the active mental excitement, there seemed to be imparted to it a stiffness quite different from that produced by the curliness; each individual hair, during the period of excitement appeared to have a special prominence of its own.

This singular condition of the hair, in states of active mental excitement, has been alluded to by Darwin in his "Expression of the Emotions in Man and Animals." His explanation, which is undoubtedly correct, affords another illustration of excessive nerve-muscular activity following cerebral cell irritation. Every hair-sac is provided with delicate unstriped muscular fibres—*arrectores pili*. These minute involuntary muscles are exceedingly liable to contract under the influence of strong emotions, such as fear and anger, as well as from the effects of cold. The contraction of these muscles causes a more or less complete erection of the hair shaft. Darwin concludes that "the erection of the dermal appendages is

Fig. 338.—Case XLII., B. Taken at time of recovery. (From photograph taken by author.)

a reflex action, independent of the will; and this action must be looked at when occurring under the influence of anger or fear, not as a power acquired for the sake of some advantage, but as an incidental result, at least to a large extent, of the sensorium being affected" (Op. cit., p. 102).

In the active mental excitement of mania, acute or chronic, persistent irritation of the cerebral cell-structure leads to the transmission of nerve-force along this channel to the *arrectores pili*—all the more readily because the natural emotions of fear and anger have made this a customary route. Hence in those forms of insanity which are accompanied by excessive nerve-muscular activity this erection of the hair is an almost inevitable result. This condition of the hair is only seen in those forms of mental disease characterized by active excitement, or marked emotional disturbance. The bristling and erection is intensified by the dryness and roughness of the hair due to the impaired action of the subcutaneous glands. Darwin also informs us "that with man the hairs on the front of the head which slope forward, and those on the back of the head which slope backward, are raised in opposite directions by the contraction of the *occipito-frontalis* or scalp muscle" (Ibid., p. 297). This muscle is, as we have seen, often kept in a state of unnatural tension in conditions of pathological cerebral excitement, and hence its action would assist the *arrectores pili* in maintaining an erect and bristling state of the hair.

The study of the portraits calls for a slight digression on the significance of the wearing apparel of the insane. When we consider its neglected, disarranged state, its unique and oftentimes bizarre arrangement; when we contrast the general appearance of the clothing of many of the acute and chronic insane with what we know is characteristic of mental health, then we become impressed with the fact that this matter of the condition and arrangement of a patient's clothing may be of diagnostic or even prognostic value to the alienist. Even in health our estimates of individual character are assisted by observation of the condition and general style of a person's clothing, so closely related to our inner selves have these outer vestments become. Carlyle, in "Sartor Resartus," made no mere imaginative allusion when he asked the question:

"How, then, comes it, may the reflective mind repeat, that the grand tissue of all tissues, the only real tissue, should have been quite overlooked by science, the vestural tissue, namely of woollen or other cloth; which man's soul wears as its outmost wrappage and overall; wherein his whole other tissues are included and screened, his whole faculties work, his whole self lives, moves, and has its being?"

In observing the condition of the clothing of the insane we shall have additional evidence for believing that this "outmost wrappage" may partially reflect the mental and moral state of the individual. For this reason no especial attempt was made in the taking of the various portraits to arrange the wearing apparel for appearance' sake. Many of the views reproduced in this article were taken in the ward, so as to secure a true likeness of the individuals as they appeared at that particular moment.

In all forms of mental disease accompanied by motor disturbance due to excessive and irregular transmission of nerve-force from the brain-cells, we find that the resulting muscular agitation causes the clothing to be disarranged and disorderly, oftener it is torn and partially destroyed. In acute mania, and in the melancholia accompanied by restlessness, the cases to which we have already referred illustrate what has been said about the condition of the clothing. One of the great difficulties encountered by asylum officers is the tendency manifested by the active insane to tear and disarrange their clothing. This is only one way in which nerve-force, generated in excess of inhibitory resistance, seeks an outlet.

In cases of mental failure, such as dementia proceeding from chronic insanity and organic brain disease, the clothing shows neglect, is often untidy unless personally cleansed by another, and seems to hang from the person rather than fit his form. A party of demented patients may be recognized at a distance by the very hanging of their clothing. The absence of healthy muscular resistance, the sluggish gait, drooping shoulders, pendent arms and hands, give to the outer garments a peculiar and almost indescribable appearance, which once recognized cannot be forgotten. It would seem as though the general lack of healthy muscular tonicity, the flabby state of the entire muscular system, characteristic of this form of mental disturbance, had been communicated to the clothing.

The subject of personal attire among the insane should not be dismissed without a passing allusion to the penchant which many of this class exhibit for fantastic dress. In some forms of subacute mania, of the active stage of recurrent mania, or in some cases of mild chronic mania, and noticeably among many of the chronic delusional insane, there is quite frequently exhibited a passion for bright colors, and for personal decoration of a fantastic character.

Artists and dramatists, from the earliest times, have always heightened the effect of their portrayal of insanity by representing the insane as peculiarly decorated with straw, flowers, feathers, or rags. Thus Shakespeare makes Ophelia enter "fantastically dressed with straws and flowers." And in King Lear, Cordelia, when reflecting upon her poor insane father, says:

> "Alack 'tis he; why, he was met even now
> As mad as the vex'd sea, singing aloud;
> Crown'd with rank fumiter, and furrow weeds,
> With hardocks, hemlock, nettles, cuckoo-flowers,
> Darnel, and all the idle weeds that grow
> In our sustaining corn."

Aside from all exaggeration due to the license universally granted the poet and painter, there is an actual scientific foundation for this time-sanctioned portrayal of insanity. It is a matter of common occurrence in asylums for the insane to see patients, suffering from the above-mentioned types of the disease, pick up shining bits of tin, brass, or glass, or brightly colored cloth, and use the same as a decoration for the hair or clothing. Such patients often attach a great value to these worthless materials. While it cannot be said that this tendency for fantastic decoration is always an indication of chronic insanity, it is frequently associated with that form of mental disease. Nearly every asylum contains, among its old residents, some who have made themselves conspicuous for years by the odd and fantastic decoration of their dress; and were it not deemed inadvisable to allow this passion for odd display to be carried too far, such cases would be far more numerous and their costumes much more striking than is usually the case.

Cases XII. (see page 515) and LIV. illustrate the tendency for striking and fantastic display, notwithstanding that in each of these patients an attempt was made to reduce it to a minimum. Case XII., one of chronic mania or paranoiac insanity, manifested a marked fondness for sensational display. In sitting for his portrait he arranged his regalia with the greatest care, wishing that his various pins, "precious stones and diamonds," as he called them, should all be included in the photograph. Case LIV., chronic mania with marked delusional exaltation, always decorated herself in some fantastic manner. At the time the portrait was taken she had evidently taken the greatest pains to produce an effect with her hair and also with the handkerchief which is elaborately displayed on her dress. The peculiar cap was made out of worsted and cotton cloth ravellings, and was considered by her to be a very choice ornament, and in some way a badge of her superiority. She entertained the delusion that she was Christ, the Virgin Mary, and that she had unlimited power. The portrait of this patient is also interesting as showing the marked inhibitory control that exists in the midst of great incoherence of idea and language. No sane person could prove a better poser for her photograph than this very excitable insane woman.

The variety of fantastic decoration that one meets in an asylum is almost endless. The interesting query suggests itself whether this singular fondness for adornment

noticed among the insane is anything more than an exaggeration of a natural proclivity common to mankind generally. In health the desire for personal decoration has certain well-defined limits prescribed by fashion and common sense; but as a result of mental disease this same natural desire is no longer controlled by a healthy judgment and inhibition, and hence this fantastic, grotesque, and odd display.

II. *Physical Expression of the Insane Caused by Deficient Nerve-muscular Activity Due to Central Degeneration.*—Deficient nerve-muscular activity plays a prominent part

FIG. 339.—Case LIV. Chronic Mania. Showing exaltation, fantastic decoration, etc. (From photograph taken by author.)

in the etiology of the physical expression of insanity. A recognition of its existence in any case frequently enables the physician to make a correct diagnosis and prognosis of the mental disease affecting the patient. In nearly all forms of chronic insanity accompanied by mental enfeeblement, deficient nerve-muscular activity corresponds to the degree of mental impairment.

Dementia is the sad termination of all chronic, as well as of many of the acute, insanities. The degree of the dementia varies with individuals, and no definite rule can be given which will indicate just how rapidly or to what extent mental weakness will advance in any particular case.

Sometimes the impairment of mind is very slight, the individual not being incapacitated from living at home and enjoying a fair amount of personal liberty, and performing many acts of life fairly well. Again, the deterioration of mind is such that the patient is incapable of sustaining the responsibilities of life outside an asylum, and yet is made very comfortable by the regularity, intelligence, supervision, and mild restraint of the hospital. Indeed, under careful direction, such patients come to be capable of performing a certain amount of fairly skilled labor. In still other cases, however, the mental impairment has advanced so far that not only is the hospital the only proper and safe residence for the patient, but his entire life in such an institution is helpless and unproductive. He becomes a veritable wreck in which only the slightest semblances of mind can be detected, nearly all the acts of whose life have become purely automatic and vegetative.

Some of these varying degrees of mental weakness are noticeable in nearly all cases of persistent and long-continued insanity, and many cases of acute insanity do not recover so perfectly but that a slight amount of mental damage may be detected. Unfortunately, our knowledge of the pathological anatomy of the brain is so limited that we cannot with precision locate the specific lesion corresponding to the various forms of mental disease. It is generally assumed that the pathological condition is one of degeneration consequent upon hyperæmic and inflammatory processes, or upon inflammatory changes succeeding malnutrition of that delicate organ.

Whatever the pathological alterations in the brain-cells may be, varying degrees of motor impairment constitute one very constant result in all cases of chronic insanity attended with mental weakness. We have already noticed how excessive nerve-muscular activity characterizes nearly all attacks of acute mania, as well as the excited stage of paresis, and the temporary exacerbations of excitement occurring in dementia. In these cases the nerve-force is discharged in excess of the power of resistance, either because the inhibitory power itself is diminished, or because there is an excess of nerve-force generated within the nerve-centres. On the other hand, in cases of persistent and long-continued acute insanity, as well as in chronic insanity associated with the varying degrees of dementia above mentioned, deficient nerve-muscular activity is a prominent symptom. And the inference seems a legitimate one, that this deficient nerve-muscular activity represents or corresponds to certain degenerative processes occurring within the brain-cells. This deficient nerve-muscular activity varies from the slightest motor impairment in a few of the delicate facial muscular strands, to an extreme degree of general muscular paresis.

Griesinger says: "The most important circumstance in regard to anatomical diagnosis and to prognosis is the existence or non-existence of *severe motory disorders*, in particular, of general progressive paralysis." We might add that the slighter motor impairments have a very important bearing upon the diagnosis and prognosis of the patient's mental condition. In nearly all cases of dementia secondary to acute or chronic mental disease, there are evidences of this motor impairment. It is not unlikely that if we possessed instruments for accurately ganging the degree of intensity of motor force in individual muscles in patients suffering from dementia, we should find a much larger deficiency than we realize by our present methods of observation.

This deficient nerve-muscular activity represents imperfect or weakened innervation on the part of the central organ—the brain. All nervous tissue is endowed with one peculiar property, that of *sensibility*. By means of it, "the nerve-cells feel excitation from without, and react in consequence, by virtue of the excitement of their natural affinities" (Luys, "The Brain and its Functions," p. 81). Impaired sensibility of the nerve-cells is a frequent result of protracted attacks of acute insanity, and a constant accompaniment of the various forms of dementia. And in such cases there is imperfect reaction to the various sensory stimulations which, in health, are being constantly transmitted from the periphery to the higher nerve-centres of the brain. Dementia is characterized by imperfect responsiveness to external impressions. It is difficult to arouse and interest such patients. They care little for their surroundings; they eat and sleep, but their energy seems lost. They lie or stand around in a listless way, and oftentimes it is necessary to speak to them in a louder voice in order to attract their attention.

Impaired nervous sensibility is attended with imperfect motor reaction, probably for the reason that the afferent and efferent tracts do not transmit impulses to and from the brain as readily as in health, and also because the brain-cells themselves are less sensitive. Those regions which, in health are most responsive to this excitation are very apt to be the first to become affected in diseases of the central nervous system. For this reason the face, in the earliest stages of dementia, begins to show evi-

dences of impaired innervation. The lines about the eyes, the forehead, and the mouth, which were formerly well defined and which represented the healthy muscular tonicity already referred to, begin to lose their precision and appear to be smoothed out. The peculiar pose of the features, due, as we have seen, to the continuous transmission of nervous force along the various efferent nerve-tracts to the muscular periphery, and which gives what we call character to each individual countenance, seems to have lost its definiteness. As a result the face begins to lose its expression, and in the very earliest stages of the disease constitutes a painful symptom for the friends to behold, and leads the physician to make a grave diagnosis and prognosis.

This defective nerve-muscular activity, which is first manifested in the faces of demented patients, in time extends to the larger muscles of the extremities. Demented patients become clumsy, and if good mechanics, gradually lose the muscular precision which formerly characterized their work. Quite frequently such individuals are obliged to give up a certain line of skilled labor in which they formerly excelled, and undertake a less exacting branch of the work, or renounce it entirely before it becomes fully apparent that their mental health is being seriously undermined. At a still later stage of the disease the muscles of locomotion become impaired, and the patient grows clumsy in gait.

In the wards for demented patients in a large asylum, one is struck with the slow, lumbering gait of the patients, with their lifeless attitudes and the general absence of healthy muscular activity which is evident on every side. A party of demented persons is easily recognizable at a distance. Their muscles, like their clothing, seem to *hang*, and there is none of that elasticity of movement characteristic of health.

This progressive muscular failure is quite noticeable in the cases of terminal dementia, which constitute so large a proportion of the population of public hospitals for the insane. Oftentimes these patients are under observation for years. In the earlier stages of their asylum residence they are capable of performing much manual labor. Gradually, as their dementia advances, they become less capable of sustained work; they may grow fleshy, but their muscles become weaker and more unreliable; and finally they cease to be efficient workers, and spend their time in the ward or on the grounds, lying and lounging about in a listless way. In these cases there is a real failure in nerve-muscular force, which is represented by an inability to enter into mechanical employment, as was formerly their wont.

In cases of structural brain disease the order in which failure of muscular innervation occurs is quite interesting, and has already been referred to. First the muscles about the mouth begin to show weakness; then those about the forehead and between the eyes; later, the articulation begins to fail and to grow more thick and indistinct; and the muscles of deglutition respond so feebly to innervation that the act of swallowing is rendered clumsy and difficult, and the patient is in danger of choking. Finally, the larger muscles of the extremities begin to weaken; the drooping head, shoulders, and arms, and the shuffling, clumsy gait indicate the steady progress of the brain disease.

Warner says: "In a strong and healthy man the head is held erect and symmetrical, unless some central condition or external agent changes the posture. In a strong man the centre of the forehead is in the mid-plane of the body, the antero-posterior and the transverse axes are horizontal, with both eyes on the same level; this is a normal position of quiescence" ("Physical Expression," International Scientific Series, p. 185).

In cases of progressive dementia, in the advancing stages of paresis, this failure of innervation is quite commonly seen in the drooping of the head.

In many cases the lower jaw drops on account of relaxation in those muscles which support it; this gives to the face an elongated expression, and quite frequently occasions the open, stupid-looking mouth so often seen in dementia (Fig. 340).

Defective innervation, as we have seen, finally extends to all the muscles, and produces that peculiar drooping of the body, shoulders, arms, and even fingers, and that almost indescribable, but when once seen never-to-be-forgotten, clumsiness of gait and attitude so characteristic of demented patients.

III. *Physical Expression of the Insane, Caused by or Representing States of Automatic Cell-activity in the Cerebrum, Occurring not Infrequently in Acute Insanity, and Quite Constantly in the Chronic Forms of the Disease.*—The subject of automatic nerve-activity is so well understood that any extended allusion to it would be superfluous. It has been a matter of frequent physiological observation, that all nerve-structure manifests a tendency toward automatic activity. This attribute inherent in nerve-tissue is noticeable in the lowest forms of animal life possessing only the simplest and most rudimentary suggestion of a nervous system. The ascidian illustrates the peculiar mechanical and automatic action of a very simple organism that is wholly unprovided with anything like consciousness. In this animal crude, imperfect sensations are transmitted from its periphery through afferent nerve-fibres to a solitary ganglion; a motor impulse is thus originated in the ganglion, and, being reflected outward to the muscular fibres of the animal's outer sac and orifices, produces in these parts a simple contractile movement. This simple movement is entirely involuntary and reflex, and, upon the presentation of the proper stimulus, is always repeated in identically the same way, during the life of the ascidian.

Fig. 340.—Case of Progressive Dementia. Dropping of lower jaw on account of relaxation of the muscles which support it. (From Kirchoff's Handbook.)

As we ascend the scale of animal life the nervous system becomes more complicated; entire regions are specialized, one part becoming subordinate to another until we reach man, in whom the completest subdivision and specialization has been attained. In him the higher centres in the anterior cerebral region preside over the nerve-structures below, both in the brain and cord. But these more highly specialized centres of the human brain manifest the same tendency to automatic and mechanical activity.

In one respect, however, man differs from other forms of animal life. His *will-power* presides over and directs those various processes which in the lower animals are not only automatic and instinctive, but are largely involuntary. In man a few of the activities of organic life—such as respiration, the beating of the heart, and the like—are transmitted at birth fully established and are entirely independent of the will. Other processes, such as walking, writing, etc., are acquired after a most careful direction of the will and laborious practice, and then become automatic. Still other higher processes, such as the psycho-intellectual activities of the individual, while under the guidance of the will, conform to the universal law of automaticity. Thought runs in certain well-established channels, and "mechanism in thought and morals" is as susceptible of proof as the mechanical action of the heart or the lungs during the processes of

circulation and respiration—the only difference being that volition directs these intellectual and acquired activities.

A high volitional power, therefore, distinguishes man from the lower animals. Even the most highly developed of these lower orders possess limited volitional powers. In them life is largely automatic, and distinct purposive direction of their actions is slight. Many of their acts that seem to display a high degree of intelligence and to suggest the power of voluntary selection, prove, on close examination, to be merely the result of an unreasoning instinct which would not have admitted of any other course. In man, on the contrary, while his daily life is largely made up of various automatic activities, still the range of purposive selection is large, so that the "mechanism of thought and feeling" is made to serve the best interest of the individual through the guidance of the will.

In some way, at present obscurely understood, will-power and functional activity of the cortex are mutually interdependent. Hence disturbance of these centres in insanity, caused by impaired nutrition, defective functional activity, or more gross structural lesions, weakens the will-power of the individual. The functional activity of the cortical centres may be completely disarranged by insanity, and, as a result, the normal exercise of the will may be disturbed, if not entirely suspended. At the same time, however, the activities of the basal ganglia, no longer under the guiding and controlling influences of the cortical centres, continue automatically. As a result, purposeless thought and action of an automatic character is quite apt to follow those serious disturbances of the higher cerebral centres during attacks of severe acute and chronic insanity.

Automatic activity of the cerebral centres in health is subject to the direction of the will, and its results display purpose. Automatic activity of these same centres in disease of the mind seems to be less under the guidance of the will, and the resulting action appears purposeless. In proportion as the will-power is weakened by the brain disease, do meaningless automatic activities of thought and action prevail.

In passing through the wards for the chronic and demented insane, one is struck with the evidences on every side of automatic activity. Here you will notice a man walking backward and forward in a mechanical way for hours together, until he has worn a beaten path in the floor; there will stand one who picks away at a certain place on his clothing for an indefinite period, until he has worn the garment through to the skin. Quite frequently one will hear curious meaningless noises repeated in a mechanical way—singular repetitions of certain words or sentences wholly meaningless. It is not an uncommon thing for chronic patients to have some peculiar word or phrase, or even a single articulate sound, and to repeat it in an irrelevant way for years. In like manner you will meet with patients who make strange motions with the arms and hands, and take singular attitudes in a mechanical way. It is difficult to arouse the attention of such patients; their monotonous repetition of words and movements continues just the same, regardless of the presence of others, and with little reference to any attempts made for their diversion. All this variety of automatic action and speech would seem to indicate that the healthy functional activity of the higher cerebral centres has been disturbed and partially suspended, and that the lower centres are acting mechanically and without the normal volitional control.

Prolonged automatic activity in thought, speech, and action, among the insane, suggests a serious lesion in the higher brain. The more mechanical and purposeless the words and acts of the patient, the graver is the prognosis.

The nervous system manifests a striking tendency to mechanical repetition of any process once initiated within its centres. One epileptic attack is likely to be followed by another, and a number of seizures renders the prospect of still others quite certain, until in a short time the disease becomes firmly established. Both mania and melancholia manifest tendencies to repetitions of the attack, and each new attack renders the probability of another quite certain, until recurrency or permanent insanity is established.

In the advanced stages of fevers, such as typhoid and scarlatina, the higher functions of the mind are often suspended, either from exhaustion, or because the cortical centres have been disturbed by the severity of the febrile action. In these grave physical conditions the automatic and purposeless repetition of words and muscular movements becomes quite noticeable. Subsultus tendinum, carphologia, tiresome utterance of some particular sound or word, indicate that the higher cerebral functions have been suspended, and that the lower centres are acting at random and without the direction of the former. In this case the prognosis is grave because the vital forces themselves are waning and volitional activity is suspended through exhaustion of the cortical centres.

In chronic insanity the prognosis as to mental recovery of the patient may be equally grave, for the reason that healthy functional activity of the cortex has been permanently disturbed by the disease, which, though not necessarily fatal to life, is most assuredly so to mental restoration.

For the reasons just outlined the chronic insane are very likely to develop objectionable habits. The study of the physiological origin of many of the habits of this class of the insane would be most interesting and instructive. Two laws underlie every form of nervous activity, and furnish a physiological reason for the constant tendency toward automatic and habit-action exhibited by the chronic insane in whom inhibitory impairment always exists. 1. The discharge of the nerve-centres occurs along those tracts which offer the least resistance. 2. The more frequently the discharge occurs along a given line, and the weaker the inhibitory resistance, the easier does a repetition of the discharge become, and the more certain its permanent automatic establishment.

If, for any reason, in those conditions of mental disease characterized by a weakening of the will-power, one especial route is established either by reason of delusion, or mere fortuitous circumstance, the probability is that this particular route will continue to be the one most frequently traversed by nervous force in its passage from the brain to the periphery. A delusion, an hallucination of sight or hearing, some peculiar condition in the patient's environment may have first initiated certain actions which, by being unresisted, and hence repeated, lead to the establishment of a habit. Probably in some such simple and purely fortuitous way are developed the pulling out of the hair, tearing the clothing, walking in a beaten path, making singular motions or uttering meaningless sounds—in fact any of the countless strange habits of the insane. It matters little whether the performance of these habits is painful or disagreeable, no other alternative seems open to the patient when, through weakness of will and intelligence, the morbid route has once been established. Some morbid sensation in the scalp or chin to act as an exciter, or merely the absence of anything of an intelligent character to engage the attention, may lead to the plucking out of the hair or beard, which impulse, meeting with no resistance, soon develops into a persistent habit. A delusion about the bed may lead the patient into the habit of standing up all night, and if not interrupted, nothing short of restraint will prevent exhaustion, so persistent will the impulse become to remain on the feet.

The importance of the early breaking up of bad habits among the insane will be readily understood. Fortunately the same tendency to automaticity of action may be utilized in a good as well as a bad direction. By careful supervision we may succeed in breaking up many useless and vicious habits by supplying some simple mechanical occupation for the hands, thereby utilizing the automatic nerve-activity characteristic of the disease. And in doing this we may even seem to retard mental deterioration. Judiciously selected, mechanical employment among the insane has become therefore a valuable means of treatment.

It is quite obvious that photographic illustration of the entire subject of automatic nerve-activity is impossible,

and yet enough in this direction may be shown to demonstrate the important part played by morbid automatic cell-activity in the physical expression of chronic insanity, and, to a certain extent, in some forms of acute alienation. It is evident that illustration of this part of the subject must be limited to postures. The significance of postures in health has been referred to by Dr. Francis Warner in an article on "Muscular Movements in Man," in the April number, 1889, of the *Journal of Mental Science*. He says: "Postures depend upon the ratios of nerve-muscular action, and to some extent they indicate the present ratios of static efferent force proceeding from the centres concerned. Observations show that the postures, when not due to a present stimulus, or when produced by a weak stimulus from without, such as a sound or sight, correspond to and are signs of the general condition of the central nerve-system."

The postures maintained, oftentimes for long periods, by the insane possess a special interest because they are a pretty sure index of the morbid condition of the central organ of innervation.

Cases LI., LVIII., and LX., illustrate peculiar and somewhat painful attitudes which were taken by patients suffering from secondary or terminal dementia. And in Case LXV. is seen a singular position maintained by a patient in a condition of stuporous melancholia. In these

Fig. 341.—Case LXV. Melancholia with Stupor. Showing persistent morbid attitude maintained for hours. (From photograph taken by author.)

and similar cases the intensely interesting question is always suggested, how came such peculiar habits to be initiated? The wards for demented patients will present numerous cases of this character which will afford material for physiological and psychological study. The careful investigation into the early development of mechanical movements, attitudes, and meaningless habits among this class of patients, would amply repay the time and labor expended in this direction, and throw some

Fig. 342.—Case LVIII. Chronic Dementia. Peculiar and uncomfortable attitude maintained daily for years. Automatic nerve-muscular activity. (From photograph taken by author.)

light on the processes of cerebration and their connection with muscular movements.

The singular postures shown in the photographs of Cases LI., LVIII., and LX., were gradually assumed by the patients while under the writer's care, and yet so very slowly were they initiated that they became fixed and habitual positions before any especial attention was called to the fact. In this way the real causes that led up to the final establishment of the habitual posture were lost sight of. From what was known of the patients, the impression would be readily formed that in Cases LVIII. and LX. delusions of suspicion or a dislike to seeing persons about, led to a habit of hiding the face, as is often witnessed among bashful and diffident children. As these particular patients became more demented, a position which was at first assumed as the result of an active delusion finally developed into a permanent habit, simply because nervous force, flowing along this route from centre to periphery for so long a time in obedience to impulses derived from morbid ideas, and meeting with little inhibition, continued to take this route long after active thinking had ceased.

Another interesting fact concerning these strange attitudes assumed by these patients is, that they seem utterly oblivious to the discomfort and even the painfulness of these constrained positions. Cases LI. and LX. would maintain the posture for hours; and Case LVIII., from

Fig. 343.—Case LI. Chronic Dementia. Showing peculiar and uncomfortable attitude assumed by demented person as a result of morbid and persistent nerve-muscular activity. (From photograph taken by author.)

the hour of rising until bed-time, was continually in the attitude shown in the photograph. The muscles concerned in the maintenance of these postures were in a high state of tension, showing that a certain amount of "static efferent force" was being transmitted continuously from the centres within the sensorium to the periphery over these morbidly pre-established routes. Nearly all the other healthy activities of mind seemed in these cases to have ceased with the exception of the mere processes of organic life, and the entire energy of the sensorium was expended in keeping up these automatic and useless positions. Any attempt to move the arms into a more easy position was met by firm resistance, which was not spasmodic but persistent in character. That these attitudes would be painful to a person in health, anyone can demonstrate by attempting to maintain similar positions for even a few minutes at a time.

There remain for consideration the various positions and expressions of the eye as modified by insanity. These, though largely dependent upon the different pathological conditions already discussed, still are deserving of separate mention.

Every writer upon physiognomy gives great prominence to the eye as an agent in expression. Bell, in his "Anatomy of Expression," has said: "The eye is the most lively feature in the countenance; the first of our senses to awake, and the last to cease motion. It is indicative of the higher and holier emotions, of all those feelings which distinguish man from the brutes" (Ibid., p. 94).

Schack, with earnest enthusiasm, says: "The eye is the most immediate and most delicate point of transition between body and soul; it is the most interesting and most *spirituelle* part of the physiognomy, and has been rightly called the mirror of the mind. Brilliant or dull, it contains remembrances of the past and enables us to prophesy of the future. Joy gives it clearness, sadness and grief fill it with shadow; it speaks a language which sympathy understands at once without the aid of words or a dictionary" ("The Physiognomy in Man and Animals," p. 76).

In speaking of the expression of the eye physiognomists generally allude to the eyebrows, the eyelids, and those parts immediately surrounding the organ as well as the eyeball itself. Indeed, it would be difficult to do otherwise, so intimately associated are the muscular movements of these various parts, and so actively do they all enter into what is commonly called the expression of the eye. Schack, in an interesting chapter on the eye, gives several pictorial illustrations which are intended to represent that organ in the various states of joy, anger, revenge, shame, and so forth. In these sketches it is noticeable, however, that the expression owes its individuality, in nearly every instance, to the position of the

Fig. 344.—Case LX. Chronic Dementia. Uncomfortable attitude maintained for a long period. Automatic nerve-muscular activity. (From photograph taken by author.)

parts about the eye as much as to any particular change in the organ itself.

In a limited way, however, the eye itself entirely dissociated from surrounding parts, is subject to certain

changes which modify its expression. In studying the eyes of the insane it is proposed to limit our observation to these very changes, the muscular movements of adjacent parts having already received discussion in previous sections.

Three conditions modify the expression of the eye:

I. The state of the iris.

II. The degree of brilliancy of the organ.

III. The position of the eyeball in its socket and its mobility.

I. The state of the iris may be either one of contraction or dilatation. Neither of these, however, plays any prominent part in modifying the expression of the individual.

II. The degree of brilliancy of the organ exerts a wider influence upon expression, and variations from extreme dulness to remarkable lustre are of frequent occurrence in the different phases of insanity. This quality of brilliancy is quite characteristic of the eye in states of health, and has been alluded to by Darwin, Mantegazza, Schack, and others. Its physiological causation is of much interest and has been variouly explained by different authors. Darwin says: "A bright and sparkling eye is as characteristic of a placid or amused state of mind, as is the retraction of the corners of the mouth and upper lip with the wrinkles thus produced. Even the eyes of microcephalous idiots, who are so degraded that they never learn to speak, brighten slightly when they are pleased. Under extreme laughter the eyes are too much suffused with tears to sparkle; but the moisture squeezed out of the glands during moderate laughter or smiling may aid in giving them lustre; though this must be of altogether subordinate importance, as they become dull from grief, though they are then often moist. Their brightness seems to be chiefly due to their tenseness, owing to the contraction of the orbicular muscles and to the pressure of the raised cheeks. But according to Dr. Piderit, who has discussed this point more fully than any other writer, the tenseness may be largely attributed to the eyeballs becoming filled with blood and other fluids, from the acceleration of the circulation consequent on excitement of pleasure. He remarks on the contrast in the appearance of the eyes of a hectic patient with a rapid circulation, and of a man suffering from cholera with almost all the fluids of his body drained from him. Any cause which lowers the circulation deadens the eye. I remember seeing a man utterly prostrated by prolonged and severe exertion during a very hot day, and a bystander compared his eyes to those of a boiled codfish" (Darwin, "Expression of the Emotions in Man and Animals," Am. Ed., p. 206).

Schack, in describing the physiognomy of laughter, says: "The glance of the eye at the same time becomes shining and brilliant, a fact which is in part due to the increased secretion of the lachrymal gland, and probably also to the inner tension of the eyeball which is the result of the increase of circulation under the influence of pleasure" (Schack, ibid., p. 126).

Mantegazza says with great truth: "The eyes have a remarkable brilliancy which goes far toward modifying the expression. The eye of one who laughs, of one who thinks or speaks with energy, is very brilliant; the eye of a stupid, feeble, or sick man has little brilliancy; while the eye of one who is moribund seems to be almost extinguished. This brilliancy deserves an attentive examination, for it is one of the most important and obscure elements that enter into the study of the eye. For the moment we ought to content ourselves with saying that this condition depends in part upon the structure of the cornea, upon its variable convexity under the influence of the ocular muscles, upon the humors secreted by the eye, and especially upon the veil of tears which bathes its entire outer surface" (Mantegazza, ibid., p. 36). And again the same author says: "Popular opinion attributes a lively eye to the man of genius, and a dull eye to the stupid man. In fact, in the former a continuous discharge of nerve-energy is being liberated from the central nervous system which finds an abundant outlet in the numerous muscles of the eye; hence the movements and oscillations of these muscles, hence also the veil of tears which renders the eye brilliant" (Mantegazza, ibid., p. 245).

These different physiological reasons for varying brilliancy of the eye under corresponding emotional and intellectual states, find interesting illustration and confirmation in the eyes of the insane. Among the insane, as in no other class, there exist in full force the very conditions noted by the physiognomists whose views have just been quoted. Prominent among the factors that enter into the causation of a brilliant eye, none are more important than the varying tenseness of the ocular muscles, due, as Mantegazza says, to the continuous discharge of nerve-energy along the efferent routes to these particular muscles. Varying degrees of convexity of the eyeball, caused by the alternate contraction and relaxation of the ocular muscles, produce variations in the refraction of light from its smooth surfaces, a fact which may in large measure account for the changes in brilliancy, assisted as it must be by the squeezing out of a greater or less amount of fluid from the lachrymal glands.

These different degrees of muscle tension, varying as they do from the ordinary tonicity of health to extreme contraction and relaxation, are, as has been seen, of common occurrence in the different types and stages of mental disease. Variations in the brilliancy of the eye among the insane would seem, therefore, to find one very natural explanation in the different degrees of efferent nerve-muscular activity, so commonly witnessed in this disease, and which is distributed to the ocular in common with all other muscles, causing thereby varying degrees of tension and convexity of the eyeball, and corresponding variations in the refraction of light from its surface.

Another cause assigned for increased brilliancy of the eye is that given by Piderit, and referred to by Darwin in the quotation given above, namely, an acceleration of the circulation consequent upon emotional excitement. Nearly all conditions of increased cerebral circulation are followed by a peculiar brilliancy of the eye. On the contrary, a slow and depressed circulation is followed by a dull and lustreless eye. Even in conditions of depraved physical health, provided the circulation is more rapid, the eye assumes a brighter aspect. We see this in the later stages of phthisis, where, as a compensation for the loss of aerating surface within the lung, the heart is urged on to greater frequency and impels the blood more rapidly through the arteries; and by reason of this heightened circulation, the eyes of such patients assume oftentimes an almost unnatural brilliancy. By reason of increased cerebral circulation it may also be quite likely that the eye of acute mania assumes its brilliancy, while in the slow circulation of melancholia and dementia just the reverse obtains.

We may conclude, then, that changes in the brilliancy of the eye may be due to either one or both of the two causes mentioned: varying tension of the eyeball caused by the transmission of nerve-muscular force from the nervous centres to the ocular muscles, or the presence of a greater or less amount of fluid within the transparent media of the eye as a result of increased flow of blood in that region. Either or both of these causes may account for variations in brilliancy noticeable in different forms of mental disease.

Unfortunately, this important element in the expression of the insane does not admit of satisfactory illustration, the flash of light from the eye being of too fleeting and evanescent a character to be caught and retained by the sensitive plate in the camera. In a general way, every form of insanity which is attended by increased nervous activity, with or without more rapid heart-action, is characterized by brilliancy of the eye. The eye of dementia, of melancholia, of the depressed stage of *folie circulaire*, is dull and lacking in brilliancy; the eye of acute mania, of the exhilarated stage of *folie circulaire*, and of those acutely maniacal conditions frequently witnessed in paresis, is brilliant and glistening.

Striking illustrations of a change from brilliancy to dulness are often very noticeable in different stages of the disease in the same individual, although it is ex-

tremely difficult to get a satisfactory portrait illustrating such change.

III. The position of the eyeball in its orbit, and its mobility. The position of the eyeball in the orbit is a very prominent factor in facial expression. Six small muscles guide the eye in various directions. Four of these muscles, the *recti*, are under the influence of the will, and during our waking hours are in almost constant activity. They conjointly balance each other and maintain that slight convergence of the eyes which Darwin says is necessary in binocular vision. The two oblique muscles are involuntary in character and apparently serve a double purpose. They rotate the eyeball on its antero-posterior axis—"this kind of movement being required," as Gray says, "for the correct viewing of an object when the head is moved laterally, as from shoulder to shoulder, in order that the picture may fall in all respects on the same part of the retina of each eye." The oblique muscles also serve the purpose of rolling the eyeball upward under the lid. The recti being voluntary muscles, their action ceases during sleep and in states of deep unconsciousness, and then the oblique muscles, meeting with no counteracting influences, roll the eyeball upward. Sir Charles Bell called attention to this interesting action of the oblique muscles, which is undoubtedly intended to protect the delicate surface of the cornea from being exposed, in case the lids remained partially opened during states of unconsciousness.

Between the extreme condition of entire relaxation, occurring in states of sleep and unconsciousness, and the varying degrees of tension necessary to the direction of the eyes during the waking hours, the recti undergo a certain relaxation corresponding to the state of the faculty of attention.

In health the faculty of attention is in nearly continuous activity. During the waking hours some person or some thing near or remote is, by this act of attention, being made an object of vision. Except in moments of introspection or reverie the sensorium is, by the guidance of the attention, being brought in contact with the environment through the sense of sight. For this reason the eyes are kept in a state of gentle convergence—such a position being necessary to binocular vision. The least withdrawal of the attention from any object in the immediate or remote environment is at once followed by a partial relaxation of the recti muscles, and as a result the eyes slightly depart from their condition of convergence and appear to be directed forward, or in nearly parallel or slightly divergent lines. This is the position of the eyes in states of reflection or absent-mindedness, which gives to the face a characteristic expression that receives a familiar and sometimes annoying illustration in every-day conversation. While conversing with a friend we are suddenly made aware, by a change in the position of his eyes, that he is not any longer looking at us, but apparently through or beyond us; and by this same parallelism of the eyes we are conscious that his attention has ceased to be interested in what we are saying and has become occupied with other things.

As before remarked, impairment of this faculty of attention is one of the first results of insanity. Disordered inhibition associated with enfeeblement of the will-power leads to a positive weakening of the faculty. The mind of the insane patient is often entirely preoccupied. Morbid trains of thought, delusions of suspicion, fears, intense subjective ideation fill his mind, and, by reason of the inhibitory incapacity consequent upon the disease, these morbid psychic processes continue unchecked. As a result the recti muscles undergo relaxation, allowing the eyes to depart from that state of convergence which is the usual result of the normal exercise of the faculty of attention.

Ocular parallelism or divergence, therefore, which follows absent-mindedness in health and is then of mere temporary character, may become in many forms of insanity a prevailing condition, thereby forming a very striking feature in the facial expression of the disease. In such a condition of the eyes the person does not seem to take any interest in his environment. Oftentimes the eyes have a staring look, and in many forms of insanity all attempts at diversion are futile, the patient continuing to manifest that painfully stony and glaring aspect which show how intense is the mental absorption. Indeed, one of the first symptoms of insanity observed by the friends is this peculiar expression due to ocular parallelism. They often refer to a certain strange, unnatural, or wild appearance about the eyes which is undoubtedly brought about by the divergence due to almost constant morbid preoccupation of the attention.

In the late John McCullough's masterly representation of the insanity of Virginius, or the feigned insanity of Brutus, one of the most striking features of his portrayal of the morbid mental condition was the apparent centring of the eyes upon vacant space, rather than upon near objects. The idea was at once conveyed to the

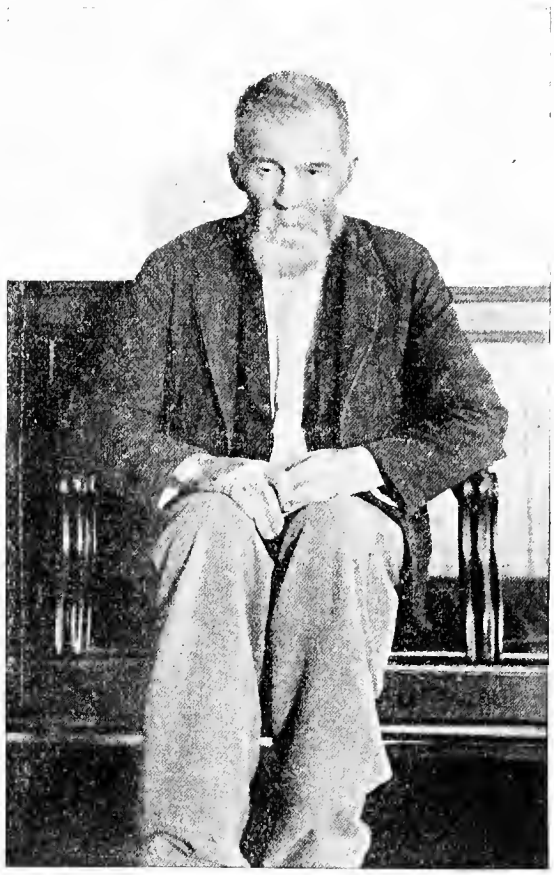

FIG. 345.—Case XLIX. Senile Dementia. Showing ocular divergence, neglect of personal appearance, general absence of healthy muscular tonicity. (From photograph taken by author.)

spectator that the mind of the character represented was preoccupied with ideas entirely outside his environment.

In the early stages of delusional insanity, in melancholia, in many conditions of mania, and in dementia, ocular parallelism is of frequent occurrence, either on account of the intense preoccupation of the mind with subjective ideas, or on account of absence of ideation, or, lastly, because ideas are so hurriedly brought up before the mind that the individual is unable to direct his attention upon anything or anybody about him, and convergence, if it does occur, is merely momentary. In conclusion, it may be said that ocular parallelism or convergence among the insane represents, if persistent, the extent to which the faculty of attention is weakened by the disease. Thus the demented, in whom the power of attention has been almost entirely destroyed, nearly always presents a

vacant, staring appearance of the eyes, and in extreme cases it becomes absolutely impossible to induce that convergence of the eyes characteristic of the healthy binocular vision. The same is true of cases afflicted with *melancholia attonita*. From the extreme and persistent ocular parallelism noticeable in terminal and organic dementia and *melancholia attonita* there may occur all

FIG. 346. Case XXXIII. Acute Suicidal Melancholia. A. Taken at height of attack. Trophic alterations, ocular divergence, and self-absorption well marked. (From photograph taken by author.)

varieties of the condition to those cases in which the faculty of attention is so slightly disturbed by the mental disease that the position of the eyes does not vary from that which is characteristic of health.

Case XLIX. illustrates the fact that deficient ideation, accompanied with actual impairment of the faculty of attention, is attended with parallelism of the eyes or slight divergence. If one should stand directly in front of this individual he would find it almost impossible to place himself directly in the line of his vision. This patient's position is very characteristic. He appears to be staring into vacancy, not because his mind is preoccupied with any particular line of thought, but rather on account of absence of active thought of any kind.

Cases XXXI. (see page 510) and XXXIII. (see page 528) present ocular divergence in states of active melancholia. In these individuals the eyes depart from the normal convergence of health because the mind is so intensely preoccupied with some one dominant idea or class of ideas as to be actually incapable of being aroused or attracted. It is impossible to interest these unhappy minds in any subject. Either some one idea of painful character has excluded every other thought, or the cortical centres themselves have been so overwhelmed by the force and intensity of the morbid ideation as to be incapable of farther functional activity. These same cases are particularly interesting because in each of them we have excellent views both at the time of greatest morbid intensity and during perfect health.

In XXXIII. the series show the gradual but steady progress of the mind toward recovery. In Fig. 346, A the eyes are fixed in a state of divergence. No amount of urging can prevail upon the person to awaken from his intense painful preoccupation of mind. In Fig. 347, B there is evidently the beginning of an awakening—the attention can be aroused momentarily. In Fig. 348, C and Fig. 349, D the change has become complete and the patient takes an intelligent interest in his environment. This case recovered and retained perfect recollection of the fearful mental torture through which he passed. He was able to give an intelligent account of his ideas, and the reason for his vacant, preoccupied, divergent stare lay in the entire suspension of the faculty of attention to anything but his own morbid ideas, and a complete lack of interest in anything in his environment.

Case XLII. (see page 519) shows ocular divergence in a state of acute mania. Here the cerebral activity is so persistent that ideas are hurried through the mind more rapidly than they can be grasped by the attention. The condition is exactly the reverse of what occurs in dementia. In dementia there is absence of ideas, while in mania there is such an excess of ideas that the attention is bewildered and paralyzed. So great is the mental confusion that the patient is incapacitated from taking any interest in his environment. The eyes of such patients are rarely centred upon anything, and complete incoherence of thought is manifested by the position of the eyes almost as much as by disordered speech and action.

Cases of mild mania and delusional insanity very frequently present this condition of ocular divergence. Either the mind is confused with a number of irrelevant ideas and the attention is thus diverted, or some one persistent idea or series of ideas so completely absorbs the patient's attention that that faculty seems to be incapable of being aroused by anything in the immediate environment.

The mobility of the eye in the orbit is quite a prominent factor in facial expression, and is subject to great variation in the different phases of insanity. The nervous supply to the muscles of the eye is abundant and is

FIG. 347.—Case XXXIII. B. Taken three months later. Self-absorption less marked. Delusions beginning to weaken. Health improving. (From photograph taken by author.)

distributed through three main tracts: the motor oculi, the fourth nerve, and the sixth, or *abducens*. The discharge of nervous energy which is constantly taking place along the various efferent tracts during periods of cerebral activity, undoubtedly follows these three nerve-tracts to the muscles of the eye. Such an elimination of nerve-force is, as we have already noticed, one cause of the brilliant and glistening eye of mental activity. In

the active cerebral excitement consequent on attacks of mania a similar discharge of nervous energy passes along these same routes to the various eye-muscles. Not only are the eyes of the actively insane quite brilliant, they

Fig. 348.—Case XXXIII. C, taken two months after B. Convalescence established. Healthy ideation and restoration of physical health. (From photograph taken by author.)

also possess great mobility; and rapid movements of the eye, giving to that organ a character of restlessness, are important factors in the facial expression of nearly every case of active insanity.

This pathological transmission of nerve-force from the

Fig. 349.—Case XXXIII. D. Recovery. Taken at time of discharge. (From photograph taken by author.)

cerebral centres to the muscular periphery, which has been referred to in the previous pages as excessive, deficient, or automatic in character, leads to a certain asymmetry of the muscles, particularly noticeable in the face. For this reason any collection of photographs of the insane presents a bizarre appearance. In acute mania, for instance, irregular and spasmodic action of the cortical centres produces meaningless expressions and asymmetrical contractions of the facial muscles, noticeable in Case XLII, Fig. 337, A (see page 519). Here it may be supposed that the centres in the motor area act independently of each other, or that there is imperfect co-ordination. One group of muscles are contracted, while the corresponding group upon the other side are relaxed. The usual bilateral contractions that occur in the normal facial expression of the emotions are absent in these cases (see Fig. 350).

Among the demented insane organic degeneration of cortical areas produces a very similar result. This is illustrated in the strange attitudes and persistent meaningless position of groups of muscles. In dementia it may be supposed that one group of cortical cells may have been destroyed by degenerative processes, and that co-ordinate action between cortical areas ordinarily associated has thus become physically impossible. Again, in acute alcoholism the same kind of irregular and one-sided action of muscles occurs. And in this case there is good reason for supposing that the toxic influence of the drug has impaired the normal activity of the cell to such a degree that there is a withdrawal of the supply of nerve-force necessary to healthy muscular action. The alcohol in the cerebral circulation affects one group of cells more than another, or so impairs normal co-ordination that muscular movements are jerky and uncertain. Both the face and the gait of the intoxicated man disclose the asymmetrical and irregular action of the centres of the motor area. In the paretic, the organic changes that have occurred in the cortical cells are clearly revealed in the imperfect co-ordination of different groups of muscles, particularly those of the mouth, tongue, and throat.

Fig. 350.—One-sided Contraction of the Facial Muscles of Expression. (From Kirchoff's Handbook.)

In studying the physical expression of insanity, one thing is worthy of note. Departure from normal expression keeps pace with functional and organic disturbance in the cortex. The distortion and agitation of mania, the dissolution of expression witnessed in organic dementia, or in melancholia with stupor, correspond to extreme functional or structural disturbance in the cortical centres. As inhibition, the power of attention, and intellectual activity depend upon the integrity of the cells in the cortical area, we may conclude that the changes in the physical expression of the insane are associated with certain inhibitory and intellectual disturbances, accompanied in the later stages with motor enfeeblement. These psychological concomitants of the physical expression of insanity represent the pathological changes that have occurred in the cortex. Hence it happens that the expression differs in different cases of mental disease according to the degree of functional or structural impairment of the cortical area. Slight departure from normal expression is evident in Cases XII. (see page 515)

and LIV. (see page 521), notwithstanding that the patients are affected with marked delusional insanity; on the other hand, in Cases XLII. A (see page 519), LXV. (see page 524), XXXIX. (see page 518), and in the woman shown in Fig. 351, there is great disturbance, and even distortion of expression in some instances. The explanation of the difference in the character of the expression in the two classes of cases may be found in the varying character of the functional disturbance in the cerebrum. In Cases XLII. A, LXV., etc., normal intellectual activity is interfered with, inhibition is diminished, and the power of attention so temporarily or permanently damaged as to be nearly useless; while in Cases XII. and LIV. the inhibitory and intellectual processes are quite well preserved, notwithstanding the fact that there is marked delusional insanity. Case XII. could sit for his photograph with as much ease and confidence as any sane person, owing to the preservation of inhibitory power and the ability to concentrate his attention upon his immediate environment. Case XLII., on the other hand, owing to his motor restlessness and his intellectual incoherence, was entirely unable to sit intelligently for his portrait, and a likeness was only secured by the aid of instantaneous photography. The greatest diversity of physical expression is encountered, therefore, among the insane. Many very natural and intelligent countenances are noticeable in the extremely deluded, simply because the functional cortical activities underlying inhibition, attention, and ordinary intellection have not been impaired.

Fig. 351.—Delusional Melancholia, with Ideas of Fear. (From Kirchoff's Handbook.)

Fig. 352.—Delusional Melancholia, with Ideas of Fear. (From Kirchoff's Handbook.)

In conclusion, it may be said that the study of the physical expression of the insane by the aid of instantaneous photography is a matter of much interest to the psychologist, indeed may become a valuable aid to diagnosis and prognosis. A series of photographs illustrating an individual in different stages of mental alienation gives a good illustration of changes that have taken place in the central nervous system. Every hospital for the insane should possess a photographic outfit and preserve pictures illustrating the individual in various stages of his disease. The slow but steady disintegration of expression preserved in the photograph will become an accurate index of the organic failure that has occurred in the brain. On the other hand, the return of normal muscular tonicity, of natural expression as evidenced in the trophic condition and normal motor activities of the muscles of the face and extremities, is an equally sure index of the reparative processes that have occurred in the central nervous system. It may not be too visionary to suppose that a careful study of photographs, taken at different periods in the life of an individual whose case has come before the courts, may prove to be of medico-legal importance, and give the medical expert valuable assistance in comparing the past with the present meutal and moral status of the case. *Charles P. Bancroft.*

INTESTINAL DISEASES: DYSENTERY. In the light of recent investigation the word "Dysentery" has but little right to occupy a place at the head of this article. Originally used to express a certain set of symptoms, which differed entirely from those included under the term "Diarrhœa," it uow covers pathological states which differ very much in nature and extent, and does not define varieties which are unlike anatomically and etiologically. The so-called dysenteric lesions may have diarrhœa as a symptom, and simple catarrhal changes in the mucous membrane may be attended by tormina, tenesmus, and dysenteric stools.

The symptoms vary to such an extent that they cannot be made a basis for study; pathological changes and etiology will alone help us to define the nature of the different forms, and a new nomenclature must be based upon new methods of investigation.

Nevertheless the word dysentery is still used to indicate certain pathological changes which occur in the intestine from various causes; it even includes a condition proven to be due to a specific cause with characteristic anatomical changes, as well as other special ulcerative changes which may be dependent upon bacilli not yet isolated.

In the present state of our knowledge the conditions formerly included under our term "Dysentery" can be differentiated into—*a*, simple catarrhal dysentery; *b*, diphtheritic dysentery; *c*, amœbic dysentery.

Catarrhal Dysentery.—In the milder cases of this form there may be no change beyond a more or less intense hyperæmia of the mucous membrane occupying areas of varying extent. Punctiform hemorrhages may be seen in the mucosa or submucosa. The mucous coat may be swollen and covered with much mucus and pus cells. The surface epithelium may be absent, and the exfoliation of epithelium may involve the glands. There may be destruction of the tissue of the mucous membrane; shallow ulcers are seen, and are formed by extension of the superficial softening. Sometimes the ulcers extend to the muscular coat. In the submucosa, which is much thickened, there are masses of granulation and pus cells, and the connective-tissue cells are enormously swollen. The solitary follicles are swollen from hyperplasia of lymphatic tissue; from distention they burst and an ulcer is formed. This form may undergo cure by an arrest of the disease and healing of the spots of ulceration, or the ulcers remain and show no tendency to heal.

This form is frequently a complication of other and generally chronic diseases. It constitutes the most frequent form outside of the tropics, and is the one which we most frequently see as sporadic dysentery.

The *symptoms* usually begin suddenly, sometimes with diarrhœal discharges, or with "dysenteric" stools from the start. These consist of blood and mucus; later, pus may be seen and the discharges may become more fluid and abundant. Tormina, rectal tenesmus, vesical tenesmus, prolapsus ani, with continued fever, constitute the chief symptoms. Improvement begins with a diminution in the number of the stools, the disappearance of blood and mucus, and the reappearance of

fecal matter. The fever subsides and there is a return of appetite and strength. Relapses may occur. The duration is from one to two weeks in mild cases, but the attack may be prolonged to four weeks.

Diphtheritic Dysentery. — Diphtheritic dysentery is so called because of the presence of a membrane on the surface of the mucous membrane of the large intestine, and sometimes of the small intestine as well. This is composed partly of a fibrinous exudation, but is chiefly necrotic tissue.

The process is as follows: On the surface of the hyperæmic mucous membrane small, whitish-gray patches appear, which cannot be removed without causing a loss of substance. By coalescence large membranous areas are formed, which may completely line portions of the tubes, or the patches may continue distinct, small membranous patches being scattered over the surface. These changes are most marked at the bends of the intestine. The intervening mucous membrane may be intensely hyperæmic in the most acute cases; in others it is unchanged.

Microscopic examination shows the membrane to be composed of necrotic cells, nuclear detritus, and masses of fibrine, which involve the mucosa to varying depths. Between it and the healthy tissue there is a line of demarcation formed of pus cells. In the submucous tissue there is intense injection. The vessels are dilated and surrounded by a zone of small-cell infiltration. Fibrine is sometimes exuded in the submucous tissue, having no connection with the surface membrane. The pseudomembrane is subsequently separated from the tissue below by suppuration, and is thrown off, leaving an ulcerated surface. The ulcers vary in size with the extent and depth of the necrosed tissue; they may heal, or exudation and necrosis may go on, destroying deeper and larger areas and causing large and irregular ulcers. By healing, large and irregular cicatrices may form, and the wall of the intestine may be thickened and its lumen narrowed. Inflammation may extend to the peritoneum or perforation may result.

This form of dysentery is the one usually found in epidemics. The *symptoms* are more pronounced, and constitutional disturbance is more marked than in the preceding form. Fever of varying intensity is observed, with great prostration, abdominal pain, and frequent discharges. The stools at first may present the same characters as those in the catarrhal form, but later they become more watery, with membranous fragments, and at times large necrotic masses of putrid odor are passed, with or without tenesmus, depending upon the location of the ulceration.

The bacteriological research in both catarrhal and diphtheritic dysentery is full of interest, though nothing positive can be stated as to any specific bacillus. In 1869 Hallier observed a number of micrococci in dysenteric discharges, which he claimed to have differentiated from the discharges of diarrhœa and healthy fæces.

There are two species of bacteria present in the healthy intestine, viz., *bacterium lactis aërogeneus*, which is usually found in the upper, and *bacterium coli commune*, found normally in the lower intestine. Councilman suggests that the part the *bacterium coli commune* plays in dysentery may be an important one. It is pathogenic in a number of the lower animals, and if the normal resistance of the tissues of the intestine is lessened from any of many causes, it may act in man as a pathogenic germ. It is found not only in the ulcerations, but it is also found to have penetrated the tissues.

Booker, in a series of careful examinations upon a child which had died of dysentery, claims to have isolated a germ not found in the normal intestine or in diarrhœal discharges. It resembles in morphology the *bacterium lactis aërogeneus*, but is smaller, and differs from it by producing fermentation in milk. The new bacterium was found in large quantities in the diseased part of the intestine, and was absent in the healthy part.

In 1876 Normand, having made a microscopic examination of the stools of soldiers returned from China with severe dysentery, discovered a parasite which he named "*bacillus stercoralis.*" It is a fusiform germ of the nematode family, and very similar in appearance and size to the filaria of the human blood. This germ measured about one millimetre in length, and was thirty to forty micro-millimetres broad, a little pointed in front and tapering to a point in the back. Normand, having first proven the constant presence of the germ in nearly all the cases of severe dysentery, did not hesitate to call it the specific agent of the disease; but this idea was soon abandoned.

Amœbic Dysentery.—The intestine is always considerably thickened, the submucous coat being considerably affected, though the other coats are involved to varying extents. This thickening is due not only to the œdematous condition, but there are sharply circumscribed projecting nodules, in which are small cavities filled with a viscid gelatinous pus. The mucous membrane covering these cavities becomes necrosed and sloughs off, leaving irregular ulcers, which may connect with others by a sinuous tract, burrowed under apparently healthy mucous membrane.

The submucous coat is generally infiltrated and œdematous; it softens, and by necrosis of overhanging tissue ulcers, with undermined and ragged edges, are formed, which have the muscular coat for their base. The cellular infiltration extends through the upper layers of necrosed muscular tissue into the septa of the intermuscular connective tissue and into the submucous coat.

Destructive necrosis goes on in the tissues of the circular muscular coat, and masses of it slough off and are passed by stool. The next step is great thickening of the adjacent peritoneum, which next becomes the seat of disintegration; adhesions form with neighboring viscera and with contiguous links of intestine.

The mucous membrane at a distance from the seat of the acute process is not altered; lower down, some of the glands are dilated and filled with mucus and pus cells, the epithelial cells are distended with mucus, and the epithelium everywhere contains an increased amount of mucus. By confluence of neighboring glands cysts are formed. Near the ulcers the glandular epithelium proliferates with bud-like projections into the tissue below.

Lambl first saw amœbæ in the intestinal contents in 1849. In 1875 Lösch, in examining microscopically the stools of a patient, twenty-four years of age, who was suffering with an ulcerative affection of the large intestine, discovered amœbæ in great numbers, which he called "amibe du colon," or amœba coli. Next, he injected these stools into the intestines of four dogs, one of which had vomiting and diarrhœa. The animals were then killed, the intestines were found to be inflamed, were covered with bloody mucus, and showed many ulcerations. The amœbæ were found in the mucous membrane and in the ulcers. The parasite appeared as a protoplasmic mass and measured on an average twenty to fifty μ; in motion and with their greatest elongation they reached over sixty μ. Their protoplasm is very granular and encloses six or eight round vacuoles.

Koch, in 1883, found the amœba in the intestines of those dying from dysentery. Kartulis attempted to prove that the amœbæ played the principal *rôle* in the pathogenesis of dysentery. He also found them in other ulcerative affections of the intestine, viz., typhoid fever and tuberculosis. In certain complications of dysentery, and especially in abscess of the liver, Kartulis found the amœbæ in the pus, associated nearly always with the ordinary microbes of suppuration. He did not believe that the parasite was pyogenic in itself, but that it only prepared the way for the microbes of suppuration. Osler, first in America, reported a case of abscess of the liver in the course of dysentery, in which he found the amœbæ in large numbers. Much that we know of this form of dysentery is due to the work done in Johns Hopkins Hospital by Osler, Councilman, and Lafleur, and we are indebted chiefly to the paper of Councilman ("Transactions of the American Association of Physicians, 1892") for our knowledge of the pathological anatomy of amœbic dysentery. Dock afterward demonstrated the amœbæ in a case of dysentery contracted in Texas. Vassi

has since found them in a case of abscess of liver; he found only a small number in the pus, but they were present in great numbers on the side of the abscess, also in some of the small branches of the portal vein.

The constancy of the presence of the amœba in the various manifestations of dysentery adds weight to their probable pathogenic influence. Massiutin has found these same parasites, with characters absolutely identical with those described by Kartulis, in other affections than dysentery (chronic intestinal catarrh, mucous diarrhœa, and acute enteritis), and on the strength of his researches he repudiates the idea held by Kartulis as to the specificity of the amœba as the parasite of that disease. In the meanwhile Kartulis is still experimenting, and his researches rather confirm his idea, though the results are not sufficiently proven to be assured. He has been able to produce a mucous and bloody diarrhœa by injecting the amœba cultures into the rectum of a cat.

The amœbæ are found in the submucous tissue around the ulcers; apparently they themselves produce few lesions in the mucous membrane, but they first attack the submucosa and the mucous membrane is affected from below.

They are also found in the lymphatics and sometimes in the blood-vessels. The tissues in which they are seen are infiltrated with cells. There is no necrosis, and the neighboring connective-tissue cells sometimes lose their nuclei and the nuclei split. Most numerous in the smallest ulcers, when the process is most rapid and where there is no suppuration, they are scattered through the tissue or lead the advance of cell infiltration.

Abscess of the liver was found in six out of eight autopsies of amœbic dysentery (Councilman); in four cases, there was more than one abscess, and in two cases they were very numerous and small; in every case the right lobe was the seat of this change, and in two cases there were abscesses in the left lobe. In the smaller abscesses there was a small amount of glairy, semi-transparent fluid; in the larger ones the contents were more fluid, of a grayish color, sometimes brownish-red, from admixture with blood. A distinct limiting wall, sometimes dense and hard, is found in the larger abscesses, but it has not been seen in the smaller ones.

The fluid of the smaller abscesses is composed of fatty, granular material, fragments of liver-cells, and pus or lymphoid cells; that of the larger abscesses contained fat, red blood-corpuscles, fragments of liver cells, and very few pus cells. Amœbæ were contained in both, but were more numerous in small and recent abscesses.

Other changes in the liver consist in extensive necrosis in the centre of the lobules, the capillaries and necrotic cells containing numerous leucocytes; but amœbæ are not associated with the necrotic process; they are only found in association with the abscesses.

Abscesses are found also in the lungs; they occurred in three out of eight cases, and were seated in the lower lobe of the right lung in every case. In two cases the lung abscess communicated with a liver abscess through a perforated diaphragm. The abscess cavity in the lung was surrounded by consolidated tissue of great extent, embracing the entire lobe. The consolidation is due to interstitial pneumonia. The contents of the abscesswere granular detritus, round lymphoid cells, red blood-corpuscles, pus cells, and amœbæ. A definite wall sometimes included the abscess. The amœbæ are more numerous in alveoli immediately adjoining the abscess, and in those places where the abscess is most rapidly advancing, and where there is no limiting wall of connective tissue; but all the neighboring tissues contain them.

These appearances are different from those found in any other disease, and show an individuality of lesion, associated with the presence of the amœba, which establishes amœbic dysentery as a distinct disease. The amœba is not an accompaniment but a cause of the destructive changes in the liver and the lungs; there is a relation between the number of the amœbæ and the activity of the process, and where the process is more recent the amœbæ are more numerous.

The attacks begin suddenly or gradually. In the former case a watery diarrhœa is followed by frequent stools of blood and mucus; there are tormina and tenesmus. In some cases blood and mucus may appear in the beginning. In cases of slow development, diarrhœal symptoms are present throughout, with intercurrent periods of constipation. In both forms there is no fever unless diphtheritic changes occur, or unless abscesses develop in the liver or lung. In more severe cases, with gangrenous destruction of the mucous membrane, the patient is prostrated, and the stools are putrid and contain fragments of necrosed tissue.

The symptoms are not uniform or characteristic, as in the catarrhal and diphtheritic forms; intermissions and exacerbations occur. Convalescence is slow. The duration is from two weeks to several weeks, but it may last months or years; it becomes a chronic disease.

Amœbæ are seen in the stools, floating in the fluid or clinging to fecal masses. They are more numerous in acute cases and in the periods of exacerbation. They disappear during convalescence, but may be seen in normal stools after the patient is well.

Treatment.—Popular favor in India still holds to the ipecacuanha treatment of dysentery. McDowell, after thirty-five years' service with the British Army, says that the horrors of dysentery are disappearing since this treatment has been employed. He gives a preparatory dose of twenty drops of laudanum an hour beforehand, and places a mustard-plaster over the stomach; twenty to twenty-five grains of ipecacuanha are given at bedtime. This treatment is to be given every evening, and no fluid is to be taken after it; by the third day blood and mucus have usually disappeared from the stools, and they are free from pain. Maclean says this mode of treatment has reduced the former mortality to from twenty-five per cent. to seventy-five per cent., and that it is the most simple, the most successful, the most conservative, and the least objectionable mode of treatment of dysentery. Year by year under this treatment the chronic cases are becoming more rare and hepatic abscesses less frequent.

Other observers, while not losing faith in the efficacy of this mode of treatment, urge its use in smaller doses. Its use in this country has been disappointing, and it has never come into especial favor, though many advocate its use in small doses ($\frac{1}{4}$ grain to 3 grains) every half-hour to an hour.

The experience of those who have had most to do with epidemic dysentery in this country, has led to a division of favor between the specific treatment by ipecacuanha alone and purgation by salines. A supposed portal congestion furnishes the theory for the purgative plan of treatment, although its good effects are confirmed by experience. The fact that the supporters of purgation advise the constant use of opiates afterward, and those who recommend ipecacuanha do not find it necessary to have recourse to them, gives ground for belief that the latter is the more successful method.

The removal of scybalæ in the early part of the attack, and toward the end of the more acute symptoms, is of unquestionable advantage in influencing favorably the condition of the inflamed mucous membrane. Daily purgation is not found so beneficial as was at one time believed, and when to give a purgative becomes one of the most perplexing questions, requiring much judgment and experience in its decision. The salines and castor-oil are the best. In those cases where the discharges are fluid, containing shreds of tissue and small clots, pointing to extensive colitis, purgatives are unsuitable; their use is confined to cases of catarrhal dysentery with small bloody and mucous stools. In amœbic and diphtheritic dysentery they are of less use.

Opium, so largely used in this country in the treatment of dysentery, has its place among proper medicaments, but its use is only to ease pain and quiet the patient; when used for any other purpose, or in large doses, its use is to be deplored.

Bichloride of mercury and salol have been favorably mentioned on account of their antiseptic properties. Ringer recommends the former in doses of $\frac{1}{120}$ to $\frac{1}{60}$ of a grain hourly. Salol is supposed to pass unaltered through

the stomach, and in the intestine to be broken up into salicylic acid and phenol; it is given in ten-grain doses every two hours.

Calomel, so long in favor in this affection, has of late fallen into practical disuse, though some few still hold that it is worthy of a place among the specifics and purgatives.

Treatment by Suppositories and by Rectal and Colon Injection and Irrigation.—The use of suppositories containing opiates and astringents, although at one time a common practice, is much less in favor than formerly. It is not desirable to destroy, or to limit to too great an extent, the tendency of the rectum to expel its contents. The retention of a decomposing fluid in the colon and rectum cannot but be a source of danger, and fatal general infection may follow. The disease cannot be cured by putting a stop to dysenteric discharges, and therefore suppositories used for this purpose are not to be recommended. After the action of a purgative an opiate suppository may arrest too free purgation and keep the bowel at rest with benefit, and after irrigation, also, advantages may follow upon the same principle, but the doses of opium should never be large. In attempting to control tenesmus the temptation is frequently to give too large doses, which induce narcotism and which involve great danger.

These same rules hold against following the once popular method of using injections of starch-water and laudanum, which may be of service with the limitations just mentioned, but as a routine treatment the plan is not without danger.

The injection into the bowels of large quantities of warm or cold water has many advocates. The sedative effect of water of a high or low temperature upon an inflamed mucous membrane is of undoubted service in dysentery. The only objection is to be found in the danger of over-distending the inflamed gut, and of adding to its irritability. Irrigation, by cleansing the ulcerated surfaces, by washing away the decomposing contents of the bowel, and by destroying bacterial life, gives promise of accomplishing a great deal more than by the mere injection of fluids into the bowel.

Cool or hot water may be used for irrigation, but if an antiseptic agent be added to the water there is an additional benefit.

Antiseptic irrigation may be practised with solutions of mercuric chloride 1 to 5,000, quinine 1 to 5,000 or 1 to 2,000, salicylic acid, thymol, carbolic acid, sulpho-carbolate of zinc, boracic acid, etc. The use of bichloride solution must always be attended with a certain amount of danger; precautions should always be taken so as to have a free exit.

Irrigation can be practised in the rectum or colon; in either case a soft rubber tube is passed into the rectum or is gently and gradually forced upward through the sigmoid flexure. This is by no means an easy task, as the instrument so readily turns on itself; an occasional examination ought to be made with the finger to see if this has happened. Experiments in the cadaver show that the smaller-sized rectal and colon tubes do not make their way as readily as those of larger size. The habit of injecting water, as the tube progresses, favors twisting; progression is more easily made if the bowel is empty, as the mucous-covered wall guides the instrument in the proper direction. In many cases the colon cannot be reached, and there is danger of perforating the ulcerated bowel if too continued efforts are made. One must be content, therefore, to pass the tube as far into the sigmoid as possible. The fluid is then allowed to flow in from a fountain syringe, or is thrown in by a Davidson; when six to eight ounces have entered, it is allowed to escape through the same tube. This process is repeated until a quart or more has been used, or until the water escapes perfectly clear. If the patient is in the dorsal position or on the left side, with the hips raised, gravity favors the entrance of the fluid. In most cases, and especially in bad cases, with putrescent fluid discharges, it is safer never to attempt to push the instrument beyond the rectum. Two tubes of different sizes are passed into the rectum; the smaller one admits the fluid, which escapes through the larger one. The irrigating liquid is injected rapidly and escapes at once; in this way the rectum can be emptied and cleansed in a few moments.

There is an important point in connection with this method which shows its advantages. In the worst forms of dysentery, where the colon is chiefly involved, the rectum is more or less constantly filled with a decomposing fluid filled with shreds; with each effort at stool the rectum is only partly emptied; the sphincter contracts and closes, retaining a certain amount of the contents. Irrigation secures a complete emptying of the rectum, washes it out thoroughly, and makes it antiseptic as far as can be done. Frequent repetitions of the procedure will sometimes arrest, at once, the frequent stools, and the patient may be made to have his evacuations only at the time of irrigation, the intervals being lengthened as he improves. In this way great suffering is relieved and the danger of general infection is avoided. The experience of the writer has convinced him of the great value of this method, as applied especially in cases with abundant fluid putrescent discharges.

Rectal irrigation may be used in this manner, at first, at intervals of two to three hours; as tenesmus diminishes and the desire for stool lessens, the intervals are increased to four or six hours; they are then gradually stopped, a relapse often following a too early interruption of the treatment. Even after all the dysenteric features of the dejecta have disappeared it is well to continue irrigation for several days.

If the tenesmus is great and the stools very frequent, an opiate suppository introduced into the rectum immediately after irrigation gives added comfort. But for intense tenesmus, combined with wakefulness, nothing answers so well as the subcutaneous injection of morphia.

In this article the attempt has been made to present the more recent views of dysenteric processes, and not to give a full exposition of the subject. Reference to the article on Dysentery in a former volume of the HANDBOOK will show that many parts of the subject have not been touched upon here, because very little has been added to our knowledge except in the differentiation of amœbic dysentery from forms already known and fully described, and in the improved treatment by irrigation.

William W. Johnston.

INTESTINAL SUTURE AND ANASTOMOSIS. The advance in the treatment of wounds of the intestine, whether they be made by accident or by the surgeon in resecting or incising the bowel, is coincident with great surgical activity in the field of abdominal work. The possibilities of safe and perfect work have increased.

The details of methods devised by many operators have multiplied until the practical surgeon is bewildered in choosing a method suitable to each emergency he encounters. The technique of some of the methods proposed is elaborate, of others comparatively simple. It may be said that in the hands of each author the method advocated by him has resulted in a measure of success, seeming to warrant him in launching it upon the ocean of surgical endeavor, strewn already with more wrecks than sailing craft. It is to be assumed that, unless a method meets with a goodly share of success in the hands of general surgeons everywhere, the appeal of any one advocate will not entitle it to a permanent position in the armamentarium of the well-equipped surgeon. Many methods are highly ingenious and appeal to the fancy of the student rather than to the utilitarian mind of the operator.

It is difficult, with the improved statistics of abdominal surgery, to know how much value to place on the help obtained in saving life by the novel methods of intestinal repair, and how much on the general knowledge of the treatment of all abdominal wounds *per se*.

Statistics of the past cannot be compared with those of recent years, because of the marked causes of former mortality from peritonitis due to infection of erysipelas, sponge and hand contamination, and sepsis, now happily so largely eliminated from our hospital operating-rooms.

The mechanical part of intestinal suturing will, therefore, concern us rather than the results as judged by the scant statistical records. The really important part of this work is a matter of contemporary surgery.

Prior to the past twenty years, recovery from injury of the bowel bordered on the marvellous, even to the mind of the older surgeons. True, an occasional recovery is recorded of successful treatment as far back as 1521, when an unknown surgeon sewed up a stab wound of the stomach and the patient recovered.

Now, we know that with strictly clean work a surgeon can, for all practical purposes, insure perfect healing of sutured wounds of the alimentary tract. His duty is first to know the simplest technique of the few useful methods of stitching, and then the application of them to more complicated methods.

His first concern is with the material used—the needle and thread. I believe nothing more perfect than the ordinary cambric needle can be used. Yet a small Hagadorn or a glover's needle may be employed in the absence of the other. The cutting edges of the latter wound the many veins of the bowel, and are pretty sure to make troublesome interstitial hemorrhages which dissect the coats for some distance from the puncture points. The round cambric needle, on the other hand, enters the tender intestinal coats readily and stops at the resisting submucosa, which, as Halsted has shown, has a definite fibrous quality which can be detected and picked up on the point of this needle, thus giving a more secure purchase for the thread. The needle should be long enough to be readily handled—one and three-quarters or two inches is the best length.

The thread should be of fine silk; No. 00 embroidery silk, iron-dyed, is best. In emergency, however, one may use common linen thread perfectly well, though it is not so smooth nor so readily drawn through the tissues as is silk. It has the advantage of being obtained of proper strength and size in an emergency, in any household, as is the needle also.

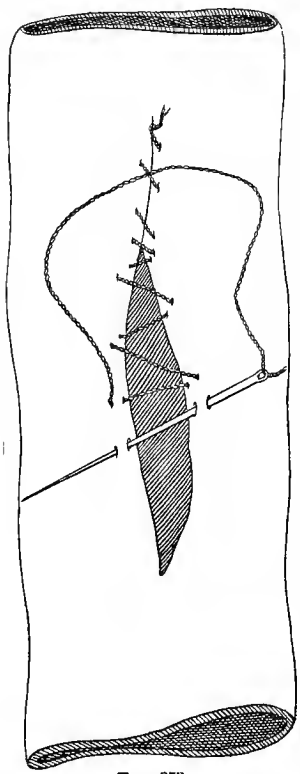

Fig. 353.

Catgut is not to be used in intestinal suturing. It is not enduring enough, its knots slip, and its sterilization is not to be trusted as perfectly as is that of silk or linen. The needle should be sterilized by passing it through the flame of a lamp three times. The thread is perfectly sterilized by boiling, after winding it on a small glass rod. Boiling for a half-hour and immersing in alcohol until needed, is the best method for preparation. It may, however, be sterilized by dry heat for three hours (oven-baking temperature, 300° F.) and kept in cotton-stoppered test-tubes without fluid, thus making it light and portable.

Safe and accurate apposition of the edges of the intestinal wound depends on the variety of stitch employed, and it is well to fix in one's mind two or three varieties of suture that have stood the test of experience, and discard all others as unnecessary.

The principle underlying the inducing of sound adhesion of the wound is that fixation of two peritoneal surfaces in contact, by means of some slight traumatism or the presence of a foreign body, such as the suture, immediately causes the copious exudation of plastic lymph, which seals the layers in from two to six hours, so that leakage is impossible without violence. To further add to the solidity of the lymph, it has been shown by Senn that gentle abrasion of the surfaces before sewing causes additional firmness to result.

The suture must take hold only on the peritoneum, the muscular coat, and an attenuated but firm and readily recognizable submucons fibrous reticulum, without penetrating the mucous coat.

The action of the circular and longitudinal muscular fibres causes a double movement of the part involved by the stitches, so that absolute fixation is a matter of skill in the use of the stitches. The stitches to be considered are the Lembert or "interrupted," the "continuous," and the quilt stitch. The "Czerny-Lembert" is characterized by the use of a separate suture of the mucous coat within the bowel, combined with the Lembert externally.

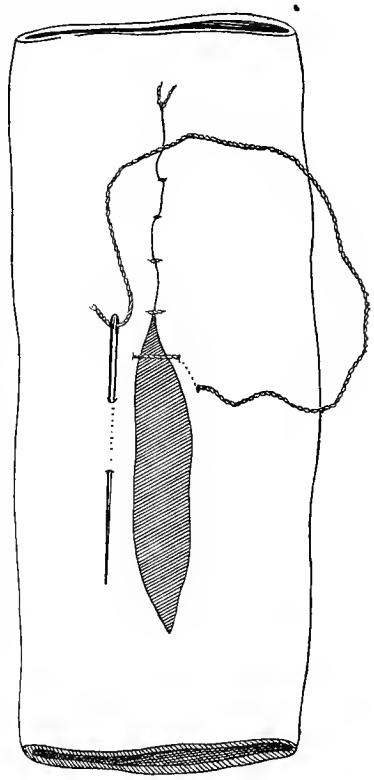

Fig. 354.

The continuous suture, as modified by Cushing, of Boston (Fig. 354), gives a method by which excellent apposition is obtained and the thread more thoroughly buried in the intestinal coats than in the simple running suture of Dupuytren (Fig. 353). When we consider the fact, however, that all these sutures turn in, and keep in contact two lips of intestinal edge which act as a valve when pressed from within, allowing nothing to escape so long as the suture holds, it seems that one has no advantage over the other from a mechanical point of view. It is argued that the lengthening and shortening of the wound by reason of the double peristaltic muscular action might allow such relaxation of the continuous suture as would cause a gap for leakage between successive stitches. Practically, this would be quite as likely to happen after the use of the interrupted suture. But in reality it never does happen after either one. What does happen occasionally, when one row is used alone, is, that some single stitch in the line gives way, owing to its insufficient hold, allowing it to cut out, and then an eversion of the mucous membrane and leakage occur. This is a uniformly fatal mishap,—hence all experience shows that a double row is needed to secure perfect union. Each row should have about six stitches to the inch and the rows should be parallel to the cut edge—one-sixth of an inch apart. With this double row carefully applied, no sutured opening can leak.

The time occupied in making a running suture is one-third that of the interrupted, and it is therefore coming into vogue as the most desirable.

The choice of sutures for the different rows lies with the operator. The interrupted Lembert has had preference in the past. It is acknowledged to take three times as long to apply as the continuous, and

is therefore being displaced by the latter in suitable cases.

After an extensive use of all methods in living subjects, having regard both to security and time, I prefer to apply a quick-running Lembert suture (Fig. 353) nearest the cut edge of bowel, and outside that the Halsted "quilt" suture or its modification (Fig. 356).

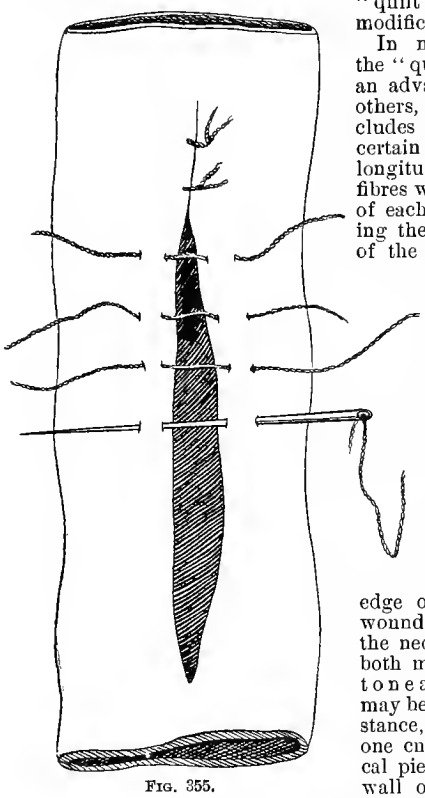

Fig. 355.

In my observation the "quilt" suture has an advantage over all others, in that it includes and ties up a certain length of the longitudinal muscular fibres within the grasp of each knot, thus fixing the definite length of the wound beyond the power of its elongation or shortening during repair. This point has not heretofore been emphasized, but it is one of importance.

There are times when a continuous suture "overhand" may be taken, of the edge of a stomach wound, for example—the needle penetrating both mucous and peritoneal coats. This may be utilized, for instance, in a case where one cuts out an elliptical piece of the entire wall of the organ to include an ulcer, or a neoplasm. It is found that the wounded edge, being thick and vascular, requires many points of clamping. It is here safe and advantageous to suture the edge as above to check hemorrhage and secure the edges. This thread then becomes turned entirely into the stomach when the outside sutures are applied.

It is of interest to observe what becomes of the threads. They all, even the continuous sutures, seem to work toward the cavity of the viscus by natural law. One end having become free, the remainder is soon cast off into the bowel. From two to six or eight weeks is usually enough time for them to work free.

Experience goes to show that if the thread, needle, and operator's finger are sterilized, there is not much to be feared from sepsis due to intestinal contents. At least, careful rinsing of the parts sutured during the operation—with plain boiled water—gives non-suppurating results, and stitch-hole abscesses must occur infinitely less often than in the case of the skin, unless the mucous membrane be involved. Where the thread penetrates and secures two edges from mucous membrane to mucous membrane, it acts as a seton, and as the inflammatory fluids exude they drain into the bowel—thus doing no damage,—provided the adjacent peritoneum is well secured by the outside row of stitches catching up only peritoneum.

To Dr. Nicholas Senn is due the credit of a thorough and exhaustive experimental study of the subject of intestinal repair, and to him will ever be credited the addition of certain aids to operative work. Abrasion of the approximated surfaces has been mentioned. Omental grafting, so called, will stand as a useful adjunct.

It has been shown by Schede and others that the peritoneal cavity will tolerate the presence of considerable masses of living tissue, such as pieces of muscles, or even cancer tissue, deposited in an aseptic state, free within it. Such pieces, quickly blanketed by a layer of lymph, are soon vascularized and digested, as it were.

If a strip of omentum two inches wide, and as long as needed, be torn from the edge of the patient's omentum, wrapped round the sutured bowel, and tacked in place by three or four sutures, it quickly becomes adherent to the parts underneath and acts as a reinforcement to the junction. This is the so-called "omental graft."

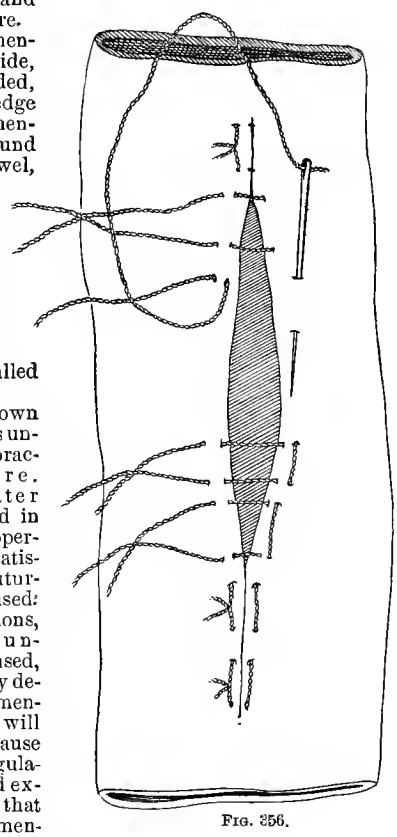

Fig. 356.

It has been shown to be useful, and is unquestionably a practical procedure. Whenever greater security is needed in cases where the operator is not quite satisfied with his suturing, it should be used. In most operations, however, it is unnecessary. If used, it must be entirely detached from its omentum, otherwise it will leave a band to cause internal strangulation. Senn found experimentally that such grafts of omentum became firmly adherent in from twelve to eighteen hours, and were freely supplied with blood-vessels in from one and a half to two days.

Having settled in our minds the best methods of suturing simple wounds of the intestine, we turn to the variously complicated conditions which the surgeon is called upon to meet. They consist of either gunshot wounds, perforating ulcers, obstructions, tumors, stenoses from contractions, kinks or twists, or resections for destroyed portions of bowel, as in hernias, or old fecal fistulæ.

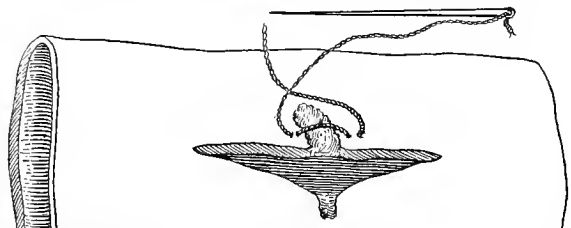

Fig. 357.

In considering these maladies we may, for the purposes of this article, regard the intestine as either the subject of a lacerated wound or ulcer, or as resected after one of the diseases named, and study the best methods of repairing the lesion.

For a lacerated wound or a gangrenous perforation one may split the intestinal wall an inch and a quarter in each direction from the perforation, lengthwise, and, bending the bowel, make an elbow at this point, turning the ulcer in and bringing the cuts together where they are stitched about, so as to restore the continuity of the bowel.

I have done this in a case of gangrenous ulcer transverse to the bowel, where it had been held under the sharp inguinal ring (Figs. 357, 358, and 359). The alternative of resection or artificial anus was avoided, and the patient was restored immediately to perfect health, which she has maintained for four years past.

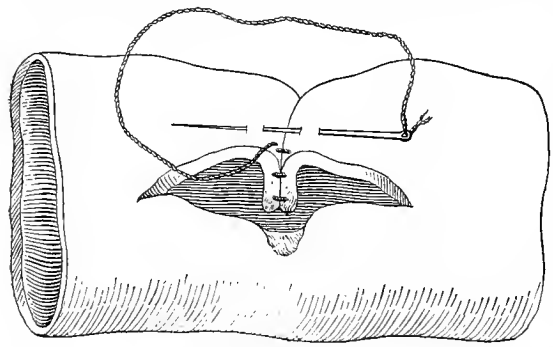

FIG. 358.

For impending perforation, instead of resecting or suturing, one may adopt Chaput's suggestion of stitching a convenient piece of adjacent intestine to the ulcerating surface, thus protecting the peritoneal cavity and insuring its safety in case the perforation follows. In such an event the attempted discharge through the ulcer would be thrown back into the bowel from whence it came, or if it perforated through the piece of bowel plastered up against it, there would be only a fistula between bowels which would soon close spontaneously.*

If a portion of intestine is torn in dissecting it from an inflammatory association with a tumor, the abdominal wall, or another piece of bowel, the degree of tearing will determine whether to suture or to resect, or to form an artificial anus temporarily. A small tear should always be sutured at once, if feasible. If the tissues are in a bad state and it is doubtful whether the sutures can be relied on, the wound should be tamponed with iodoform gauze for thirty-six hours. At the bottom of the wound is the wounded bowel. If when the tamponade is removed the lymph has sealed the wound, nothing need be feared, no replacement of the tampon is needed — at most, a small drain may be established through the abdominal wall; and to insure prompt union between the parts displaced by the tamponade, all that is required is to bring them into close contact. On the other hand, if leakage from the bowel occurs, it will form a fecal fistula which will, in nine out of ten cases, spontaneously close in a few weeks.

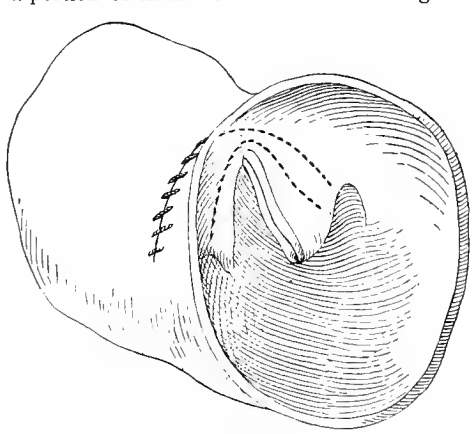

FIG. 359.

If, after a fecal fistula has formed, the edges of the abdominal wound and the surface of adjacent skin become quickly excoriated from the intestinal juices, it is an evidence that the portion of bowel which is wounded is situated high up toward the stomach, even though the loop seemed to be anatomically as low as the supra-pubic region. The seemingly acrid secretions, though really of alkaline reaction, have so powerful a digestive capacity, that they do not spare the horny non-vascular layer of skin, and only stop at the papillary. The most exquisite pain follows from exposure of the nerve-ends in the skin. I have tried everything to relieve this distress and tide the patient over the few weeks during which the stenosis goes on so surely, and I have found no remedy as good as zinc ointment smeared on the cleansed skin, over which is laid coarse surgical gauze, in small compresses so disposed as to confine the discharge well. Simple spreading of salve cloths is useless, but the superimposed compresses draw away from the skin the discharging intestinal juices, and only the lowest layer, which soon becomes neutral, touches the tender skin. All other methods than the above I have found to fail.

I will not consider here why, when, or where the surgeon has to resect portions of intestine, but will review his resources for restoring the continuity of the canal, after he has resected a complete piece of the intestinal tube.

For the history of the earlier adventurers in this field one may refer to works on general surgery, such as Treves's "Manual of Operative Surgery."

Practically, at present, we have a choice of three methods to accomplish our purpose :—

First. End-to-end union.

Second. Lateral implantation.

Third. Lateral anastomosis.

Each method is capable of being done by sutures alone, or we may use artificial mechanical devices aided by sutures.

The ideal result would undoubtedly be attained by end-to-end union, if possible, without narrowing the canal. Practically, however, the operator has to consider the security of his suturing and the time consumed by this method.

When intestine is cut across there is a part lying beneath the mesenteric attachment which has no peritoneal coat. When this is sewed to the corresponding part of the other end, the reparative lymph thrown out from the peritoneal surface is wanting here, and it is therefore the point at which fatal leakage of fecal matter often takes place.

This can be avoided by extreme care, as follows: Place an independent stitch at the cut edge of the mesentery close to the bowel, uniting its two layers. This practically makes the peritoneal coat continuous around the circumference.

Two layers of sutures are essential: one of the mucous edges only, which must be knotted on the inside; the second, limited to the peritoneum.

In this, the so-called Czerny-Lembert suture, the continuous suture is not available, because, if tightened securely enough, it acts like a purse-string, and leaves an annular stricture. The time consumed in making the circuit of the bowel by interrupted sutures, a double row, is very great, amounting to from an hour and a half to two hours, in thoroughly perfect work. The result, however, when complete, leaves nothing to be desired.

One risk must be borne in mind, namely, that if the

* This method of Chaput (Gazette des Hôpitaux, 1892, No. 138) applies as well to torn or gunshot wounds of the bowel, and may on occasions prevent a resection. It requires nice judgment, however, on the part of the operating surgeon to choose between these methods. In badly torn wounds, especially if a bullet traversed the gut, I would prefer the resection and lateral anastomosis, as described later on.

arterial supply coming to the cut edge from the mesentery is interfered with by too close suturing there, where it is most demanded, there is danger of gangrene of the sutured edge, with late extravasation of fæces. This is due to the anatomical fact that the arterial circulation in the intestinal coats courses around the bowel and not lengthwise of it.

With fifty per cent. of deaths from this method in the

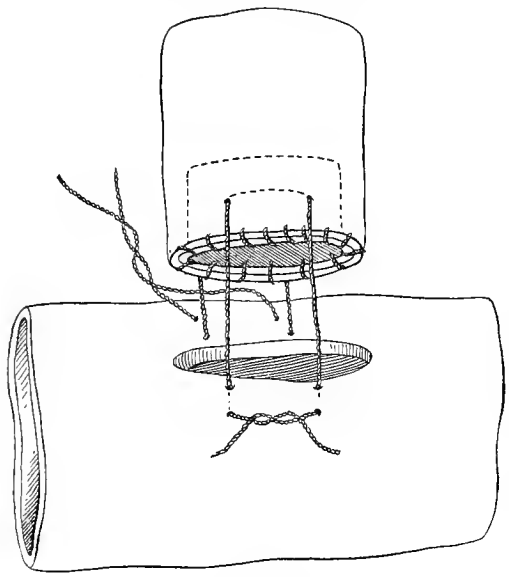

Fig. 360.

hands of good operators, it is not surprising that we have to turn to less tedious and dangerous methods.

End-to-end invagination has been advised by many—in imitation of the accident of intussusception. The distal divided end is first inverted, and the proximal drawn into it by two sutures fixed to its peritoneal edge, thrust into the lower end, and brought out on its surface where it is temporarily secured, while a series of circumference sutures is applied to the edge where the inverted cuff of the lower lies against the surface of the upper end.

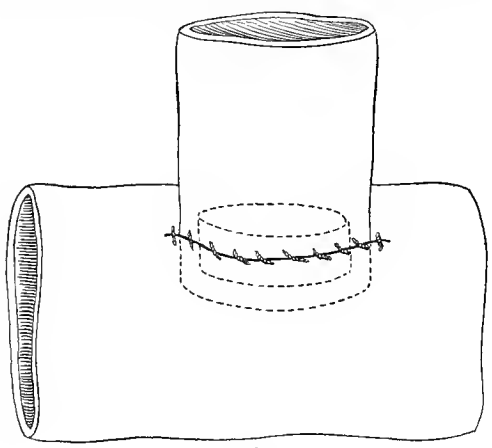

Fig. 361.

This method has been very successful in canine experimentation, and may be used successfully in men. It is likely to get blocked by the obstruction of the thickened coats plus the food products, and thus be pushed on by peristalsis and beget a severe and genuine intussusception.

A modification of this method consists in stripping the mucous membrane from the inside of the distal end for a half-inch or more by curette, and stitching the proximal end into it so that the serous membrane of the latter is stitched to the freshened interior of the distal end.

This has been found to work well in dogs' intestines, but it seems a perilous method to use in the relatively thinner human bowel, where much depends on the maintenance of perfect circulation in the edge.

Where resection of a stricture has been performed, or a malignant growth has been excised and the tube of bowel above is dilated to a much larger size than that below, Wehr has suggested that the smaller be trimmed obliquely, so as to match the second in diameter, and then the stitching of two equal openings, one circular, the other oblique, can be accomplished by double suture. This jointure will make a wide angle elbow in the course of the bowel, but not one that would be disposed to kink. The oblique cut being made at the expense of the side opposite to the attached mesentery, there would be no danger of a sloughing edge from interrupted blood-supply.

The second method, of "lateral implantation," is in

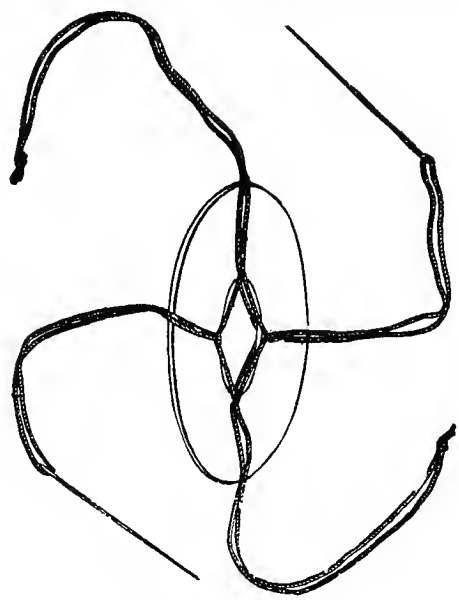

Fig. 362.—Senn's Decalcified Bone Plate.

imitation of the normal anatomical relation of the ileum to the caput coli.

If we have a free end of the ileum left after a resection near the colon, we may resort to this simple procedure after the method first devised by Jobert, but best modified by Senn, as illustrated herewith (Figs. 360 and 361). This method may be described as follows:—

A flat band of rubber is stitched by the edge on the inside of the proximal gut to hold this firmly open. A slit is made in the colon, and by two stitches, one on either side, taken like large quilt stitches, the small end is drawn into the large bowel, whose edges are inverted thereby. A continuous suture is made around the line of meeting, thus shutting it off perfectly. This method is not tedious and deserves attention. Whether the aperture would tend unduly to close later, or whether intussusception would take place from peristalsis, and blocking ensue, cannot be said. To this method may be applied some of the aids mentioned later, such as bone buttons, etc.

In lateral anastomosis we have a method that has a great field of usefulness in the future. The operation essentially consists in establishing an opening between two adjacent portions of bowel tightly secured together, thereby switching off the intestinal contents to another channel.

The proposition of thus making a short circuit for the intestinal fluids originated with Maisonneuve, who practised the method on two patients, who died. This discouraged further efforts to perform the operation. It was not resorted to again until 1881, when Billroth and Wöllfler each operated on a case of pyloric stenosis from cancer, by establishing an opening between the stomach and small intestine, calling the operation gastro-enteros-

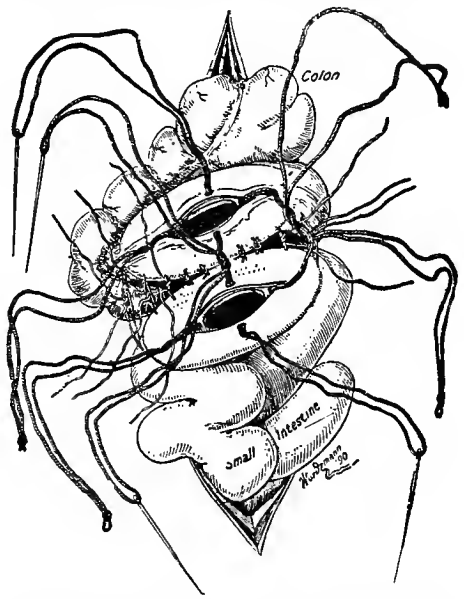

FIG. 363.—Ileo-colostomy with Decalcified Bone Plates, showing plates in position, one in the ileum, the other in the colon.

tomy. Since then it has been widely used. To obviate the tedious suturing of the openings, Senn, of Milwaukee, used disks of decalcified bone (after trying all other absorbable but firm substances) for the purpose of approximating the serous margins about the anastomotic openings. His two objects were, first to save time, second, to make safe apposition.

That the principle of lateral anastomosis has been universally accepted by surgeons as worthy of adoption, is proved by the energy and ingenuity shown by operators everywhere to modify and simplify the technique. The two objects aimed at have been to save time and add security. Up to the present writing, no device has shown itself better than Senn's bone plates in saving time.

These aids are made from the hard bone of an ox thigh sawed in a plane so as to make a bone plate three inches long, an inch wide, and a quarter-inch thick. This is soaked twenty-four hours in ten per cent. hydrochloric acid, to decalcify it. A brief washing in alkali removes the acid. The pliable bone can be cut with a penknife. A hole is made in the centre an inch and a half long, and four small holes are drilled beside it. Threads are now secured in it as shown in the diagram (Fig. 362), and the plate is kept in a solution of equal parts glycerine, alcohol, and water, ready for use.

The mechanical part of its application is extremely simple. The two parts of bowel to be joined are drawn up into view and confined by compresses of gauze or damp towels. An incision is made lengthwise of each bowel an inch and a half long, opposing each other, and into each opening a bone plate is slipped. A needle having been threaded with each of the two side-threads, is to be carried through the plate and the edge of the cut from within outward. This secures the plate against slipping. The two end-threads lie in the angle of the cut. The same is done to the other plate. The two plates being then in position, a half-dozen Lembert stitches are placed behind the plates to secure the coats of the bowel together where the edges of the plates press them together. The plates are then laid together, and the edges of both openings are thereby tightly sandwiched between them, when the four strings are tied in strong, square knots. These knots are cut short and tucked in between the plates. The intestinal edge being so slippery, will often be squeezed out between the plates; hence a few outside Lembert sutures, or one continuous suture, are needed to complete the operation. Senn advises a light abrading of the peritoneum between the plates before tying.

The excellence of the method has been proven by many successful cases, I have myself used it with perfect satisfaction in the case of a carcinomatous stricture of the hepatic flexure of the colon, in which, after twenty-five or thirty pounds of soft fæces had been evacuated by inguinal colotomy, and ten days had been allowed for recuperation, I united the ascending and transverse colon by lateral anastomosis, by means of Senn's plates, with perfect success. Six months later, the man died of cancer, and I found the opening I had made had contracted to a small orifice only large enough to allow fluid fæces to pass, hence requiring him to use laxatives for three months before death. The original aperture was an inch and a half in diameter. I felt the need of making larger apertures than the plates allowed, and devised the catgut rings, which have since been used with great success by many operators. This was the first modification of Senn's device, and has the double advantage of being made large (the opening measuring two inches in length) and of not interfering with the course of fæces through the aperture from the moment of operation. This device has been used many times with perfect success in grave cases of lateral anastomosis, and has usually required twenty-five minutes for complete adjustment. Senn's method can be satisfactorily done, when everything is prepared, in fifteen minutes; but I consider the small aperture obtained, the blocking by bulky plates, the leaving of complicated knotted threads attached to the wound, the imposition, upon the sensitive intestine, of a mass of comparatively indigestible foreign substance, the removal of which is to be effected by peristaltic action, which causes a tugging at the wound, as a menace to perfect security that is illy compensated for by a gain of five or ten minutes' time over another method by suture alone, to be described further on.

Among many modifications of Senn's bone plates published later, I may mention Brokaw's segmented rubber rings ("Trans. Southern Surgical and Gynecological

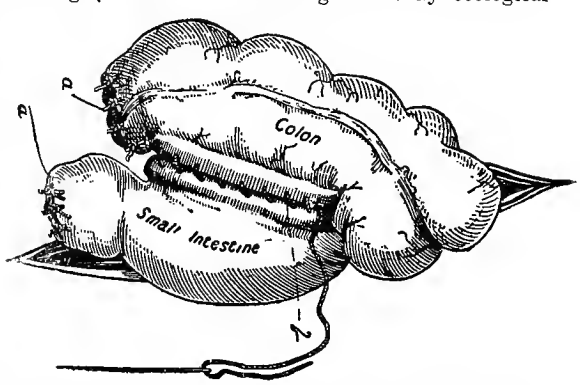

FIG. 364.—Ileo-colostomy without Resection of the Cæcum, showing plates in position, one in the ileum, the other in the colon.

Ass., November, 1889"); also Robinson's rawhide plates, made of a long disk of beef's hide, shaved, macerated one day in saturated salt solution, then dried, cut into shape, threaded, and kept in alcohol until used. This material has been found serviceable.

Davis's catgut mats (*Virginia Med. Monthly*, September, 1889) were devised later, and have been used, but the author of them has abandoned their use.

Dawbarn advises oval rings, cut from raw potato, to be used much as Senn's plates are, and claims that they ought to remain firm twelve hours, which would give time for plastic adhesion to be fairly secure. He adds to the usual technique two features that seem unnecessary and unwise, namely, the use of hydrostatic pressure through one of the open ends of bowel, to test the security against leakage after the plates are tied in; and, second, the introduction and fixation of the plates through the open ends of bowel, and cutting of the anastomotic opening through both walls of the bowel at once by a knife passed into one open end (*Annals of Surgery*, February, 1893).

Jessett, of London, has devised a bone plate like Senn's, with a cylinder of bone fitted into the central hole. This pushes into the opposite plate hole and secures the exact fixation of the plates, with the addition, of course, of some suturing.

Baracz has devised plates of raw turnip, which he has used successfully on the human subject, the anastomosis occupying three-quarters of an hour. They are like the potato, hard, easily prepared, and do not tear (*Centralblat. f. Chirurgie*, July 9, 1892).

Mayo Robson has devised a spool of bone, or "bone bobbin," as he calls it, having a diameter of an inch, over which he sutures the bowel ends in end-to-end union, or inserts it in lateral implantation.

Murphy has devised metallic buttons of oval shape, whose stems clinch each other when pressed together after the button part has been passed into the lateral opening in the bowel, and thus pinch the involved walls

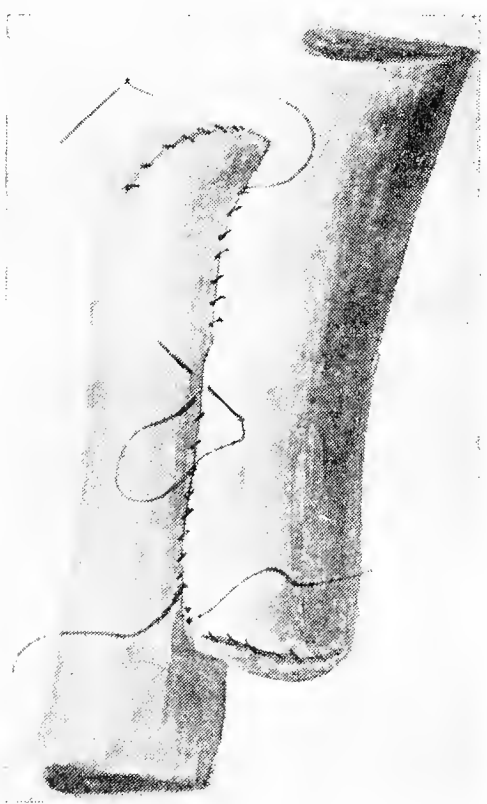

FIG. 365.—Suturing Intestines in Apposition before Incision.

so that adhesive inflammation is engendered at the margin of pressure, and this sloughs when the united buttons come away. This device he has used to produce quick anastomosis between the gall-bladder and intestine, as well as between two different portions of the bowel (N. Y. *Med. Rec.*, December 10, 1892).

Thus the devices multiply, and in the hands of each inventor success is reported.

The writer has tried many of the devices upon animals and the human subject, and with what is commonly called brilliant results. Yet it seems to him that perfect work, after all, follows the use of the suture alone.

FIG. 366.—After a Four-inch Incision and Sewing the Edges.

Improved technique of lateral anastomosis by suture gives a marked shortening in time. Twenty minutes have sufficed on several occasions to complete thorough anastomosis in human subjects.

The operation should be conducted as follows: Let us suppose resection to be called for. If the bowel has fæces in it, a ribbon of iodoform gauze is drawn through a small wound of the mesentery at the bowel edge, some inches above the trouble, and tied about the bowel so as just to stay the flow of fæces. The resection is quickly done with scissors, and the cut ends inverted by a double row of continuous fine black silk suture.

The two ends are then overlapped four inches or more, or laid side by side with ends together, as may be most convenient. I have tried both methods on the human subject, and cannot see that the results are less perfect either way.

Several needles are prepared, armed with fine black silk twenty inches long, tied with a double knot at the eye of the needle, and with one end cut off one inch from the eye.

Two rows of continuous suture of the peritoneal and muscular coats are made, about four inches long and one-quarter inch apart (Fig. 365). An opening is now made with blunt-pointed scissors parallel to the sutures, and an eighth of an inch from them, leaving both rows on one side the cut. The latter should be between three and four inches long. Some bleeding points may now need clamping.

A fresh thread and needle are now made to secure both the cut edges next the sutures together; a simple overhand suture is best (Fig. 366). It arrests all hemorrhage, and the clamps are removed as the needle reaches them. The stitch is now made to quickly overhand each free edge by itself.

We have thus far made two long button-holes, secured on one side by three rows of sutures. It remains only to rinse the parts with pure water and continue the two outer rows around the still unsecured edge. This is easily and rapidly accomplished (Fig. 367).

On one side of the opening are three rows of stitches, which give great stability to the union, especially as the

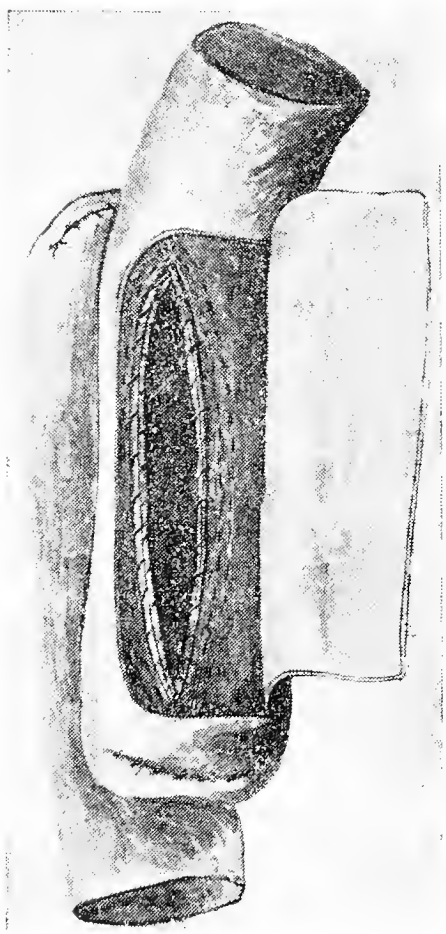

Fig. 367.

innermost includes the entire thickness of both edges. This is especially a strong point in uniting bowel to stomach (gastro-enterostomy), inasmuch as the disposition of both viscera to sag away from each other brings a little added strain on the back of the union.

Anastomosis thus done may be tested by water pressure, and will be found never to leak.

The question of time gained, during what is usually a prolonged operation—perhaps five or ten minutes' gain, at most, in the face of the uncertain advantage of plates, rings, buttons, and bobbins—is one that in the author's opinion is greatly outweighed by the superior advantage of having absolute security against leakage, blocking, etc., by the method of simple suturing. The technique of the latter procedure is a matter of easier accomplishment and far greater satisfaction in its results than that of the newer methods.

The absence of all paraphernalia but scissors, thread, and needle, makes the procedure most attractive.

There is one feature of the lateral anastomosis operation which has been largely overlooked, but which the author believes to be of the greatest moment in determining the lasting benefit of the operation; that is, the question of stenosis of the newly made orifice.

The law of cicatricial contraction, which operates so effectually in closing accidentally made fistulæ into the intestinal tract, or comparatively large ulcerations between the gall-bladder and the intestines, is here the direct antagonist of the surgeon in his endeavor to create a permanent and adequate anastomotic opening.

The incised opening for Senn's plates is about an inch and a half in length, for others it is still smaller, and the contraction of such an opening, sometimes with great rapidity, has in some cases rendered it entirely inadequate to its service. Not many autopsies remote from date of operation are recorded.

Three of my own cases of lateral anastomosis illustrate my point admirably. In the first, done in 1888, where I united the transverse and ascending colon by Senn's plates, the patient lived six months. The aperture had contracted from an inch and a half down to three-quarters of an inch, and the man required constantly to use laxatives. In the second, where I united ileum to ileum by catgut rings, the patient lived six months. The contraction reduced the opening from an inch and a half to one-half inch. In the third, eight months after lateral anastomosis of the sigmoid flexure following resection, the aperture of three inches contracted to one and a half. This was perfectly competent to do the functional work of the bowel.

These results were relatively good, but two cases done after the suturing method above described, around openings of between three and four inches in length, have maintained perfect functional action for over a year and a half.

I believe the future utility of lateral anastomosis lies in making these long openings. This, I think, is almost impossible with bone plates, and only to be done with very long rings or vegetable plates, and then only with less security and with the consumption of as much time.

The contrast is enormous between dropping back into the abdominal cavity a beautifully sutured, absolutely tight and flexible anastomosed end of intestine to any position in the abdomen which its natural surroundings demand, and returning a huge, stiff bunch of bowel, inside which there is a pair of big plates of bone or raw potato, to remain as irritating foreign bodies, stimulating peristalsis, and tugging at the wound until they become softened enough to be swept on by the current; or, as in one of Dr. Senn's cases, to be vomited up after dangerous retching.

As regards time, even were it proven that a hand equally expert at each method could do that by plates a few minutes quicker, the relative advantage of the two procedures for safety would still lie with suturing.

But, as a matter of fact, I have found that to do thoroughly a lateral operation in the living subject, by either plates or rings, takes twenty or twenty-five minutes, and the same operation by simple suturing, done with the greatest nicety and perfect security, has taken me twenty minutes.

In conclusion, the author still feels that what gain has been made in intestinal anastomosis and suturing is due to improved understanding of the needs of aseptic work and intelligent handling of the viscera; that the attempt to simplify the technique of lateral anastomosis by plates, rings, and the many devices extant has not improved it; that lateral anastomosis is, in most cases, the speediest, safest, and best method of restoring the canal; that simple and thorough suturing with fine silk continuous suture, after the manner detailed, is the most satisfactory; that, in order to allow for the inevitable tendency to stenosis, an aperture nearly four inches long should be made between bowels; that, while it may assist in fortifying the lymph union, abrasion of the opposed surfaces of peritoneum is not necessary to quick and solid repair. *Robert Abbe.*

INTESTINES, WOUNDS OF Intestinal wounds depend on the same causes as wounds elsewhere. The injury usually comes from without; rarely, it is due to a foreign body in the intestinal canal.

Each anatomical division of the intestinal tract is liable to injury, but those portions that are most extensive or most exposed are obviously in greatest danger. For these reasons the ileum and jejunum suffer most frequently, the colon occasionally, the duodenum least of all. In contusions, however, the duodenum seems to suffer a little more frequently than the colon. The latter, especially its vertical portions, has but a limited range of motion, and is therefore poorly protected against traumatic influences. It possesses, however, the immunity afforded by a deep location, comparatively limited use, and dense protecting structures.

The mobility of the intestines, due to their lax attachments and to the peculiar nature of their investing membranes, their elasticity, and the yielding nature of the tissues about them, affords the greatest possible natural immunity from violence that is consistent with the proper performance of the functions of the human body.

While in normally developed adults the divisions of the intestine present no decided variations from each other in their relations to the abdominal wall, yet Treves has shown it to be impossible to definitely localize any certain portion of the jejunum or ileum by external examination. In Treves's own words, "there is no systematic arrangement of the coils of the small intestine. There is a disposition for the bowel to follow an irregularly curved course from left to right, but this disposition can never be relied on. Such as it is, it may be expressed as follows: The gut starting from the duodenum, will first occupy the contiguous parts of the left side of the epigastric and umbilical regions. The coils then fill some part of the left hypochondriac and lumbar regions. They now commonly descend into the pelvis, reappear in the left iliac quarter, and then occupy in order the hypogastric, lower umbilical, right lumbar, and right iliac regions. Before reaching the latter situation, they commonly descend again into the pelvis. The coils found in the pelvis belong usually to the lower ileum and to the bowel, between two points respectively six and twelve feet from the duodenum."

Causation in General.—The violence coming from without, or arising within the canal, may be called the *exciting*, while the habits, occupation, idiosyncrasy, and surroundings of the patient are the *predisposing* causes. The nature of all intestinal wounds usually indicates the cause, though a single form of violence may produce a wound of multiform characteristics. The direction and degree of the force, the magnitude and character of the agent transmitting it, determine the extent, and largely also the number and variety of the wounds inflicted. The direction of a wound of the intestines, as well as the size, exerts an important influence on its local physical phenomena.

Causation of Contused and Lacerated Wounds.—Contused and lacerated wounds differ only in degree. In contusions the intestinal walls are bruised, in lacerations they are torn. These forms are commonly due to external violence, and when thus caused both varieties may be well marked at or near the same situation. A considerable degree of external violence is required to cause a laceration or a severe contusion of the intestines, owing to their mobility and flexibility, and also to the nature of their investing tissues. Despite this fact, however, cases of laceration occur from blows so slight, or through agents of such a character, that no injury is done to the abdominal walls. MacCormac has reported several such cases. Usually the agents transmitting the force have a blunt outline. The passage of the wheel of a loaded vehicle over the abdomen offers a frequent illustration of the manner in which the violence is inflicted; also a blow from the clenched hand or from the kick of a horse or a man, especially if the intestine be forced against the spinal column, or if the violence be received at a point where dense fecal impaction exists. Partial distention, according to Curtis, who made an analysis of 116 cases, diminishes the danger of rupture, while great distention of an isolated loop increases it, even for a loop not in contact with bony parts. The intestines may be bruised and even lacerated by imprudent manipulations for the reduction of herniæ, and the colon has been torn by the incautious introduction of the hand or an instrument into the sigmoid flexure. Contusions with or without lacerations have been caused by kneading the abdomen to overcome intestinal obstructions dependent on fecal impaction, and rupture has occurred from the force exerted by circumscribed collections of gas generated in morbid obstructive conditions. The force of spent pieces of shell has caused laceration of the small intestine. In 113 of the cases analyzed by Curtis, the duodenum was injured in 6 instances, the jejunum in 44, the ileum in 38, other portions of the intestine in 21, and the colon in 4.

Non-penetrating gunshot wounds of the intestine are essentially contused injuries of that structure. However, in penetrating gunshot injuries, the character of the intestinal wound assumes a different aspect, due, of course, to the penetration of the intestine by the missile causing the abdominal injury. Still, in these instances one frequently meets with both contused and lacerated wounds, independent of those due to direct penetration, since the mobility of the intestine or a mere impingement upon it of the missile fails to cause direct penetration. It is proper to say, however, that the borders of a penetrating gunshot wound of the intestine possess the characteristic features often of lacerated and contused wounds, although, for obvious reasons, in a much less degree.

Penetrating gunshot wounds of the intestine are more frequent in civil than in military life, as in the latter the trunk is exposed as little as possible and the missiles fly high, while in the former the attacks are often unexpected, and, therefore, the recipient is illy prepared to guard against them. Moreover, the range of the former is shorter, therefore the aim is better. It is interesting to note at this time that the percentage of gunshot injuries of the abdomen that are reported as resulting from the late war, is astonishingly small (about 0.035), while those of the head were 0.15. The increased percentage of the latter is due to the greater exposure of this part of the body. No definite estimate can be made prior to investigation of the number, size, direction, or exact nature of the injuries of the intestine that may follow penetrating gunshot wounds of the abdomen. The original text (see Vol. IV.) discusses this in greater detail.

Abdominal Symptoms.—Pain, tenderness, tympanites, and bloody stools, with or without the protrusion of the viscus and the escape of the intestinal contents, are common symptoms of intestinal wounds. They are greatly modified, however, with reference to their presence and their association with each other, by the nature of the wound itself.

Pain and Tenderness.—Pain is not a reliable symptom. Soon after the occurrence of an injury, there may be little, or indeed none, even when perforations are present. Commonly, however, pain and tenderness are among the first of the abdominal symptoms. Located primarily at the seat of the wound, it is dull or lancinating in quality, the former being more characteristic of contused wounds. As a rule it increases rapidly, becomes burning in character, and is accompanied by exquisite tenderness of the abdomen, retraction of the thighs, and obstinate constipation. It is increased by any muscular exertion, even the act of breathing. Sometimes there are griping pains with a desire to stool. Retention of urine may occur, due to the shock, to the peritonitis, or to the treatment employed.

Emphysema.—This sign is not associated very frequently with penetrating wounds of the abdomen, but when present is usually due to the escape of intestinal gases into the connective tissue situated between the intestine and the abdominal walls; hence it is associated especially with injuries of those portions of the intestinal tract that are not entirely surrounded by peritoneum. It may be limited to the immediate neighborhood of the injury, or may become general by spreading gradually into

the surrounding tissue, and it also may be due entirely or in part to a complicating wound of pulmonary tissue. Emphysema has been considered by some writers as a certain sign of intestinal perforation, when associated with a suspected penetrating abdominal wound. Its diagnostic value is much lessened, however, by the fact that it has been frequently observed in connection with non-penetrating wounds of the abdominal wall, one such instance, at least, having fallen within the observation of the writer. If decomposing processes occur in the course of a penetrating wound of the abdomen, emphysema may result even though the intestines themselves have not been injured. In such cases, however, the appearance of the emphysema is delayed.

Contused Wounds.—The diagnosis of contused and lacerated wounds can readily be made from that of all other forms, but to differentiate between these two is more difficult. There will be a history of abdominal injury received in some such way as already indicated. There may be external evidences of such injury, though in some instances there are none. If the intestinal wound be a *contused* one, there will be evidence of *shock*. *Respiration* may be modified by the pain attendant on the act of breathing. *Vomiting* is a frequent but not constant symptom. *Pain* is usually present in the beginning, not so acute as in lacerated wounds, but dull, deep-seated, and burning, denoting a beginning inflammation. These symptoms may subside in a few days, or they may be quickly followed by a sudden increase in the pain and more urgent manifestations of peritonitis, or by collapse. These unfavorable symptoms may be caused by the rapid increase of a localized inflammation, by a sudden hemorrhage from a previously contused vessel, or more commonly by a sudden extravasation following sloughing of some portion of the intestinal wall. The constitutional symptoms keep pace with the local. The temperature rises, the pulse becomes more frequent and harder, and the patient soon shows evidence of collapse.

The degree of tympanitic distention of the abdomen is usually proportionate to the extent and intensity of the inflammation. The tympanites may be due to air in the peritoneal cavity or in the intestine. In the former condition it comes from a wound in the gut, and in contused wounds it will, therefore, occur at or soon after the exacerbation of symptoms, while in lacerated it follows quickly the intestinal injury. Tympanites due to intestinal distention comes more slowly and is less in degree. *In lacerated wounds*, fecal extravasation occurs as a rule. It was present in 107 out of 113 cases (Curtis). The symptoms will, therefore, appear earlier than in contused wounds and be more severe. In both varieties there may be vomiting of blood, particularly if the duodenum or jejunum be injured. Blood may also be passed at stool, and if the amount be small and clotted, it indicates injury to the ileum. If the blood has to traverse a considerable portion of the intestine, it will be darkened in color and consistency by the intestinal fluids. The possibility of coincident diseases of the intestines causing hemorrhage must not be forgotten.

Nor must it be forgotten that a patient may have received either a contused or a lacerated wound of the intestines, and yet present no symptoms for a few hours. MacCormac has reported one such case, and two others where vomiting was the only symptom, yet all three had rupture of the intestine and died within forty-eight hours.

Hydrogen gas has been recommended by Senn as a means of determining whether or not, in a case of penetrating abdominal wound, there co-exist perforations of the intestines. He has demonstrated that under slight but steady pressure, the patient being relaxed by an anæsthetic, the gas may be forced from the anus past the ileo-cæcal valve to the mouth. If perforations exist the gas escapes into the peritoneal cavity, its presence being denoted by free tympanites, loss of liver-dulness, etc., or it will appear at the abdominal wound, where it may be ignited. If the distention follows the line of the colon, and, after passing the valve, be confined to the umbilical and hypogastric regions, it indicates that the intestine is intact. The gas in passing the valve causes a blowing or gurgling sound which may easily be heard with a stethoscope. The method of using it is as follows: The gas, generated in the ordinary manner (care being taken to have it pure), is collected in a rubber bag holding about four gallons. This bag is connected with a rectal tip by means of a rubber tubing and stop-cock. The rubber bag being filled, the rectal tip is inserted and the margin of the anus pressed against it to prevent the return of the gas; the bag is now subjected to gentle pressure, the valve yielding to a force varying from one-half to two pounds. If the external wound points to the possibility of stomach injury, then insufflation should be practised through a stomach tube. The disadvantages of the method are that it prolongs the operation, sometimes makes the returning of the bowels a very difficult matter, and occasionally, when perforations exist, it fails to discover them—items which, according to the majority of observers, outweigh its advantages. In addition to this, there exists the danger of forcing a portion of the intestinal contents into the abdominal cavity, particularly if they be fluid, and be located in or at the point of perforation.

Local Treatment of Hemorrhage.—Hemorrhage through the abdominal wound may arise either from the wound itself or have an intra-abdominal origin. In either case the indication is to tie the bleeding vessel. This can be easily done if it be situated in the abdominal wall, although it may be necessary to enlarge the opening for that purpose. Bleeding from within the cavity is considered in the great majority of cases a positive indication for laparotomy. Its treatment by and during laparotomy will be considered under gunshot wounds. If, in a given case, for any reason laparotomy may not be performed, the treatment must be palliative. The patient is kept quiet, and cold applications made to the abdomen. The external wound must remain unobstructed, so as to permit the free escape of blood that might otherwise collect in the abdominal cavity. A dressing of moist antiseptic gauze will serve the double purpose of protecting the wound and acting as a drain. In these admittedly hopeless cases, it is not impossible that pressure on the abdominal aorta, combined with transfusion, may prolong the patient's life. Should the hemorrhage thus be controlled, laparotomy during continuance of the pressure may yet offer an additional means of preserving life.

Treatment of Lacerated and Contused Wounds.—A lacerated or contused wound of an intestine may or may not admit of abdominal section. There is, of course, less danger of fecal extravasation in such a wound than in one associated with abdominal penetration, as the penetrating agent may carry the infection from all parts of the wound into the peritoneal cavity. If the symptoms are mild and rupture seems improbable, adopt the expectant plan. At all events, the performance of laparotomy should be deemed unwise in these cases after sufficient time has elapsed to permit the formation of adhesions contiguous to the injured portion. Severe hemorrhage, or serious visceral lesion, demands prompt operative interference. Laparotomy to be serviceable must be done early, and not left until peritonitis sets in. In a collection of eleven cases operated on after a few hours had elapsed, and as peritonitis was beginning, all died. Shock, usually great in these cases, is much increased by a long operation. For this reason many advocate the formation of an artificial anus. The choice between this and enterorrhaphy will depend in a measure on the experience and preparation of the operator. A wound located at a point of the intestine that would lead to rapid impoverishment of the patient from the formation of an artificial anus, should be treated by enterorrhaphy, even though the patient be exposed to greater immediate danger.

Treatment of Punctured and Incised Wounds.—In all uncomplicated punctured wounds of the intestine not more than 8 mm. in length, the question of abdominal section need not be raised. If it be thought larger than this, the measures adopted will be governed directly by the size of the wound and acuteness of the symptoms.

Incised wounds of the intestines are more dangerous than punctured ones, because of the greater liability to hemorrhage and extravasation. Their general treatment is similar to that of other varieties. In performing laparotomy the incision is usually made in the line of the wound rather than in the median line, because it affords the most direct route to what is usually a limited injury.

TREATMENT OF GUN-SHOT WOUNDS.—In opening the peritoneal cavity, the initiatory incision should be made in the median line, especially when it shall appear that if the opening be made at the seat of injury, it will not offer an adequate opportunity for a proper inspection and treatment of the injured parts. The probable direction taken by the missile should be considered in all such instances. It has been advised, and wisely, that when the intra-abdominal wound is probably limited to the more fixed portions of the intestinal tract, or to other abdominal viscera, in the absence of symptoms of hemorrhage the incision be made in the line of the abdominal wound. After opening the peritoneal cavity, instead of using forceps, which bruise the tissues, to limit peritoneal retraction, a long suture of silk or catgut should be passed through the peritoneal borders for this purpose, and held by an assistant or otherwise properly anchored.

The agents employed in repairs of the intestine include materials for ligatures, sutures, etc.; carbolized iron-dyed silk may be employed for both purposes. Antiseptic catgut of small sizes may be used exclusively for ligatures, although some prefer to rely solely on silk. The needles required for sewing peritoneal and intestinal surfaces will depend on the preference of the operator, some using curved needles of small size and without sharp edges, others ordinary straight, slender sewing needles. The latter are particularly serviceable in introducing the Lembert suture. In addition, there are required thumb and mouse-tooth forceps to raise the borders of the wound, artery and needle forceps for obvious purposes, large catch-forceps with horseshoe-shaped blades to close the openings at the side of the intestine, of a similar shape, two or three long-bladed catch-forceps with the blades protected by rubber tubing to compress the intestine transversely, holding back its contents above and below the wound. (Several instruments have been devised for this, but the fingers of an assistant are best and safest.) Curved and straight scissors, aneurism needle, grooved director, scalpels, and other common surgical instruments are also necessary.

After opening the abdominal cavity, the blood and fecal matter under observation should be removed with small sponges as soon as seen. This should be done very carefully, when possible by gentle pressure rather than by wiping movements, as the latter provoke the further spread of the infecting agents. In either instance, a sponge should be changed with each effort at removal. The bleeding points immediately under notice should be tied. It is important to remember that penetrating intestinal wounds should be closed as soon as found, otherwise they may escape notice, and thereby furnish an additional risk of still further infecting the peritoneal cavity.

The repair of the intestine should be accomplished by one of two methods: 1, by directly closing the openings; 2, by excision of a portion of the intestine and the union of the divided extremities, which union may be accomplished by either circular enterorrhaphy or lateral anastomosis. The former method may be done when the closure of the wound will not diminish the intestinal calibre more than one-third. Either of the latter methods when the gut is extensively injured. In certain wounds where direct closure will narrow the calibre more than one-third, additional room may be gained by closing the wound transversely. To do this it may be necessary to increase the length of the wound by making longitudinal incisions at either end of it of suitable and equal lengths. The intestinal wall is then grasped at corresponding points on opposite sides, and drawn upon; the longitudinal wound is thus converted into a transverse one, and in this position its borders are united. By this means a certain amount of "elbowing" is produced. While, as a rule, it is unwise to trim the borders of intestinal wounds, yet care should be taken to examine the border of a wound contiguous to an important vessel, to ascertain if the integrity of the vessel be endangered; otherwise the closure without this precaution may be followed by secondary hemorrhage.

The wound may then be closed by either the Gely, Lembert, or continuous sutures. A double row of the Lembert or continuous varieties may be made, or a single row of each instead, or the Czerny-Lembert. (Of the continuous varieties, Treves recommends the right-angle continuous suture of Cushing.) See article on Sutures.

The sutures, to be reliable, must go down to and embrace a thread or two of the submucosa, and not be more than three lines apart. The best material for suturing the intestine is the loose-textured carbolized iron-dyed silk.

If the mesenteric border only of the intestine be injured, the injured portion of the gut should be excised, because gangrene is liable to follow from injury to the vessels of this part.

When the intestine is completely severed, either by the original injury or the knife of the surgeon, the difficulty of adjusting the cut borders is much increased. The portion to be repaired must be drawn well out of the abdominal wound and carefully isolated by sponges and towels that completely prevent blood, fæces, etc., from entering the abdominal cavity. The uppermost extremity of the divided intestine will be known by the greater amount of fecal matter seen at its open end. The intestinal contents must be pushed aside for some distance from the part to be operated on, and the bowel occluded above and below. This may be done by using the clamps already referred to, or by making a hole in the mesentery and ligating the intestine either with a cord of iodoform gauze or a flat india-rubber band. The fingers of an assistant serve better than anything else. The use of the clamps may, as shown by Parkes, cause sloughing if carelessly or continuously applied. The excision is made with sharp, straight-bladed scissors, at a right angle with the long axis of the intestine. The length of the portion removed will depend on the extent of the injury; it should always be sufficient to include it, even though it be six or eight inches in extent, and where multiform perforations exist near each other, it is advised to include them in one resection, even if the intestine removed be three feet long. The danger, however, of removing a so large and absorbing surface, must be remembered.

The vascular supply of the intestine at the seat of injury must be carefully examined, and all that portion of gut excised that has an impaired supply of blood, else gangrene of the bowel may ensue. In fact, it is a wise precaution in excision always to divide the gut at those points which will afford the best vascular supply to the extremities to be united—that is, close to the entrance of a mesenteric vessel into the unimpaired portions. The mesentery corresponding to the portion of gut removed can be cut away in the form of an isosceles triangle, the base of which shall correspond to its intestinal attachment, or it may be ligated *en masse*, or in sections at its point of attachment, and allowed to remain free in the abdominal cavity. Parkes and others consider the latter plan unsafe, since, owing to the feeble vitality of its tissue, gangrene of the distal extremities of the mesenteric stumps frequently ensues. Parkes advises that the entire mass be included in one ligature drawn tight enough to check the bleeding, and that after the intestine has been united, the stump be stitched to the seat of operation, thereby forming again as nearly as possible a continuous mesentery. This method was in his experiments followed by less mortification. Another method is to make two incisions, one on each side of the mesenteric vessels, at a distance of about half an inch from them, through the wall of the intestine in its long axis corresponding in length to the portion of the intestine to be removed. Tear away the mucous lining of this mesenteric strip, and unite its peritoneal borders by a continuous suture of fine catgut. After the excision is completed

and the ends of the intestine have been united, the mesenteric strip will present a looped appearance due to the approximation of the intestinal extremities. The opening of this loop should be united by sutures, and the opposed surfaces of mesentery should also be transfixed, to prevent the formation of a pocket there. When the ligature *en masse* is employed, it is not considered safe to use catgut.

As soon as all hemorrhage is checked, the extremities of the intestines are approximated by an assistant and some form of suture is introduced. The suturing is begun at the mesenteric border, care being taken to thoroughly close the triangular space at this point caused by the reflection of the peritoneum from the walls of the intestine. After this, the protruding mucous membrane is pushed into the intestine and a suture is introduced at each of the three remaining aspects of the bowel, and then the intervening spaces are properly sewed. This is a better plan than to begin to sew at any given point and go directly around. In no instance should a suture be passed through the mucous membrane. If a Lembert or Gely be used, at least three to four lines of peritoneum should be included in the grasp of the suture at each extremity of the intestine. A suture should be drawn only sufficiently tight to bring the severed borders in close apposition, for if drawn too tightly the tissue grasped by it will slough. If a single row of sutures alone is to be made, they should be placed about five millimetres apart. If a double row is to be employed, those of the first can be deposited within six or seven millimetres of each other, and those of the second at intervals between the former. After the bowel is united, it is well to return to the mesenteric border. This is the weakest portion of the wound. It should be covered by stitching the two peritoneal layers of the mesentery over it, or by an omental graft.

A great many instruments and agents have been devised and recommended for the purpose of holding the divided ends of the bowel open while it is being sutured, but they are all or nearly all useless.

Omental Grafting.—In certain experiments on dogs, Dr. Senn fixed a flap of omentum over the seam of an enterorrhaphy, the free or distal end being attached over the seam, the proximal remaining continuous with the omentum. These soon grew in place and thus reinforced the bowel. To avoid the danger of strangulation occurring through the loop thus formed, isolated grafts were employed and fixed round the suture. In every instance they retained their vitality. The intestinal peritoneum is lightly scarified before the flap is put in position, and in a few hours it is adherent.

Senn's operation for intestinal anastomosis by means of bone plates, though devised to meet the requirements in cases of obstructive disease of the intestine, is yet applicable to certain cases of injury, especially when time is a very important element.

Recently intestinal anastomosis is being performed without the use of bone or any other form of approximation-plates. The advocates of this method claim for it exemption from the special dangers following the use of approximation-plates, viz., leakage, irritation and suppuration or hemorrhage, also obstruction from the plates themselves, or, later, from contraction of the cicatrix, etc. The operation, as described by Abbe, is briefly as follows: The resected ends of the intestine are inverted and closed by Lembert sutures approximating the serous surfaces. They are then overlapped to the extent of five inches and held there by two rows of continuous Lembert sutures, each row being an inch longer than the proposed opening. These rows are straight, in the long axis of the gut, parallel, one quarter of an inch apart, and are both to be on one side of the anastomotic opening. The needle with its thread is to be left at the end of each row ready to be continued. The openings in the bowel are now made about four inches long, parallel with and one-quarter of an inch distant from the nearest row of serous sutures. The bleeding points are clamped and the clamps left on. A suture is then started at one end of the wound and unites by a continuous overhand stitch, which penetrates the entire thickness of the intestinal wall, the cut edges lying near to the rows of serous sutures. The free or more remote edges are whipped in turn by separate threads. This controls the bleeding without ligatures, the clamps being removed as they are reached, and it also prevents any union of the edges at the angles of the wound. The serous surfaces around the openings are now united by a continuation of the first two rows of sutures, their relations to each other and to the opening being preserved and ending where they began.

Cleansing the Peritoneal Cavity and Closing the Abdominal Wound.—All the bleeding points must be closed by ligaturing if possible, if not, then by cautery. It must not be forgotten that the tendency of intra-abdominal vessels to bleed when not exposed to the air is very great; therefore a simple oozing before the closure of the abdominal walls is likely to become a formidable hemorrhage thereafter; and even though the secondary oozing be not sufficient to imperil the life by loss of blood, it is liable to do so by causing inflammatory or septic processes. The blood, other fluids, fecal matters, and all other foreign agents must be removed from the abdominal cavity and its contents and culs-de-sac thoroughly wiped by warm soft aseptic sponges soaked in Thiersch's fluid, a two per cent. solution of carbolic acid, or a solution of bichloride of mercury (1 to 10,000). Too great care cannot be taken in sponging away the foreign matter. As already stated, the same portion of the sponge should be applied to a serous surface but once, for to apply it repeatedly causes quite as surely the dissemination as the removal of the irritating agents.

Malcolm, of London, advises flushing out the abdominal cavity for the purpose of adjusting naturally the intestinal folds. Water or antiseptic solution at the temperature of the body is poured into the cavity from a pitcher. The intestinal folds floated up, subside later into their normal positions. The fluid is poured in until it returns clear. That remaining in the cavity is siphoned off or sponged out thoroughly. This flushing with hot fluid also aids in cleansing the peritoneal cavity, and, besides, acts as a stimulant.

The abdominal wound should be closed by two rows of sutures, a superficial and a deep. The latter should be a continuous one of strong silk, and should include the serous and subserous tissues and the transversalis fascia. The practice of making a deep row of interrupted sutures widely separated, or of including the whole thickness of the abdominal wall in one such row, is to be condemned. The pockets or dimples of peritoneum which are thereby formed between the stitches invite the occurrence of hernia. The superficial row may be of silk or catgut, interrupted or continuous. If necessary, the wound may be drained. And last of all, an antiseptic dressing is to be applied. The patient should be quieted by small doses of an opiate; the diet should be light at first and of a nature to leave little or no residue. The bladder should be evacuated with a catheter.

PROGNOSIS.—Ruptured or lacerated wounds have thus far proved more fatal than any of the other forms. Of five cases reported during the late war all were fatal. Curtis reports eight cases which were operated on, and all died. Since then several others, in which laparotomy was performed, have been reported, only one of which, that of Crofts, was successful.

The prognosis in gunshot wounds of the intestines, when treated by laparotomy, has of late years vastly improved. In 1887, Morton published a series of twenty-two cases with a little less than twenty-three per cent. of recoveries. About the same time MacCormac collected thirty cases in which laparotomy had been performed (Morton's were included), and gave the recoveries at a little over twenty-three per cent. Since then a collection of thirty-five cases shows eighteen recoveries, or a little over fifty-one per cent.

Of stab wounds which were operated on, Morton reported nineteen cases with sixty-three per cent. recoveries; MacCormac eighteen cases with over fifty-five per cent. of recoveries. A collection of nineteen cases made since then gives over seventy-nine per cent. of recoveries.

Joseph D. Bryant.

INTRA-UTERINE TAMPON.—The present methods of treating morbid conditions of the interior of the uterus are revolutionary when compared with the methods of a generation ago. Nay, they are revolutionary when compared with the methods of some teachers who are still high in authority, and deservedly so. That which in all past ages of medical science and practice has been considered *noli me tangere* is now approached with perfect unconcern, if with perfect cleanliness, and with clear foresight and expectation of beneficent results. The cases are rare indeed in which this expectation is disappointed if the manipulation has been attended by the requisite cleanliness and without undue rudeness.

It must ever be remembered, now as well as in preantiseptic days, that the uterus is a contractile organ, that it is enormously vascular, and that it is enormously absorptive, and no one should invade the organ without due regard for this headlight. Another point of great importance which has received due recognition only in very recent times, is that morbid secretions or accumulations within the uterus should be drained away as thoroughly as they would be drained from any other cavity; that is, the principle of drainage applies to the uterus as well as to other cavities containiug poisonous material, and if such drainage is not free and unobstructed the chances of mishap are very great. Many of the ills of womankind are due to the fact that uterine drainage has been ignored or misunderstood. If nature provided an outlet for decomposing material, well and good, but if not, nature and not man must be held accountable, to the great detriment, however, of the patient. Such reasoning has filled many grave-yards, and is in harmony with that other sophistry, "meddlesome midwifery is bad"—apologies, both, for the timid and the ignorant. The intelligent management of uterine drainage is one of the most valuable adaptations of modern uterine pathology, and it is the tampon more than any other means or instrument which has made such treatment efficacious.

That the unimpregnated uterus is susceptible of dilatation is a fact which has long been known, but only in recent years has dilatation been practised to any great extent. The use of tents composed of various materials has been advocated and practised for many years, but owing to imperfections in the materials used and want of care in the way of using them disaster has not infrequently resulted, and the profession has come to look upon them with more or less distrust. The field of their utility was believed to be limited, and they were often used with fear and trembling, perhaps, when no other means seemed available. The inflatable rubber bag invented by Barnes for the facilitation of the first stage of labor was a most ingenious and valuable device, but the material was unreliable and might betray one in the hour of utmost need. The stems of glass, rubber, and metal which have been devised by Sims, Peaslee, Wylie, and others, have served, and still serve, a useful purpose in demonstrating the dilatability of the unimpregnated uterus, and the many useful ends which can be subserved with an open uterine canal and free drainage. The powerful uterine dilators which are now in such common use, and which are, for the most part, modelled after the powerful instrument of Sims, must be mentioned in connection with the means which have been, and still are, used for the dilatation of the uterus, and for preparing it for the use of the curette or the tampon. It finally remained for Vulliet to demonstrate that the uterine cavity could be greatly enlarged by the gradual use of a tampon of antiseptic cotton, and that by its aid one was enabled to treat the various diseases of the endometrium and uterine muscle with a convenience and success which had previously been unknown, or at any rate unpractised.

Materials for the Tampon.—The object of the tampon is, primarily, dilatation. This may be effected by any material with which the uterine cavity can be filled. But the presence of a foreign body within the uterus excites secretion; hence two conditions are pre-requisites in the tampon material—it must be aseptic and it must be absorbent. The imbibition of the secretions of the endometrium by the tampon increases its volume and its dilating power and at the same time favors the absorption of poisonous material; hence the necessity of absolute certainty that the tampon material be aseptic, and that the tampon be not retained too long. Of all the substances with which the uterus may be tamponed, there are but two, so far as I know, which commend themselves for general use—absorbent cotton and gauze. Absorbent cotton imbibes the secretions of the uterus with great avidity and quickly becomes converted into a hard, firm mass, which may become painful and irritating in a very short time. Nevertheless, it is readily introduced, can be adjusted with great compactness, and is highly approved by many writers, notably by Vulliet, whose credit it was, as already remarked, to advocate the persistent and extensive dilatation of the unimpregnated uterus. Preferable to absorbent cotton as a tampon material, at least in my opinion, is antiseptic gauze, which has all the merits of absorbent cotton and none of its objections.

Introduced in narrow strips, from twelve to eighteen inches in length, it is readily adjusted, adapts itself to the shape of the uterine cavity, absorbs secretions readily, does not become hard like absorbent cotton, and is more readily removed. Either the plain sterilized gauze may be used, or gauze which has been prepared with iodoform, carbolic, boric, or salicylic acid, and it frequently happens that it may be retained several days without acquiring the odor of decomposition.

Conditions in which the Tampon is Indicated.—The gauze tampon is equally indicated for the impregnated and the unimpregnated uterus. The conditions may be tabulated as follows:

I. The impregnated and puerperal uterus:
   1. During pregnancy.
   2. During parturition.
   3. Post-partum either at term or prior to it.

II. The unimpregnated uterus:
   1. For exploratory and operative purposes.
   2. For the relief of hemorrhage.
   3. For endometritis.
   4. For the relief of stenosis.
   5. For the drainage of accumulations within the tubes.

I. The Impregnated and Puerperal Uterus.—1. *During Pregnancy.*—There are many conditions associated with the impregnated uterus which have heretofore been treated, and with fair success, by tampon of the vagina, the pressure of the tampon being the efficient agent. This method, however, is often indirect and troublesome, and will eventually be superseded by the more logical and effective tampon of the uterus. Of course there are cases in which a tampon of the vagina will be preferable, and yet others in which both uterus and vagina may be tamponed with advantage. Tampon of the uterus is indicated when an abortion is imminent or is necessitated. It is simply a substitution of means. Instead of a bougie or tent a tampon of gauze within the cervix, or within the corpus, if necessary, will bring on the desired uterine contractions and facilitate the emptying of the organ. On the other hand, a light tampon within the cervix, with a moderate tampon of the vagina, will in some cases avert an abortion, checking the hemorrhage and permitting the pregnancy to continue. No fixed rules for action in such cases can be given; one must exercise his discretion according to the situation. The wounding of the uterus, which so often occurs in induced abortion by the use of instruments of various kinds, may usually be avoided when the tampon is used.

2. *During Parturition.*—A slowly dilating uterus in the first stage of natural labor is often one of the most vexatious conditions, especially with primiparæ, for both patient and physician. In such cases an uterine tampon is of great value. Its use requires judgment and a certain degree of skill, for the soft uterine tissue may be readily torn, or undue violence may be shown to the organ in its insertion. It is best introduced with the patient in Sims's position, the uterus being steadied with a volsella, and the narrow strips of gauze pushed as high as the lower

pole of the advancing fœtus. As labor progresses the tampon will be extruded into the vagina, and it should be at once removed, as its function has been accomplished.

3. *Post-partum, either at Term or Prior to It.*—When Dührssen suggested the tamponade of the uterus for post-partum hemorrhage, his proposition was received with incredulity, almost with ridicule. To tampon effectively a bleeding, viciously inert uterus is indeed an operation for which one is seldom prepared. The quantity of gauze which can be stuffed into such an organ is almost unlimited, and there is no time to send for supplies when the emergency is present. But one can always carry half-a-dozen rolls of sterilized gauze bandages, three or four inches wide, and, if this is insufficient, clean pocket-handkerchiefs, or strips from napkins or pillow-cases, are usually available for such a crisis. Of course there must be no suspicion of dirt about anything which is introduced into the uterus, and the mass must be removed at the earliest practicable moment. This operation has proved a life-saving measure in so many instances that it must now be regarded as one of the recognized expedients in severe post-partum floodings.

In hemorrhage after abortion the intra-uterine tampon will be found quite as effective as in the similar accident at term, and the operation in the former case may usually be done with more deliberation and precision than in the latter. In cases in which there is septic matter or a suspicion of septic matter within the uterus after labor or abortion, the intra-uterine tampon will sometimes be of service. The statement is made thus cautiously because in such cases curettage and irrigation have a field which will sometimes be adjunct to the tampon and sometimes will take its place. The possibilities which the tampon has for usefulness in this class of cases are very great, and I can speak with much satisfaction and assurance of the valuable aid which it has rendered me in my practice. The usefulness of the tampon may also be mentioned in cases in which the uterus contracts imperfectly or irregularly after labor or abortion, a condition which is commonly known as subinvolution. The tampon stimulates such uteri to contraction, relieves the turgid veins, effects good drainage, and may prevent protracted or even serious disease.

II. The Tampon in the Unimpregnated Uterus.—Useful and sometimes invaluable as the tampon is during pregnancy and the morbid conditions which attend and follow it, it is equally valuable for many conditions which are unassociated with pregnancy.

1. *For Exploratory and Operative Purposes.*—In the presence of intra-uterine neoplasms, whether benign or malignant, dilatation is always necessary prior to operation, and exploration will frequently decide what the condition is, and whether an operation is practicable or advisable. Such dilatation may often be effected rapidly by means of the powerful steel dilator of the Sims, or a similar, pattern. But there are cases in which such violent treatment may be inadvisable, and in these the desired effect may be obtained more gradually by means of the tampon. The field which has heretofore been occupied by the uterine tent is destined to be reserved for the tampon. In those cases in which the uterus is to be opened from the abdominal cavity or to be extirpated, the danger of sepsis from its interior may be entirely anticipated by a preliminary tampon, and in those cases in which tumors have been removed from the wall of the uterus, which have so often proved fatal because of deficient drainage, the value of the tampon will be inestimable. It is a singular fact that so useful an adjunct for such operations has so long remained unappreciated.

2. *For the Relief of Hemorrhage.*—The indications for the tampon to relieve uterine hemorrhage are many, and doubtless some which might not be deemed valid by the majority of the profession at the present time, will be so considered in the near future. Among such indications may be mentioned profuse menstruation in the feeble and anæmic, hypertrophy and inflammatory conditions of the endometrium, malignant disease of the cervix or corpus, intra-uterine tumors of all descriptions, uterine congestion accompanying disease of the adnexa, retention of the products of conception, etc. The profuse menstruation of the feeble and anæmic, which has so long been treated by the profession with nauseating drugs, or with expectancy, that is, with a confession of helplessness, should no longer subject us to reproach. Does not nature sometimes shame us by plainly teaching that the rational method is to check such loss of vitality when she checks the menstrual flow in connection with some of the wasting diseases? The wonder is that such losses can be so long tolerated by those who suffer them, and who wait in vain for the relief which is promised them—in time. Tamponade of the uterus in the unmarried, especially in young girls, is an operation which a sensitive and conscientious physician naturally shrinks from, but it is immeasurably the lesser evil and should be boldly and thoroughly carried out. The necessity for the tampon in the other conditions mentioned will probably be admitted without further argument. If mistakes are occasionally made by such a procedure they will only be the exceptions proving the rule. In almost all cases it will be well to precede the tamponade by a careful curettage. With me such a procedure is a routine method, for it frequently clears up a diagnosis which may have had elements of obscurity.

3. *For Endometritis.*—Endometritis is not necessarily accompanied by hemorrhage. In the septic varieties, in endometritis accompanied with hypertrophy, with excess of glandular secretion, with inertia, and atony of the uterine muscle, the benefits to be derived from curettage, tamponade, and drainage are unquestionable and extensive.

4. *For the Relief of Stenosis.*—Unwilling as many are to admit the existence of evil arising from mechanical obstruction within the uterine canal, especially with reference to the performance of the menstrual function, the facts are against them, the facts of induction on the one hand and the theories of deduction on the other. Those who pin their faith upon clinical experience through a series of years, in a series of careful observations, may have reasonable confidence in their conclusions. The day of stems and tents for the relief of uterine stenosis is past, or rather a better instrument for the treatment of this condition is at hand in the tampon. Whether the stenosis is natural or the result of disease or traumatism, whether the condition to be relieved be sterility or dysmenorrhœa, the indication may usually be met by the judicious application of the tampon.

5. *For the Drainage of Accumulations within the Fallopian Tubes.*—The use of the tampon for this purpose, which has been so ably advocated by Polk, does not seem to me to have so extensive an application as he thinks. I have operated upon several cases in which the dilatation of the tubes did not extend far beyond the uterine cornua, the cornua themselves being distended and the tissue friable with infiltrated pus. The tampon undoubtedly drains such cases very well, but suppose the case is not seen sufficiently early to drain thus efficiently. Suppose, moreover, that the ovaries are seriously diseased, while the abdominal ostium of the tube is still pervious, as is not infrequently the case; or suppose the tube is divided into loculi, each filled with pus, and separated from each other by impervious septa, or that the tubes are dislocated and the purulent accumulations beyond the reach of the tampon; under such unfavorable conditions, which are far more numerous than the favorable ones, temporizing or palliation may be dangerous. Therefore, while conceding the value of Polk's propositions and suggestions, the utility of the tampon seems to me here to be very limited.

Methods of Using the Tampon.—Polk's broad proposition that the tampon should be introduced with all the precautions and all the adjuncts of any surgical procedure, including the administration of an anæsthetic, is, of course, susceptible of limitations. In the tamponade of the uterus for hemorrhage post partum the urgency of the situation will forbid the deliberation and attention to details of a less serious condition, and in many other cases in which the uterine canal is patulous, the tissue soft, and the patient not unduly sensitive, an anæsthetic

will be unnecessary. I have tamponed such cases many times in office and clinic practice. For other cases the safeguards which Polk mentions are timely and requisite. As I have already said, the introduction of the tampon should invariably be preceded by curettage with the dull or sharp curette, as the case may require, by irrigation, and frequently by dilatation. Roughly speaking, if the canal is half an inch in diameter the gauze may readily be introduced. For some conditions (which will suggest themselves as occasion arises) the lateral position of the patient will be preferable for the operation; for others the dorsal. I have sometimes been obliged to change the one for the other. The lower lip of the uterus may be steadied with a volsella while an assistant steadies the upper lip. The gauze, in strips two inches wide and twelve to eighteen long, may then be passed up the fundus with long dressing-forceps until the entire cavity is sufficiently packed. The firmness with which it is to be packed will depend upon the condition for which it is used. I have not been able to use Polk's cannula to advantage, nor do I like to recommend the use of the auger-pointed introducer. The latter is too dangerous for unskilled hands, and unskilled hands must frequently perform this operation. The tampon may be retained from one to seven days, according to the indication, and it may be renewed as often as necessary. (I have kept a myomatous uterus dilated for weeks in succession.) No special rules are necessary for its extraction; it may readily be removed with long dressing-forceps. With regard to contra-indications the tampon may be so modified, as to quantity, firmness, and duration of retention, that I am unable to conceive of the impropriety of its use in any case in which intra-uterine treatment is admissible. Combined with the principle of drainage and the use of the curette it forms one of the most powerful and efficient means in uterine therapeutics. *Andrew F. Currier.*

INTRA-VASCULAR AND SUBCUTANEOUS INFUSIONS OF BLOOD AND OF SALINE SOLUTIONS.

The treatment of extreme conditions of exsanguination, whether from the direct and immediate loss of a large amount of blood by sudden hemorrhage, or from the effects of rapidly exhausting disease, has long been the subject of careful study on the part of skilful practitioners, and of elaborate and protracted experimentation by the most able and diligent observers. Such an alarming loss of blood is so terrifying, the degree of prostration is so profound, the shock to the system is so great, that few of the emergencies of professional life appeal more strongly to the sympathy of the physician, or urge him to greater exertion to ward off the fatal termination which must speedily occur if aid to the sufferer cannot be promptly rendered and efficiently applied. In the greater number of accidents and injuries followed by hemorrhage, it is possible to control the loss of blood by the adjustment of a tourniquet, by occlusion of the lacerated vessels by means of a ligature, by compression of the bleeding vessel by direct force applied over the seat of the injury, or by acupressure or other appropriate means. These means are not, however, applicable to many cases of bleeding, such as post-partum hemorrhage, secondary hemorrhage after amputation, and the accidental hemorrhages attending certain of the febrile diseases to which the human organism is susceptible—*e.g.*, typhoid—or the purpuric condition, or in cases of hemorrhagic diathesis, or in certain organic affections of the internal organs, such as ulcer of the stomach, cancer of the alimentary tract, occasionally tuberculous ulcerations of the intestinal wall, and other analogous conditions, which at times present themselves.

From the nature of the case, all patients with sudden and alarming hemorrhage must be considered as cases of the gravest emergency, and any treatment applied for the relief of the patient must possess certain special advantages, chief among which must be its universal and easy procurement and simple preparation; and in addition to these it must be harmless in its relations to the tissues or organs with which it may come in contact during its presence in, or action upon, the system.

F. P. Henry and Alfred Stengel publish in Sajous's Annual (1892, vol. ii., E., p. 16), a paper in which Thompson reports twelve cases of acute anæmia, such as those due to hemorrhage after labor, operation, etc., treated with sterilized solution of sodium chloride. Of the twelve cases, eight were treated by intra-venous injection, two by intra-venous and intra-peritoneal, and two by intra-peritoneal. Four recovered and eight died. Thompson regards the intra-venous the best method, because, when the heart is weak, solutions injected subcutaneously may not be absorbed, and because the action is more prompt. His experience would lead him to condemn the intra-peritoneal injections. Injections of saline fluids prolong life, but must be followed by injections of defibrinated blood. The sugary solution of Landerer has no special merit. Holmes, from studies of injections in acute anæmia, draws the following conclusions: 1, Auto-transfusion should be done first; 2, then infusion of large quantities of saline solution; 3, immediate intra-vascular injection of salt solution should not be practised; 4, secondary intra-peritoneal or subcutaneous injection of blood, when there is dangerous anæmia, is a conjectural matter, but should not be practised until reaction occurs; 5, immediate subcutaneous injection of blood is problematical; and, 6, the rotary surgical pump is the best apparatus. Several of these conclusions are now antiquated.

Marshall experimented with rabbits to study the effect of injections of mixtures of defibrinated blood and sodium chloride, and found, after a week, restoration of the number of corpuscles, and after three weeks, of the hæmoglobin. Stahle obtained good results from Landerer's sugar solution, as did Weber and Frank with simple salt solution. Weldon thinks that blood-transfusion has fallen into undeserved neglect, because dissimilar bloods were employed, and therefore untoward results obtained. Castellino speaks favorably of injections of 14 to 16 fluid ounces (420 to 480 grammes) of a three-quarters of one per cent. solution of soda. Lapine advocates the introduction of goat's serum directly into the veins. He uses about 50 c.c. (1¾ ounce), and has found no evil consequences, though such might be feared theoretically. He suggests that possibly the introduction of the serum of non-tubercular animals may prove useful in the treatment of tuberculosis. It is noticeable that in this somewhat extended review, no suggestion is offered as to the temperature of the solution or of the blood which is to be injected into the vascular system of the patient. In the earlier attempts to replace the blood lost by the system, it was supposed that the blood of the human organism, or that of only a few animals, could be utilized for this purpose. After this operation it was found that accidents of peculiar kinds were apt to occur, such as the coagulation of the injected blood in the vessels, this often inducing embolism, or thrombosis. Defibrination of the blood was then substituted for immediate transfusion, in which the blood was whipped with straws, and the fibrin thus collected upon them was in this way removed. The remaining fluid, supposed to be normal blood, minus only the fibrin, was then injected into the vessels. A certain number of the patients survived this procedure, but the dangers from the introduction of air into the circulation, of septic infection of the blood in the processes of preparation or otherwise, together with the peril attaching to instruments and to hands which are not aseptic, have led most practitioners to abandon this mode of treatment of sudden and alarming hemorrhage.

Among the procedures which have proved the safest and best, and which should certainly be employed in preference to the more complicated and elaborate methods, is the infusion of *hot saline solutions* into the vascular channels; thus adding to the bulk of the circulating fluid, and relieving the heart from the danger of sudden and fatal collapse. We now know that as good, if not better, results are reached by injecting warm saline-alkaline water as by transfusing blood. "Aside from the obvious dangers—clotting, embolism, sepsis, etc.—attend-

ant upon the use of any kind of blood, we now know that blood-cells other than human are broken down and disintegrated almost at once within the human body; and in consequence, a great mass of detritus is thrown upon the organs having charge of metabolism of tissue, threatening to overwhelm them with work. Even human blood-cells are probably so destroyed, though more slowly, when transferred into another body than that which gave them birth. What seems needed is only some unirritating fluid, which can supply the lacking volume within the heart and vessels; that is, to give to the heart a sufficient amount of some harmless current running through its chambers to excite systolic action. If this is done, and done promptly, at the right temperature, before the patient suffers too much from the shock caused by sudden and extreme anæmia, it is wonderful how large a loss of blood may be sustained; and how rapidly, as if by magic, nature supplies multitudes of new red blood-cells to supply those which have been lost."[1]

The following quotation from William Hunter (*British Medical Journal*, August 10, 1889, p. 309), is of interest in this connection: "After the greatest loss of blood in animals a sufficient number of red corpuscles always remains in the circulation to carry on respiration, provided that the circulation is maintained. In animals, after the loss of half to two-thirds of the total quantity of blood in the body, the number of corpuscles per cubic millimetre may be found as high as 3,000,000 or 4,000,000. The absolute loss is great, but the relative loss is slight, and is of little importance. The animal's health is in no way injuriously affected by the loss. . . . In man, a loss of blood can never be so great as in animals; syncope occurs earlier. Transfusion of blood is, therefore, never required for the purpose of supplying red corpuscles to carry on respiration after sudden loss of blood, in a patient previously healthy. The immediate source of the danger in such cases is not the want of red corpuscles, but the disturbance of the relations between the vascular circulation and its contents. . . . It is remarkable how slight the disturbance may be in cases, for example, of pernicious anæmia, in which the red corpuscles may be reduced to the extent of ten per cent., or even less, of their original number. I have observed cases in which the number of corpuscles was as low as 500,000 or 600,000 per cubic millimetre, instead of 5,000,000 as in health; the respirations never rising above 20 per minute, and the breathing, during quietude, being perfectly natural."

In cases in which the loss of blood is not immediate, as in conditions of great prostration from exhausting disease, or in pernicious anæmia and kindred diseases, the introduction of saline solutions into the connective tissue of the body, whence it is rapidly and easily absorbed into the systemic circulation, has been followed by most gratifying results. It would seem that the presence of a large amount of circulating fluid within the vascular channels, must exercise a stimulating influence upon the cardiac muscle, and possibly upon the tissues at large, with the result of invigorating the entire body. This application of *hot* saline solution has not, however, had the extensive use which has attended the intra-vascular injection of saline liquids, at bodily temperature, and its beneficent effects are not so well known.

Of course, if one had abundant time in which to prepare it, the best saline-alkaline fluid would be one identical in its components and their proportionate quantities with blood-serum. Most surgical text-books give a formula more or less approaching this. Of late it has been recommended by Ludwig, of Leipzig, to add to our saline-alkaline water a little sugar; this being a natural ingredient of the blood. Simplest of all, and so far as we can see, practically about as good as the most complicated of these formulæ, is simple warm water plus a little table-salt. It has the great advantage, too, of being always at hand when wanted. The best proportion of salt is six parts in one thousand parts of water, or about the density of blood-serum. This would be, roughly estimated, a heaped teaspoonful in a quart of warm water. The water should be first boiled, for aseptic reasons. We must never forget the salt. Such an omission would be fatal. Pure water, devoid of sodium chloride, when injected in any considerable amount, will at once dissolve out of the blood-cells their hæmoglobin, and thus promptly kill the patient.

Dr. F. C. Shattuck, in "Hare's Therapeutics," Vol. I., p. 780, has recently contributed to our latest knowledge in relation to transfusion and infusion, an article which is so carefully weighed in its estimate of the worth of these procedures, and so fair in its judgment, that I take the liberty to transcribe a portion of it in this connection. He says, "It is estimated that a person can stand a single blood-loss of at least one-third of its total volume without a directly fatal result; perhaps with a surprisingly rapid recovery.

"If the patient does not show signs of rallying from the collapse following hemorrhage, the question naturally arises of artificially supplying, to a greater or less degree, the loss sustained.

"A simple and ready means of stimulating the circulation is the application of heat, internally by a rectal injection of a quart of warm saline solution; externally, by hot bottles; some form of alcohol being given by the mouth if the patient can swallow. Or a sterilized solution of common salt, of 0.06 per cent., or 0.07 per cent., can be thrown into a vein, into the subcutaneous tissue, or into the peritoneum. It has been, and is still maintained by some, that such a saline solution is just as potent to save life as is the transfusion of pure or defibrinated blood, while it is free from some of the dangers incident to the last procedure. There are numerous cases recorded in which the saline solution seemed certainly to save life, though it is possible to assert in these that recovery would have ensued without its use. The last word has probably not been said as yet on this question. For intra-venous injection of defibrinated blood, or of a 0.05 per cent. or 0.06 per cent. solution of salt, all the apparatus required consists of a glass funnel, some rubber tubing, and a cannula; the rapidity of the flow being regulated by raising or lowering the funnel. According to Mayette, if the median basilic vein be selected for infusion, the amount should be about a fluid ounce per minute, though not much harm is likely to arise if ten ounces be injected in six minutes. This should generally be the maximum, except in cases of extreme urgency, in which the relative emptiness of the vessels is the chief source of danger. The same simple apparatus is also sufficient for the subcutaneous infusion of salt solution, from 500 c.c. to 1,000 c.c. (from 17 to 33 ounces fl.) may be injected under the skin of the back or in the axillary region, absorption being aided by gentle massage. Should the skin become too greatly distended, a second injection may be made in some other locality. This method of rapidly making up a deficiency in the quantity of the circulating liquid is free from danger, can easily be done without trained assistance, and in many cases in practice has been successful."

Ziemssen has largely practised another method which seems to be at least safe—namely, the substitution of defibrinated human blood. Its first results were not satisfactory, but after an interval of about ten years he has lately resumed his work in this line, and has now so perfected his technique as to avoid all undesirable effects and obtain marked benefit. Strict antiseptic precautions are observed throughout the operations of drawing and injecting the blood, which is done under the skin of the thighs. He uses a syringe containing 25 c.c., the contents of which are thrown slowly into the tissues, while an assistant, with hands well anointed with vaseline, puts his "full strength" into the massage of the part, so that the blood is diffused widely and thus put into a favorable form for rapid absorption. From six to sixteen syringefuls are injected at a sitting, the patient being under anæsthesia, as the injection and the massage are alike painful.

In attempting the operation of infusion, certain precautions against septic infection should be preserved. These relate to the apparatus which is used as well as to the vessel holding the liquid itself. If the instrument be

a hypodermic needle, after the wire is withdrawn from the canal of the needle, this should be cleansed by forcibly passing several syringefuls of boiled water through it, and then holding it above the flame of a lamp or gas-jet, until the water contained within the hollow needle is transformed into steam and issues as such from the end of the needle. The needle may then be considered aseptic. The rubber tube, if this is used, should be subjected to thorough disinfection by some efficient germicide, and may remain in the solution until wanted for use. If a common Davidsou syringe is used it should be most carefully disinfected, as this instrument is exposed to unusual dangers from septic infection.

A very simple and perfectly efficient plan of disinfection is to fill the syringe, and hypodermic needle, or the cannula, with boiling water, and then to immerse and boil them in water for a few minutes.

Previous to operation, the place selected for the introduction of the needle should be thoroughly washed, and subsequently scrubbed with some form of antiseptic solution. The hands of the operator, as well as those of his assistants, should also receive the necessary cleansing appropriate to a surgical operation. The solution to be injected should consist of freshly boiled water, preferably distilled water, in which has been dissolved common salt (sodium chloride), in the proportion of 0.06 per cent. or 0.07 per cent., and which has then been allowed to cool to the required temperature. Most authorities assert this to be anywhere about 100° F. There is reason to think that a much higher temperature, as first pointed out and insisted upon by Professor Dawbarn, of New York,[1] is to be preferred on account of the added stimulation from the elevation of the temperature of the liquid as it comes in contact with the visceral organs in which the vitality is reduced from the loss of blood, and in which there is also greater radiation from the surface and no corresponding rapid production of heat in the body. It is a noticeable fact that in cases of extensive hemorrhage there is always a feeling of chill on the part of the patient, and that the surface of the body is covered with a clammy and decidedly cold sweat. The infusion of *heat*, as well as the increase of volume of fluid in the circulating organs, may therefore be considered as a distinct advantage, and is undoubtedly of positive benefit in cases of extreme danger.*

Transfusion of blood has been urged as a remedy in the coma of diabetes mellitus by Dieulafoi,[2] but the measure has been found to be practically of no advantage, while the dangers and difficulties are almost of themselves sufficient reason for its abandonment, except possibly in institutions where the apparatus and necessary assistance can be readily procured. It need hardly be added here, that blood-transfusion, either mediate or immediate, has now been dropped by almost all surgeons (Dawbarn). The results so far obtained do not warrant us in believing it to be a measure that can in many instances enable us to save from death patients who have become comatose. The use of such injections has, however, in some cases, apparently been the means of cure, while in others it has been of decided benefit, although not completely successful. Dickinson reports a very interesting case in which he employed the method with apparent benefit. The account is chiefly of interest from the fact that after the injection the patient regained consciousness for a time, and that during thirty-two hours, four hundred and fifty-six ounces of fluid were injected. In his opinion the best site for the operation is the prominent vein upon the instep, the tissues there being easily dissected and the vein hooked up, while its distance from the heart insures a more perfect admixture of the solution and the blood-column before they reach the heart and the medulla. The solution should be freshly prepared from boiled and filtered or distilled water, to which has been added a drachm and a half of sodium chloride and fifteen grains of sodium carbonate to each quart of fluid used. The fluid should be warmed to 100° F. and then injected slowly by means of gravity pressure, the reservoir being held at a height of three feet above the cannula. The latter should be of about one-sixteenth inch bore. Professor Dawbarn urges, upon physiological grounds, that the salt-water should be *very hot*, not less than 120° F., which is as hot as the hand can possibly bear. It was shown in his kymographic experiments that no harm could result from less than forty degrees hotter than this; on the contrary, the stimulant effect of the hot water on the heart, and also upon the unstriped muscular tunics of the vessels in restoring their lost "tone," was almost magical. In Dickinson's cases above mentioned, there were added to the water potassium chloride, and the sulphate and phosphate of sodium. Alkalies may also be administered by the mouth, but they are not in this way so rapidly utilized as by intra-venous injection. Struempell recommends the subcutaneous injection of ether or camphor, with lukewarm baths and douches.

The new and simple technique which Dr. Dawbarn has applied to the operation of infusion of salt solution, "involves no cutting whatever, no searching for a collapsed vein, no freshened knowledge of anatomy, no tying in of a cannula, no cannula at all, in fact. All the appliances needed are such as are likely to be right at hand (it can be reasonably assumed) in nearly every instance. The instruments are, an ordinary Davidson syringe, and an ordinary hypodermic needle—large size preferred, though this is not essential. Even if the patient be pulseless at the wrist, we can almost to a certainty feel the femoral beating just below Poupart's ligament. Now, take the needle and push it directly into this artery, going slowly, until bright-red blood is seen to well up from within the needle. (As the artery here is large enough to carry a lead-pencil, the needle will not miss it, if a little care be exercised.) As soon as the arterial blood is seen in the needle, slip over its base the syringe-end, or other tube, both being filled with the hot solution, and tie a thread tightly about the syringe, securing it to the base of the needle. Now, holding the needle firmly and steadily, pump the fluid directly into the arterial current. To avoid possible pumping of air by an old or leaky syringe, make an abundance of the salt water, and keep the entire syringe, with the hand working it, beneath the surface. From the moment the determination to use the saline solution is reached, until the moment when the infusion is actually entering the blood-current, need not exceed five minutes. Should it be objected that this plan injures a very important artery, I would reply, that this is decidedly a lesser evil among those which confront the patient dying from loss of the circulating fluid. Furthermore, I have several times used this plan upon the human subject, saving the patient's life, and with no subsequent annoyance regarding the femoral artery. A further advantage of this technique is the fact, that thereby it is difficult to make the otherwise common error of throwing in the injection-fluid too fast, suddenly overwhelming the tired heart. Until one has tried it, one hardly realizes how much the intra-vascular pressure will obstruct the inward flow through the needle, even in a patient with a badly flagging heart. There will be so much resistance that it will seem as if the needle *must* be plugged with a clot or some other foreign body, so slowly, in spite of vigorous pumping, does the stream pass in; and yet in the course of half an hour's steady work, a pint or more can be made to enter.

"Whoever has noted the vigor with which unstriped muscular fibre everywhere reacts to the use of heat (for example, the much stronger and decidedly more permanent contraction which results from *hot* post-partal injections as opposed to cold ones), must believe it probable that such unstriped muscle, forming as it does a most important tunic of the blood-vessels, would be aided

* In two cases of acute anæmia recently reported by Dr. E. Sternberg, in the New York Medical Record, the *hot* infusion of salt water (120° F.) as advocated by Professor Dawbarn, was followed by complete recovery; whereas several patients treated in the same way, except that the fluid was injected at the temperature of the normal blood, died in succession. There appears to be no good reason why the injection of saline fluid should not be repeated at intervals, both for the support of the circulation and also for the purpose of aiding the elimination of excrementitious matter from the systemic emunctories.

by *hot* saline infusions in regaining its lost tone. Perhaps, too, the central sympathetic centres would feel and respond to this stimulus."

So far as the writer has been able to discover, the extremely simple and ready method of saline infusion herein described by Dr. Dawbarn—*i.e.*, using an ordinary hypodermatic needle in an artery, etc., has not heretofore been published, nor his suggestion of the value of a very high temperature in the injected fluid, instead of that normal to the body. *Albert N. Blodgett.*

[1] Arterial Saline Infusion. Dr. Dawbarn. A report of three additional cases by the New Technique, etc.; reprint from Medical Record, November 12, 1892.

[2] See Dr. F. A. Packard's article in Hare's Therapeutics, Vol. ii., p. 1035.

INTUBATION. Since the publication of Vol. IV. of the HANDBOOK, six years ago, intubation, then in its infancy, has made rapid progress in public as well as in professional favor. In fact, its progress in some respects has been altogether too rapid for the good of all concerned, especially for that of the little sufferers from croup who are too often the innocent victims of bad instruments and incompetent operators, the two evils that beset this procedure and for which there seems to be no remedy.

Intubation is unfortunately a difficult and dangerous operation to attempt without a previous training on the cadaver, and but few of those who practise it have had such training. It is difficult solely because respiration is suspended during its performance, which requires that it must be done quickly, and to acquire the dexterity and educated touch necessary to do it thus quickly, and at the same time gently, requires a large amount of practice. Were it possible, without endangering life, to consume half a minute in any single attempt to locate the larynx, fix the epiglottis, and pass the tube, there would be little difficulty or danger attending the operation, but cutting off the small supply of air the patient is getting—when the operation is necessary—for even one-third of this time, is not always safe in bad cases.

No amount of skill in the performance of other operations affords the least aid to that of intubation. The most accomplished surgeon or laryngologist is therefore no more competent to do this operation without the practice referred to above than the merest tyro in these arts.

The laryngologist educates his sense of sight while the intubationist requires an educated touch combined with manipulative skill, a sufficient degree of which can be acquired on the cadaver to insure, in the performance of intubation, safety to the living.

The following case, reported by Dr. G. Hunter Mackenzie (Edinburgh *Medical Journal*, February, 1892), is a good example of many that might be published but are not: "Case X., girl aged two years, under the care of Dr. Henry Hay, February 3, 1891. Diphtheria of pharynx and larynx. At 11.30 A.M. the pulse could not be counted and great inspiratory dyspnœa was present. Intubation was at once performed, with immediate and marked improvement to the breathing and strengthening and slowing of the pulse. February 4th, the child has breathed freely all day and is apparently going on well. She had slept well during the night. Brandy is being freely administered, a moderate degree of difficulty in swallowing is present. February 5th, the child continues to do well. At 4 P.M. I considered it advisable to remove the tube, which had been forty hours in the larynx, and this I tried to do with the assistance of the child's father. The process of gagging and the insertion of the extractor, along with some struggling on the part of the little patient and some difficulty in locating the blades of the extractor inside the very small tube, appeared to completely exhaust the patient, and induced a condition of death-like collapse. Artificial respiration was immediately resorted to and produced a partial revival only, for the child never returned to her former condition. She died a few hours afterward without a recurrence of the symptoms of obstructed respiration."

The fatal result in this case was undoubtedly due to apnœa from prolonged attempts to remove a tube from the larynx of a child free from dyspnœa at the time the operation was begun. How much more liable is this accident to occur either in the introduction or removal of a tube when the dyspnœa is extreme! In unskilful hands a fatal result from this cause is not by any means rare. Yet there are many who claim that every practitioner should be prepared to intubate in case of emergency.

Any immediate danger to life attending the introduction or removal of a tube from the larynx, excepting cases moribund at the time, is chargeable to the operator and not to the operation. Cases very difficult to intubate are met with not unfrequently, owing principally to the engagement of the distal extremity of the tube in one of the ventricles of the larynx or in a subglottic stenosis, but the skilful operator, knowing the cause of the obstruction, knows also how to overcome it.

The most convincing proof of the popularity of intubation as compared with tracheotomy, is found in the large individual experiences that have been accumulated in the short space of time that has elapsed since the introduction of this operation. Dr. F. E. Waxham has recently reported four hundred and twenty-one cases intubated by himself. Dr. Dillon Brown has also passed the four hundred mark, and the author is approaching it. Over twelve hundred cases by three operators in a few years; and many others have passed well into the second hundred.

Individual experience with tracheotomy, on the contrary, with very few exceptions, is comparatively small, Dr. Jacobi being probably the only tracheotomist in this country who can number his cases by hundreds.

In a recent discussion of intubation versus tracheotomy at the New York Academy of Medicine, Dr. L. S. Pilcher, a well-known tracheotomist of Brooklyn, reported sixty-six tracheotomies as the outcome of seventeen years of active professional life, while Dr. McNaughton, from the same city, has intubated over one hundred and forty cases in five years. This difference is not due to any greater prevalence of croup in recent years than in the past, but to the fact that the people, especially of the poorer class, among whom this disease principally prevails, would not tolerate the cutting operation except in a small percentage of the cases.

As far as private practice is concerned, the comparative merits of the two operations in saving life constitute therefore a subject of scientific rather than of practical interest.

Diphtheritic, fibrinous, or membranous croup, with rare exceptions, is the only form of acute stenosis of the larynx in children that demands surgical interference, and this disease is so complex in its nature and is attended with so many elements of danger, independently of the laryngeal stenosis, that no brilliant results can ever be expected from any mechanical method of treatment. The principal cause of the great mortality after both intubation and tracheotomy, is the extension of the disease to the bronchial tubes where surgery cannot reach it. Then come catarrhal pneumonia, systemic poisoning, nephritis, and paralysis, all of which may be combined in the same case, but any one of which alone is sufficient to produce a fatal result.

For a description of the intubation instruments, with illustrations and method of operating, see Vol. IV., page 419, of this HANDBOOK. The only material difference in the construction of the tubes since the article referred to was written, consists in making the distal extremities somewhat bulbous, in order to prevent them from engaging in one of the ventricles of the larynx, the usual starting-point of a false passage. In the article referred to, the production of a false passage by forcing a tube through one of the ventricles and into the cellular tissue of the neck underneath the skin was barely mentioned as an accident unlikely to happen, but I have since learned from various sources that it is not at all uncommon in the hands of beginners; hence this modification in the form of the instrument, which renders the penetration of the tissues almost impossible.

Almost all the other accidents attributed to the operation of placing a tube in the larynx are due to the same cause, viz., want of skill on the part of the operator. Pushing membrane down before the tube is far more curative than dangerous, because this membrane, if detached above, and if also free below the partial or complete cast of the trachea, is easily expelled. If the pseudo-membrane is anchored below by extension into the bronchial tubes, it is difficult to get rid of it through the natural passages, even with the aid of the short, large-calibre tubes devised for this purpose. In all the cases in which casts of the trachea with numerous bronchial branches attached have thus been gotten rid of, death has resulted from reproduction or still further extension of the disease, and the same result would follow its removal by means of secondary tracheotomy.

A gradual obstruction of the tube may occur from the scanty tenacious secretions that usually accompany a high temperature, especially if associated with occlusion of the nostrils and mouth-breathing, which can be prevented by keeping the inspired air moist by means of sprays, steam, or the frequent administration of mild alkaline solutions, such as Vichy, lime-water, etc., some of which (the patient being in the upright position) will then enter the tube.

The only danger worthy of serious consideration while a tube remains in the larynx, and one which cannot always be guarded against, arises from loose membrane in the lower portion of the trachea which closes like a valve around the distal extremity of the tube and obstructs expiration almost exclusively. The only absolute safeguard against this accident is to remove the tube and attach a thread to it whenever loose membrane is detected at the point indicated, which can always be done if the child be induced to cough. It is, in fact, the best plan, for those who have had but little experience with the operation, to have the string attached in all cases in which it is possible, as the removal of the tube is more difficult than its introduction.

The method of feeding adopted by Casselberry, of Chicago, has practically done away with the two greatest objections urged against intubation, viz., the difficulty of nourishing patients with a tube in the larynx and the possible danger of pulmonary complications from the aspiration of portions of solid or liquid food swallowed. It consists in placing the patient's head considerably below the horizontal while being fed, so that anything that enters the tube during deglutition will escape by force of gravity alone. In the upright position this can only be accomplished by the act of coughing. In young children the best position is lying on the back across the lap with the head hanging so well down that it is necessary, when the child is fed from a spoon, to reach the mouth over the nose instead of over the chin. The bottle can be given in the same manner, and when wet-nursed the child can be given the necessary inclination of body by passing its legs over the opposite shoulder of the nurse. Older children may be permitted to assume any position they wish, provided the head and neck be considerably below the level of the body.

Patience and perseverance are necessary to induce some children to adopt this unnatural position in the beginning, but they soon learn that they can swallow so much better than when they are sitting up or even lying flat, that they readily assume it.

Intubation in the Treatment of Chronic Stenosis of the Larynx.—The value of intubation in the treatment of chronic stenosis of the larynx, as well as in the acute forms, is now generally recognized, and is practised in many parts of Europe as well as in this country. Dr. C. H. Knight, of New York (*Boston Medical and Surgical Journal*, July 7, 1892), reports the case of a boy, aged ten years, in whom intubation was resorted to for the relief of urgent dyspnœa due to what was supposed to be a subglottic neoplasm or a tubercular thickening of the mucous membrane, although no disease of the lungs could be discovered. The tube was worn intermittingly for about three months, and with comfort, when it was decided to do thyrotomy for the removal of the growth. Death from general tuberculosis rapidly followed the operation. Dr. Knight comments on the slight amount of disturbance excited by the tube in the larynx and the absence of objection to its long retention.

Drs. Pitts and Brook, of the Great Ormond Street Hospital, London ("Trans. London Medical Society," December 1, 1890), report four cases of chronic stenosis of the larynx in children in whom intubation was resorted to for the purpose of getting rid of retained tracheal cannulas, one of which had been retained three and another five years. They were all originally cases of croup for which tracheotomy was performed, and were all practically cured, the cannulas having been dispensed with, but at the time the report was made two cases required occasional dilatation by means of an intubation tube.

In one of my own cases of cicatricial stenosis in an adult, of syphilitic origin, after thorough dilatation of the stricture occasional intubation had to be practised for three years before the tendency to recontraction was finally overcome.

If we take into consideration the limited amount of experience with intubation which these gentlemen must have had at the time when the treatment of the above cases was begun, it must be admitted that it was admirably managed, very few mistakes having been made. The necessary precaution of keeping the external wound open until sufficient breathing-room in the larynx was obtained to sustain life in case the tube should be expelled, was adopted in each case. This was accomplished by means of a hard-rubber plug attached to a collar similar to that on the tracheal cannula.

In one case, aged three years, the largest intubation-tube for children, or that suitable for a child of twelve or thirteen years, was used without injury, which was due to the fact that the cricoid cartilage had been divided not long before the intubation was practised, thus permitting this naturally narrow and unyielding portion of the larynx to expand and accommodate itself to the very large tube. While it is true that larger tubes can be used with safety in chronic stenosis of a non-cicatricial nature than in croup, the increase should not extend beyond two sizes. When a very small tube has to be used, as is often necessary to begin with, the upper end of the instrument should be increased in size to suit the age, and when the size proper for the age is expelled the dilated lower end alone should be made larger rather than the whole of the tube. There is no necessity for haste in the treatment of this class of cases, because the difficulty of swallowing met with in the beginning, the same as in croup, is soon overcome, and all kinds of food can be taken with ease. The gentle, long-continued pressure of a tube suitable to the age is much safer than forcing in a large one which may endanger the integrity of the cricoid cartilage.

In a boy of eight years, in whom I used a tube several sizes too large, in order to hasten the process of dilatation, there developed a cricoid perichondritis with abscess which opened externally. This promptly disappeared when a smaller tube was substituted. Sloughing of the subglottic mucous membrane and necrosis of the cricoid cartilage would undoubtedly have followed had the large tube been allowed to remain long in position.

It is important to remember that it is that portion of the larynx which is bounded by the cricoid cartilage and not the chink of the glottis that determines the size of the intubation-tubes, and that it is the high operation involving this portion of the larynx that is the cause of retained tracheal cannulas in the great majority of cases.

The difficulty of getting rid of a retained tracheal cannula usually bears a direct proportion to the length of time during which it has been retained.

Anchylosis of the crico-arytenoid articulations and atrophy of the muscles that move them, together with general shrinkage of the larynx, are the inevitable result of long-continued disuse. In the normal condition these little joints never rest, and were never designed to do so, but continue their motion with every inspiratory expansion and expiratory relaxation of the glottis, day and night, during sleeping and waking. Enforced rest in

consequence of allowing the air to enter through an artificial opening is, therefore, more disastrous to these articulations than it would be for the same length of time to any other joint in the body.

Dr. E. Schniecgelow, of Copenhagen, practised intubation in eight cases of chronic stenosis of the larynx, six of which were for retained tracheal cannulas. One of the remaining two cases was that of a man, aged twenty-four years, who as a child had contracted cicatricial stenosis of the trachea following tracheotomy; the other was one of aphonia spastica. One of the cases was lost because the external wound was allowed to close before there was sufficient breathing-room in the larynx to sustain life without the tube, and another on account of plugging of the tube by tenacious, muco-purulent secretions, the case being complicated with a purulent tracheo-bronchitis.

With ordinary precautions there should never be any danger, at least in adults, of an intubation-tube becoming obstructed from secretions, because a few vigorous coughs will expel any accumulation as long as air enough can be obtained to make this act effective, and patients should be so instructed. The use of steam or sprays aids materially in keeping the tube clear by rendering the secretions less viscid.

In adults the external wound can be kept open in many cases by wearing a small tracheal cannula with the intubation-tube, as was done in one of my own cases, both tubes having been kept in position at the same time for several weeks, the outer one being corked. When the wound involves the subglottic portion of the larynx there is not room for both.

Dr. V. Nicolai (*Bolletino della Paliambulanza di Milano*) reports five intubations in adults, in four of which it was employed for the purpose of relieving dyspnœa due to laryngeal tuberculosis, which result was accomplished. In the other case the dyspnœa was the result of an intense inflammation following the removal of a foreign body which had been long impacted in the larynx. This case proved fatal from perichondritis with suppuration and burrowing of pus as far down as the bifurcation, followed by hemorrhage, the exact source of which could not be determined. The perichondritis may have been the result of injury done to the larynx in the removal of the foreign body or of pressure from the use of too large an intubation-tube.

In chronic stenosis the same tube, if metallic, should not be allowed to remain in the larynx longer than about two weeks, on account of the irritation produced by the calcareous deposits that always take place to a greater or lesser extent on its surface. Such deposits do not occur on vulcanite tubes, which can therefore be allowed to remain for a much longer time. In croup the tube becomes coated more rapidly, and for this, as well as for other reasons, it should not be allowed to remain in position longer than a week at a time. *Joseph O'Dwyer.*

INTUSSUSCEPTION.—During the last few years some advances have been made in the treatment of intussusception by operation, and the mortality of laparotomy performed for that variety of intestinal obstruction has diminished considerably. The mortality in the article in the main work was calculated from seventy cases collected from the literature of 1873 to 1887 inclusive, and reached seventy-six per cent.

In a paper published in 1891, the writer was able to analyze a total of one hundred and five cases, and found a mortality of only seventy per cent.—a very encouraging improvement. (*Medical Record*, 1891, xl., p. 534.) The corrected table would then read as follows: (see at top of next column)—

Out of sixty-five cases in which the intussusception could be reduced, only thirty-eight died, a mortality of fifty-eight per cent. Among the children of this group, the mortality was sixty-six; among the adults, only forty-seven per cent. Of seventeen cases in which the affected bowel was resected and sutured, only two recovered, both adults. Of sixteen cases in which an artificial anus was made (with or without reduction or resection

Results of Laparotomy for Acute Intussusception.

	Children.		Adults.		Age unknown.		Total.		Mortality. (Per cent.)
	Recovered.	Died.	Recovered.	Died.	Recovered.	Died.	Recovered.	Died.	
I. Intussusception reduced	15	29	10	9	2	..	27	28	58
II. Intussusception not reduced:									
A. Nothing done	..	5	..	2	..	..	..	7	100
B. Resection and suture	..	7	2	8	..	..	2	15	88
C. Artificial anus made:									
1. After resection or reduction	..	6	1	1	..	..	1	7	88
2. Without resection or reduction	..	1	1	6	..	..	1	7	88
Total	15	48	14	26	2	..	31	74	70

of the intussusception) two cases recovered, also both adults. These figures show again that prolonged operations are almost invariably fatal, and furnish another argument against delay, which is the usual cause of the conditions that render operations difficult, besides being directly responsible for the fact that the majority of the patients are in very bad condition when operation is finally resorted to.

In the technique of treating the bowel when laparotomy has been performed, no new suggestions have been made for those cases in which the intussusception is reducible, unless it be Senn's suggestion (*Canadian Practitioner*, August, 1891) to prevent recurrence of the invagination by making a fold or plait in the mesentery, parallel with the long axis of the bowel, and securing it with a few sutures. The efficiency of this manœuvre can, in the nature of things, only be verified by its successful use in many cases, but that the danger is real and serious is shown by the very considerable number of cases in which relapses have occurred, even directly after reduction, whether by injections or by operation. Thus Gould (*Medical Press and Circular*, 1891, ii., p. 385) reports a case in which he operated successfully upon a patient upon whom Hulke had also operated three months previously; and Pick (*Lancet*, 1891, i., p. 1312) had a recurrence necessitating reopening the wound thirty-six hours after the first operation, the patient dying of shock finally.

The method of dealing with doubtful and even half-sloughing gut demands a few words. Recent experience has shown that the isolation method suggested by Hahn for intestinal resection and suture, consisting in wrapping the sutured portion in iodoform gauze and allowing it to lie just within the abdominal wound, or even entirely outside of the wound on the wall of the abdomen, can be applied to such cases. If perforation should occur, the escaping contents would be taken up by the gauze and conducted outward, and the peritoneal cavity would not be infected. In a case reported by the writer (*loc. cit.*) in which reduction was accomplished with difficulty and the condition of the bowel was doubtful, the suspected loop was wrapped in iodoform gauze, the ends of which were brought out of the abdominal wound, and the latter packed with the same, its lips being prevented from gaping by being drawn against the packing with temporary sutures of silver wire or coarse silk. The patient was almost moribund when the operation was performed, and died of shock, but the bowels moved before death, showing that this method can be employed in such cases without producing obstruction at the point where the gauze is packed around the bowel. If it is feared that the loop might be displaced by peristalsis, a strip of gauze can be passed around it, penetrating the mesentery at a point free from blood-vessels.

If the intussusception be irreducible, Senn (*loc. cit.*) strongly recommends anastomosis, when there is no gangrene of the sheath, if the invagination be small. If the intussusception, on the other hand, be large, he advises a preliminary resection of the intussusceptum through a

longitudinal incision in the sheath, after having secured the neck with a rubber ligature, the anastomosis being made subsequently. In either case the obstruction in the bowel is left unrelieved, but a passage is made around it for the circulation of the contents. Barker (*Lancet*, 1892, i., p. 79) appears to deserve the credit for the suggestion to remove the intussusceptum through a longitudinal incision in the sheath, but he advised it as a part of a form of circular suture, Lembert sutures being introduced around the neck before opening the sheath, and the two coats of the intussusceptum being sewed together by a few stitches through all the coats after the resection. Maunsell has lately ("Transactions of the Intercolonial Medical Congress of Australasia," 1889, p. 236) advocated a similar proceeding for all cases of intestinal resection, first making an artificial invagination of the portion to be removed. The danger of these methods lies in the liability to continued invagination, fresh portions of the gut becoming involved, and also in the possible occurrence of stricture at the point of resection. Barker lost both of the cases upon which he operated, but through no fault in the method, and states that two others operated upon according to a similar method gave no sign of stricture several months, and five years later.

Kammerer (*Medical Record*, 1890, xxxvii., p. 113) reports a successful laparotomy for intussusception in an infant only six months old, which together with Sands's case (*N. Y. Medical Journal*, 1877, xxv., p. 561) shows that extreme youth is no barrier to successful operation for this condition. Körte (*Berlin. klin. Wochenschrift*, 1892, p. 652) found an ascending intussusception in a patient upon whom he operated successfully—a variety which some suppose never to occur in the clinical form, although some cases of chronic intussusception have been reported in which this variety was found after death.

Prolapsed intussusceptions have been frequently extirpated by drawing them out of the anus until the upper limit could be reached, and sewing the layers together circularly before the intussusceptum was cut away. Until recently the sutures were passed through all the coats of the bowel at once, the surgeon inserting one finger into the lumen of the intussusceptum until normal bowel was reached above, and assuring himself by pressure between that finger and another outside, that there was no loop of bowel or other abdominal organ between the peritoneal surfaces of the intussusception, and then introducing a curved needle from without into the lumen of the intussusceptum under the guidance of the finger, and then out again, so as to make a stitch which took up a small portion of both layers of the intussusceptum. This was tied on the outside, and when the entire bowel had thus been surrounded with sutures above the neck of the intussusceptum, the latter was cut away just below the line of stitches. But a loop of bowel has occasionally been wounded in operating by this rather blind method, and, moreover, sutures thus introduced through all the coats of the bowel may be the cause of infection, leading it from the mucous membrane through the wall of the gut into the peritoneal cavity. The latter danger has compelled the rejection of all methods of intestinal suture which depend upon such stitches, and although it is true that if the sphincter were paralyzed by stretching, or were divided, there would not be quite the same danger in the rectum as elsewhere in the intestinal tract, because the intra-intestinal pressure could be reduced to a minimum, yet there would certainly be some danger, and most modern surgeons would prefer the method suggested by Mikulicz (*Wiener medizin. Presse*, 1883, Nos. 50 and 51). In this procedure the intussusceptum is drawn down until its upper limit is reached, and then a superficial incision is made on its anterior surface, and gradually deepened until the peritoneal cavity is opened, the vessels being tied as they are divided. A row of fine silk sutures is then inserted through the peritoneal coats only, like Lembert sutures, securing the peritoneal surfaces of the two layers of the intussusceptum together. The posterior half is next treated in the same way, and then the intussusceptum is removed by dividing the internal layer step by step, securing its cut edge to that of the outer ("middle") layer by sutures, taking up all but the peritoneal coat, as the incision is carried around the tumor. In this manner the peritoneal cavity is shut off before the bowel above the point of obstruction is opened, and this is a great advantage, for even if there is no fecal accumulation, it is impossible to cleanse this part beforehand. The danger of penetrating sutures, moreover, is avoided, and it is impossible to overlook any loops of bowel which may lie prolapsed between the coats of the intussusceptum.

In case of emergency it might be well to remember the excellent expedient employed in three successful cases by Weinlechner and by Hofmokl, quoted by Mikulicz. They passed a stiff tube into the intussusceptum and ligated it at its neck upon the tube with a rubber ligature, allowing the ligated mass to slough off, by which time the adhesions were complete. This would answer very well where it was impossible to command the assistance and skill necessary for the operation of excision and suture, although the danger of sepsis from the sloughing process should limit the use of the method to such cases.

B. Farquhar Curtis.

IODANTIFEBRIN. This is prepared from acetanilide by substituting iodine for one hydrogen atom. Its formula is $C_6H_4INHC_2H_3O$. It was prepared by Dr. Ostermayer, who also introduced iodantipyrin. It is a white crystalline powder insoluble in cold, but soluble in hot water and alcohol. The experiments of Dr. Ostermayer showed that it was devoid of any therapeutic action. No effects were observed that could be attributed either to the acetanilide or to the iodine, nor could either be detected in the urine after its administration. It appears that the iodine destroys the activity of the compound and that no absorption takes place.

Beaumont Small.

IODANTIPYRIN; IODOPYRIN. This compound, introduced in 1891 by Dr. Ostermayer, is antipyrin in which one hydrogen atom has been replaced by iodine. Its formula is $C_{11}H_{11}INO$. It forms in colorless, shining, prismatic needles, not very soluble in cold water or alcohol, but readily soluble in either when hot.

Iodopyrin was supposed to be a soluble combination of the therapeutic properties of antipyrin and iodine, but experience has shown that in the stomach it is decomposed by the hydrochloric acid, and forms antipyrin and iodide of sodium. The same object may be obtained by administering iodide of potassium and antipyrin. Its antipyretic effects are those of antipyrin. In typhoid fever, pulmonary phthisis, rheumatic fever, and other febrile conditions, it lowers the temperature rapidly, and lowers the pulse and respiration; at times it produces a free perspiration. The dose is from seven and a half to twenty-two grains. The value of the iodine is uncertain, as no decided benefit has been traced to it. One case of a persistent headache, thought to be syphilitic in character, is reported, in which a cure was effected in twenty-four hours. The iodine may be detected in the urine after fifteen to twenty-two grains have been given.

Beaumont Small.

IODINE TRICHLORIDE. A compound introduced by Langenbuch, of iodine and chlorine, made by passing chlorine gas over iodine. It forms a reddish crystalline powder, hygroscopic, very soluble in water, alcohol, and glycerine, and has a pungent and disagreeable odor. It is a stable compound, and will keep for a long time in powder or in solution; it must be dissolved in distilled water, as any organic matter decomposes it at once. When brought in contact with the pus and secretions of the tissues, it is at once decomposed and its constituents eliminated. It is a powerful antiseptic and bacteriacide; a one per cent. solution sterilizes cultures of the ordinary pus-producers—staphylococcus and streptococcus.

Belfield (*Medical Record*, vol. xiii., No. 3) has used it extensively in surgical practice. He considers that it combines the valuable properties of iodoform and hydro-

gen peroxide. It is a more active antiseptic than iodoform, and is more stable than the peroxide, remains longer in contact with the parts, and sterilizes all moist animal tissues as well as pus. Its disadvantages are its caustic properties when used in strong solutions, and its injurious action on instruments and clothing. It must be kept from the light and air. It has been used in various tubercular diseases and all forms of suppuration, and in all it proved of decided value. Internally the dose is one-fifth grain; it is also used by hypodermic injections of one-tenth to one-half per cent. solution, and the same solution is used for washing out the bladder, the urethra, and other sensitive mucous membranes. For irrigating wounds, a one to five per cent. solution, either alone or with glycerine, may be employed; for putrid surfaces, a five to twenty per cent. solution in equal parts of water, glycerine, and alcohol. Gauze may also be prepared by medicating with the solution. In eye affections, a one to five thousand solution is used as an ordinary antiseptic wash. *Beaumont Small.*

IODOFORM. This drug has recently acquired a reputation as an autitubercular agent, and has been extensively employed in the treatment of the various forms of tuberculosis. In chronic abscesses, disease of bones, of joints, and of the tissues about the joint, and in all forms of tubercular disease subject to the surgeon's knife, iodoform may be applied to the affected part with as much confidence in its specific and curative action as has always been placed in it in the treatment of wounds of a simple character. It is well known to be antagonistic to the growth and extension of tubercle. It checks the growth of the bacilli and counteracts the ptomaïnes and other products of their growth, and evidence is now showing that it exerts a decided destructive action on the bacilli themselves. It was shown some years ago by Sanger and Braus [1] that the bacilli of tuberculosis and anthrax were both influenced by the presence of iodoform, becoming lessened in number and weakened in virulence and infective power. Others have confirmed these facts, and among the more recent reports are the experiments of Drs. G. Troje and F. Tangl.[1] They report the result of their investigations upon the effects of iodoform, in the form of vapor, powder, and emulsion, upon cultures of the tubercle bacilli. It was found that the vapor killed the organisms after fifty days. After it had acted six days the growth was decidedly diminished, and, at the end of six weeks, had ceased. The powder, when strewn on the bacilli, rapidly checked their growth, and the culture when mixed with the powder, in the proportion of one part to fifteen, was rendered innocuous in eight days. A ten per cent. mixture of iodoform with oil or glycerine, was found to have greater destrucive properties than either the vapor or the powder. The oil proved somewhat stronger than the glycerine mixture.

During their experiments they found that the influence of the emulsion was less when a mixture of the oil and culture was injected in the tissues than when they remained outside the body. The tissues proved a suitable soil for the growth of the bacilli, and they acquired a new energy. It was also found that the bacilli, when acted upon by the iodoform, could be so weakened that only chronic forms of abscess followed their inoculation. In the cold abscess arising from bone disease and other chronic forms of suppuration, the bacilli are few in number and less active, and more readily acted upon by iodoform than the cultures outside the body, or when freshly inoculated. The conclusions they reached, as a result of their experiments, were: that iodoform is a true disinfecting agent, and that it has a direct poisonous action on the bacilli, if left sufficiently long in contact.

In addition to the action on the bacillus, iodoform also exerts a stimulating action on the diseased tissue, and promotes an active granulating surface inclined to repair. It has been shown[2] that the walls of a tubercular abscess consist of four layers: (1) a layer of thick porous tissue; (2) a layer of spindle cells in active proliferation; (3) actual tuberculous granulations; (4) necrotic and degenerated tissue. The two inner layers contain the bacilli, and these, under the action of the iodoform, disappear, and healthy granulations spring from the spindle-cell layer.

Whatever may be the influence of iodoform, clinical evidence is very clear regarding its decided curative action. In a report of two hundred and fifty-five cases over forty per cent. were decidedly improved. Other authorities claim that eighty per cent. of all abscesses may be made to disappear by this treatment, and in our own journals the numerous reports of cases in which a cure has been effected indicate the value of the drug.

To obtain the benefits of this method of treatment the remedy must be brought in direct contact with the disease. As generally followed, the abscess is evacuated and washed with an antiseptic solution of carbolic acid or boracic acid, and a ten per cent. solution of iodoform is then to be injected. The amount to be used varies greatly, from one or two drachms up to one and even two ounces having been recommended by various authorities. Bryant [2] advises the use of two or three ounces; Curtis [3] and Darling [4] find the most satisfaction by using from one to two drachms. The injections are repeated in accordance with the recurrence of the pus and subsidence of the effects of the former injection, the time varying from a few days to two or three weeks. In contrast with this mild treatment are the heroic methods of the European surgeons. Professor Billroth [5] has adopted this method of treatment since 1881, and the results have exceeded his expectations. His method is to open the abscess with a free incision, and when its contents have been evacuated the walls are rubbed with iodoform gauze, the cavity washed with sublimate solution, and then stuffed with iodoform gauze until all bleeding ceases. Before opening the abscess he uses an Esmarch bandage, which is removed after the cavity is emptied. When the bleeding has been checked the gauze is removed, the emulsion poured in, and the wound stitched. If diseased bone is present it is scraped and cleansed also. In most of the cases the operation was followed by fever, varying in degree. In the most favorable cases there is very slight fever or pain, no tension, and healing by first intention; the dressings are allowed to remain for two weeks, the stitches are then removed and dressed again for another two weeks, when a cure is complete. Generally there is sharp fever and pain, and serum escapes through the incision. In these cases the dressings are removed every few days and drainage-tubes used until serum ceases to be discharged. If recovery does not take place in five or six weeks, the operation of opening the wound and cleansing the cavity is repeated. Professor Jassinski [6] reports the result of eighty-six cases treated by aspirating and injecting with the emulsion. The results were much the same. A number healed without further interference, and others had to be opened and treated by washing and pouring in the emulsion. Fever and pain generally followed, but in no case was there any toxic action produced, although as much as one hundred and eighty grammes were injected.

In tuberculous disease in which suppuration has not taken place, the emulsion (from ten to twenty minims) is injected into the diseased tissue and made to diffuse itself by gentle massage. In enlarged glands the same treatment is adopted, and also in tubercular disease of the testes, bladder, and rectum, and in tubercular empyema.

The iodoform is prepared for use by dissolving in alcohol, or ether, or by forming an emulsion with oil or glycerine. The formula of the emulsion used by Mosetig-Moorhof, who first used iodoform for this purpose, was: iodoform, 10 parts; ol. ricini, ol. amygdalæ, āā 15 parts. This has passed through various modifications, until at present a ten per cent. mixture is very generally adopted, and oil or glycerine is the menstruum selected. The alcoholic or ethereal solutions are not so frequently employed, on account of the pain and irritation that follow their use. They are, however, more diffusible, and correspondingly more active. The more concentrated solutions, particularly the ethereal, are very unstable, iodine being set free and coloring the solution. The preparations should be recent, and the oil employed should be

sterilized. This may readily be done by boiling for half an hour. Camphor increases the solubility of iodoform, and a six per cent. solution may be obtained by using a saturated solution of camphorated oil. The use of oil heated to 100° F. will allow of more iodoform being dissolved, and this is now recommended as a more efficient way of securing a suitable solution.

There is very little danger of toxic symptoms, especially if the emulsions are used. Whenever any constitutional disturbance has occurred it has generally been in cases where the ethereal or alcoholic solution was used. No definite quantity that may be injected with safety has been determined. In some instances a few grains have caused much trouble, and in others very large amounts have been used with perfect safety. When the system is affected there is a sense of lassitude and sickness, a bad taste in the mouth, accompanied by headache, restlessness and delirium, and fever in some cases, and in others by drowsiness and collapse. Bromide of potassium is said to act as an antidote, not only as a neutral potash salt, but also by its specific bromide action. This is thought to arise from its solvent properties for iodoform. The presence of iodine in the saliva may be detected by placing in the mouth a piece of silver, when a garlic taste is immediately developed. The saliva may also be tested by mixing it with calomel. If iodine be present a canary-yellow color is produced, due to the formation of iodide of mercury.

Iodoform has been employed in the treatment of tuberculosis of the respiratory organs, but not with so much success as in the forms of tuberculosis in which it may be applied directly to the part. Its administration by the mouth was found to be very uncertain in its action, and to cause gastric irritation. This method has been replaced by subcutaneous injections which convey the drug more directly to the lung tissue and enable it to act more energetically. It is said to lessen the mucopurulent secretion and render it more fluid. It softens the hardened tissues and allows the air to permeate deeper into the lungs. Although it is not thought to act on the cause of the disease, it aids the elimination of the broken-down tissue and favors the cicatrization of the ulcerated surfaces in the alveoli. The ethereal solution, or an emulsion of sterilized oil, may be used. The dose for internal administration is one-third to one-sixth grain several times a day, or, if used hypodermically, two doses in the day will be sufficient. In tubercular phthisis it is more frequently combined with guaiacol for hypodermic injections, and in this form has given much satisfaction.

Beaumont Small.

[1] Berlin. klin. Woch., November 20, 1891.
[2] New York Medical Journal, February 20, 1892.
[3] Ibid., August 27, 1892.
[4] Ibid., October 29, 1892.
[5] British Medical Journal, April 19, 1890.
[6] Ibid., July 5, 1890.

IODOL (Tetra-iodo-pyrrol). This compound of iodine may be prepared by dissolving pyrrol in alkaline water and mixing it with a solution of iodine in iodide of potassium. The precipitate is collected, dissolved in alcohol, and reprecipitated. It is also obtained by the reaction that takes place when alcoholic solutions of pyrrol and iodine are mixed for twenty-four hours. Iodol separates when the mixture is added to water.

It is a pale yellow, finely crystalline powder. It is without taste and does not possess any disagreeable odor. It is insoluble in water, and very slightly soluble in dilute alcohol. Strong alcohol dissolves one part in six; glycerine, one part in thirty-four. Iodol is very soluble in ether and chloroform. It contains about ninety per cent. of iodine. Heated to 140° or 150° C. it is decomposed with the evolution of violet iodine vapors.

Iodol was introduced in 1885 by Ciamician and Silber, as a substitute for iodoform, its freedom from any disagreeable odor being a decided advantage. Like iodoform it does not rank high as a germicide, but it has the same power of inhibiting the growth of bacteria and maintaining a surface clean and aseptic. To wounds, ulcers, and all suppurating surfaces it is applied in the same manner as iodoform, by dusting the powder on the part, or making it into an ointment with lanoline or vaseline. It may also be used in solution of alcohol, ether, or collodium. Ether, 5 parts; collodium, 50 parts; iodol, 1 part, is a favorite combination for local application. For gynæcological purposes a solution of iodol, spirits, and glycerine, 1 : 16 : 34, may be used for saturating tampons, etc. Its local use has been highly recommended for ulcerations of the nose, pharynx, and larynx, particularly when due to a tuberculous or syphilitic cause.

Iodol has been employed internally with success in conditions of the stomach and intestines accompanied by putrefactive and fermentative changes. It has been used with success in gastro-intestinal catarrh and ulceration of the mucous membrane. When its action is directed to the stomach it should be given in the intervals between meals; when it is desired to act on the intestinal canal the most favorable time for its administration is immediately at the close of the digestive process. As its constituent iodine is excreted in part by the pulmonary organs, it has been used in bronchitis, phthisis, and various diseases of this locality. In these conditions, in addition to its internal administration, inhalations and insufflations were used. In syphilis it is also recommended: in tertiary forms of the disease it has given the greatest success. It is well borne by the system, having no effect on the temperature, circulation, or respiration; iodism is of very rare occurrence. It is also thought to be of benefit in diabetes. The dose is from five to fifteen grains, two or three times a day: it should be given in wafers or pill form. Although the proportion of iodine is very large, toxic effects are very rarely noticed. The iodine is evolved very slowly, and its action is slow and gradual.

Beaumont Small.

IODONAPHTHOL-BETA (Naphthol-beta di-iodide). This derivative of iodine was introduced by Dr. Braille (*Répert. de Phar.*, November 10, 1891) as a substitute for iodoform, aristol, and other iodine compounds. It is prepared by mixing a solution containing 24 grammes of iodine and 27 grammes of potassium iodide with another solution containing 110 grammes of naphthol-beta and 40 grammes of caustic soda. There is then added a little solution of the hypochlorite of sodium corresponding to ten times its volume of chlorine. Iodonaphthol is then precipitated. It is a greenish yellow powder, inodorous, tasteless, insoluble in water, very slightly soluble in alcohol, but soluble in ether and chloroform.

It is recommended for the treatment of wounds, ulcers, and all conditions in which iodoform and other antiseptics are employed. It is applied as a powder dusted on the part affected.

Beaumont Small.

IODOPHENIN (Iodophenacetin). This compound of iodine and phenacetin was described by Dr. Scholvein, in 1891, at a meeting of the Berlin Pharmaceutical Society. It contains fifty per cent. of iodine and forms in steel-blue crystals, with an odor of iodine, and a burning taste; it colors the skin yellow. It is insoluble in water, soluble in alcohol and glacial acetic acid. Heated, or even when mixed with water, it is decomposed and iodine is set free.

Owing to the looseness with which the iodine is retained in combination, it is recommended as a useful antiseptic. Experiments show that it possesses this property in a marked degree, but also has the irritating effects of free iodine, and it is doubtful if it has any advantage over pure iodine.

When employed as an internal remedy it forms combinations with the alkalies of the intestinal canal, and, from the readiness with which iodine is given up, poisonous symptoms often follow the use of even small quantities.

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IODO-SALICYLIC ACID. A compound of iodine and salicylic acid in which one atom of hydrogen is replaced by one of iodine. It contains fifty per cent. of iodine. A *di-iodo-salicylic acid* is also prepared in which two atoms of hydrogen are replaced by iodine. It contains two parts of iodine in three of the compound. They are white, fine crystalline powders, slightly soluble in water, soluble in alcohol, ether, fixed oils, and collodion.

They possess the combined action of iodine and salicylic acid, and are said to be very serviceable antiseptics. Internally, in doses from twenty to sixty grains daily, they have proved servicable in rheumatism and have succeeded in relieving the fever and pain when the other salicylates have failed.

Sodium di-iodo-salicylate. This salt occurs in white needles, and is recommended as an antithermic and antirheumatic. It is also said to be of great value as a local application in parasitic affections of the skin. The dose for internal administration has not been determined.

Beaumont Small.

IODOSULPHATE OF CINCHONINE (Antiseptol). This compound is obtained by the action of iodated iodide of potassium upon a solution of sulphate of cinchonine, twenty-five parts to two thousand of water. It contains fifty per cent. of iodine. It is a very light, brownish powder, odorless, insoluble in alcohol and chloroform.

It is an antiseptic and is said to prove serviceable in all conditions in which iodoform and similar compounds are employed. It may be combined with powdered talcum, one part to two; or mixed with vaseline or lanoline, one part to ten.

Beaumont Small.

JAMAICA. Brief mention was made of this island in the article on the climatology of the West Indies in Vol. VII., but owing to its increasing importance as a health resort and as a winter residence for invalids and others from the United States and Canada, it has been thought advisable to give a rather more detailed account of its climatic and other advantages in the present volume.

Jamaica, a British colony, is an island in the Caribbean Sea, lying between 17° 43′ and 18° 32′ North latitude, and 76° 11′ and 78° 20′ 50″ West longitude. It is about 90 miles south of Cuba, nearly 5,000 miles from Southampton, and a little more than 1,400 miles from New York. It is 144 miles in length and from 21½ to 49 miles in width. The surface of the island is crumpled up into a central mountain range with numerous outlying spurs. The highest points of this range, contrary to the usual rule, are in the eastern portion, whence the surface slopes irregularly toward the west, where the only level parts of any extent are found. There is one principal range, called the Blue Mountains, running east and west through the centre of the island, and from this secondary ridges run north and south, themselves giving off other and shorter spurs in a direction parallel to the central range. The highest point is Blue Mountain Peak which rises to an elevation of 7,360 feet; Catherine's Peak has an altitude of over 5,000 feet, and there are several others, varying in height from 4,000 to 5,000 feet. The island is in general well watered, the abundance of rivers and springs in most parts giving plausibility to the generally accepted interpretation of the name, Jamaica, which is believed to have signified in the aboriginal tongue the "Isle of Springs," or the "Land of Wood and Water."

It is difficult, in a brief article of this nature, to describe satisfactorily the climate of Jamaica, as owing to the diversity of elevation and other causes, it varies greatly in different parts of the island; in some parts it is hot, in others temperate and even cool; in some it is dry in others the rainfall is very great; and indeed the only characteristic common to all the varying climates of Jamaica is equability. Thus at the sea-coast the average temperature is 78° F. (the extreme range for the entire year being only 35° F.), while on the mountains at an elevation of between 4,000 and 5,000 feet the mercury ranges from 50° to 70° F., occasionally falling, on the summit of the highest peak and in midwinter, even to the freezing-point. In the accompanying charts, compiled from the official figures in the "Handbook of Jamaica," the mean temperature is given for the city of Kingston, and this may be regarded as the mean maximum for the entire island. Unfortunately, systematic observations of the variations of temperature in the more elevated portions of the interior are wanting, but numerous unofficial readings of ordinary thermometers, taken with more or less regularity for a number of years by private individuals, show that the indoor temperature in places in the interior is on an average from 5° to 15° below the figures here given. From June, 1880, to the end of the year 1886 the readings of the thermometer were taken at eight-hour intervals, to wit, at 7 A.M. and 3 and 11 P.M., but since that time at 7 A.M. and 3 P.M. only.

Meteorological Charts for the City of Kingston, Jamaica. (Compiled by MAXWELL HALL, M.A., F.R.A.S., F.R.M. et S.)

Month.	For the Ten Years from June, 1880, to May, 1890.										For the Year 1891.														
	Barometrical pressure (Inches).	Temperature (Degrees).				Wind, miles per diem.	Cloud, per centage of whole sky.	Humidity.	Rainfall (Inches).		Mean temperature (Degrees).					Extreme of temperature (Degrees).			Wind, miles per diem.	Cloud, per centage of whole sky.		Humidity.		Rainfall, Kingston only (Inches).
		Mean.	Maximum.	Minimum.	Range.				Kingston.	The island.	7 A.M.	3 P.M.	Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.		7 A.M.	3 P.M.	7 A.M.	3 P.M.	
January	30.054	74.6	86.4	66.8	19.6	68	29	78	0.96	3.87	68.4	83.6	86.8	66.5	20.3	90.4	61.5	28.9	53.9	13	48	84	60	0.41
February	30.049	74.7	85.8	66.8	19.0	72	27	78	0.32	2.62	69.6	83.9	86.7	66.9	19.8	90.2	63.6	26.6	127.1	30	40	79	55	0.27
March	30.034	75.8	85.7	67.8	17.9	77	29	77	1.59	2.88	70.4	82.9	85.8	67.4	18.4	91.4	63.2	28.2	73.5	25	42	80	59	0.04
April	30.008	77.9	86.5	69.8	16.7	68	39	75	1.02	4.18	74.9	84.6	86.3	71.9	14.4	89.1	68.4	20.7	70.0	31	53	78	61	1.25
May	29.979	79.4	87.2	72.4	14.8	74	56	78	6.00	8.40	77.1	85.2	87.0	73.1	13.9	91.0	69.9	21.1	63.5	48	63	78	63	2.03
June	30.000	80.8	88.5	73.8	14.7	115	57	78	5.51	7.83	79.0	85.9	87.7	74.9	12.8	90.9	72.2	18.7	112.7	50	74	76	65	6.47
July	30.024	81.1	89.7	73.5	16.2	103	52	76	2.15	4.32	78.6	88.6	90.4	75.0	15.4	96.1	72.0	24.1	116.7	38	62	72	56	0.49
August	29.983	80.4	89.4	73.2	16.2	80	55	79	4.09	6.83	76.8	85.6	91.2	74.5	16.7	96.7	70.0	26.7	69.8	44	74	79	66	3.08
September	29.956	80.1	89.7	73.3	16.4	70	62	80	3.59	6.86	76.9	85.6	89.4	74.4	15.0	91.7	70.5	21.2	41.6	56	84	80	69	1.54
October	29.957	78.9	88.9	72.1	16.8	56	58	81	4.69	7.84	75.6	83.2	87.1	74.0	13.1	91.7	70.3	21.4	77.8	74	90	84	71	9.10
November	29.962	77.8	88.9	70.7	18.2	53	44	78	1.22	5.07	72.7	83.6	84.1	69.3	14.8	89.9	66.9	23.0	63.1	36	68	88	66	3.95
December	30.005	75.7	87.0	68.4	18.6	57	38	78	1.50	5.60	69.8	84.0	87.1	69.4	17.7	89.3	63.9	25.4	77.1	23	61	83	59	0.23
Means or totals	29.999	78.1	87.8	70.7	17.1	89	55	78	32.64	66.30	74.1	84.7	87.5	71.5	16.0	91.5	67.7	23.8	78.4	39	63	80	62	28.86

During the entire period the highest temperature observed was 96.1° F., recorded on September 12, 1880, and the lowest was 56.7° F. recorded on December 4, 1887. The *absolute* maxima and minima are not given in the first table; but their averages are about four degrees above and below the maxima and minima deduced from the daily readings.

The most striking peculiarity of the climate of Jamaica is its variety combined with equability. A ride of a few miles into the hills will bring one from the torrid zone to the temperate—from an average temperature of nearly 80° F. to one of 65° or 70° F. But whatever district one may select, whether a warm or a cool one, he

will find the temperature very nearly constant, the extreme range for any one month being seldom over 25° F., while that for the entire year at Kingston is but 35° F., and in some parts of the island the excursions of the mercury are even more restricted than this. As regards humidity, also, there is the same choice of climate open to the invalid or the pleasure-seeker, who may select a place of residence with a humid or a dry atmosphere as suits best his inclinations or the necessities of the affection from which he suffers. Jamaica, indeed, enjoys all the advantages in respect to uniformity of temperature of island climates in general, while the differences in elevation and in exposure to, or protection from, the prevailing trade winds, give to it the pleasing diversity, as regards temperature, humidity, and rainfall, of the most temperate of continental climates.

In the first of the meteorological charts the rainfall is given in two columns, one for Kingston and the other the average for the whole island. There is, as a rule, less rain in Kingston than in most of the other parts of the island, the trade winds being drained of their moisture by the mountains to the north and east of the city. The heaviest precipitation occurs in the Parish of Portland, which forms the northeastern extremity of the island. There are two principal rainy seasons, namely in May and October, but there is usually more or less rain all through the summer months; in the winter season in the neighborhood of Kingston the precipitation is very light. The rain usually comes in heavy showers of only a few hours' duration, and the days during which the sun does not shine at all are very rare. It is always possible to tell when rain is coming, as it can be seen, quite a while before its arrival, advancing from the mountains, thus giving one ample time to get under cover before the downpour begins. This is fortunate for the visitor, as a wetting is one of the three things that an unacclimated person in the tropics must avoid, the other two being exposure to the direct rays of the noonday sun and to the cool night air.

The population of Jamaica, according to the census of 1891, is 639,491, an increase of about 60,000 since the census of 1881, and of 133,000 since that of 1871. The capital and chief city is Kingston, the largest and most important as well as the healthiest seaport town of the British West Indies. It is a city of 48,500 inhabitants, situated on gently sloping ground on the shores of a large land-locked harbor. The land on which the city lies is a gravel bed, and as it has a slope to the sea of about ninety feet to the mile the natural drainage is excellent. The water supply is drawn from two rivers at a distance of several miles from the city, and, as regards freedom from contamination, is above reproach.

The Myrtle Bank Hotel, pleasantly situated on the shore of the bay near the outskirts of the city, affords excellent accommodation for visitors, and there are also several other hotels and a number of boarding-houses where one may live modestly and at moderate expense. Another well-built hotel, having accommodation for one hundred and fifty to two hundred guests, is at Constant Spring, six miles from Kingston, near the foot of the mountains which enclose in the form of an amphitheatre the Liguanea plain. The hotel lies at an elevation of five hundred feet above Kingston, and from it is had a fine view of the harbor and Caribbean Sea beyond. The temperature here is uniformly ten to twelve degrees lower than that of the city. Other comfortable hotels are found in Santiago de la Vega, usually called Spanish Town, which was formerly the capital of the island, and at Moneague, a charming spot in the Parish of St. Ann, on the northern slope of the central mountain range. Mandeville, a beautiful little place in the hills, celebrated for its delicious oranges, is a favorite resort for Jamaicans from Kingston and other coast towns who may feel the want of a change of air and scene. There are a hotel and several boarding-houses here, but intending visitors must take the precaution to apply in advance if they would be sure of being well suited. Among the coast towns on the north side of the island, Lucea, St. Ann's Bay, and Montego Bay are the most important from the point of view of the tourist and the invalid. In these and the other towns of the island visitors may find accommodation at various boarding- and lodging-houses; about which, however, it would be wise to inquire before making a selection, as they are of varying degrees of excellence and the reverse.

At Port Henderson, on the southern shore of the island, at the entrance to Kingston harbor, there is a saline calcic spring which is said to possess tonic properties of no mean order and is much resorted to as a bath by convalescents and others from the neighboring districts. There is also a good beach for sea-bathing. There are several buildings here in good order, but the accommodations are not extensive. The place can readily be reached, however, by a steam launch from Kingston in forty-five minutes. No analysis of the water of the spring has ever been published.

The diseases for the climatic treatment of which Jamaica is well suited are bronchitis, fibroid phthisis, incipient pulmonary tuberculosis, catarrhal affections of the respiratory passages, Bright's disease, rheumatism, various forms of dyspepsia, and nervous prostration. All parts of the island are naturally not suitable for the treatment of all these varied affections, but for each one a locality exists where the patient can find the climate especially adapted to the necessities of his particular disease. Respiratory affections especially do well in this mild and equable climate, as may be judged from the records of one of the life insurance companies doing business on the island, which show that the company lost but one life from diseases of the respiratory organs (bronchitis) during a period of thirty-five years. Patients suffering from these troubles are relieved in almost any part of the island, although there is even here a choice, as cases with scanty expectoration are most benefited in those districts where the atmosphere is most laden with moisture, while those in which there is free or even profuse secretion are more quickly relieved in the neighborhood of Kingston and other parts where the humidity of the air is at a minimum. Patients with nervous prostration receive more benefit from a stay near the seashore than they do in the uplands, and the same is in a measure true of dyspeptics, especially of those in whom the gastric trouble is partly nervous in its origin. Sufferers from Bright's disease do well, as a rule, in all parts of the island, except possibly in the most elevated regions, where in the winter months the thermometer is apt to fall a little too low after the sun goes down, and where, especially on the northern slope, there is at times rather too much rain to be agreeable. The same remarks apply also in the case of rheumatic patients, but the latter would do well to take a course of the waters at one of the numerous mineral springs, of which a few words may be said in closing this article.

There are several medicinal springs in Jamaica, some thermal and others cold, which possess therapeutic properties of no little value, and which are deserving of more careful study by balneologists than they have hitherto received. The most important of these, or at least the best known and the only ones at which passable accommodations for visitors are as yet provided, are the Bath of St. Thomas the Apostle, about a mile from the town of Bath, in the Parish of St. Thomas, the Jamaica Spa, at Silver Hill, in St. Andrew's Parish, and the Milk River Bath at Vere, in the Parish of Clarendon. The first of these is a thermal sulphur, the second a chalybeate, and the third a thermal saline water. The table on the next page, extracted from a brochure on the "Mineral Springs of Jamaica," by the Hon. J. C. Phillippo, M.D., shows the results of analyses of these three and two other springs on the island. All of these springs are quite easily accessible from Kingston.

The limits of this article will not permit of a detailed description of each of these springs, but the subjoined analyses will suffice to indicate their character and to suggest their therapeutic application. The waters of one or the other of the springs are of value, taken internally and applied in the form of baths, in the treatment of gout, rheumatism, chronic bronchitis, catarrhal conditions of

MINERAL SPRINGS OF JAMAICA.

One Pint contains:	Milk River Bath. (Analysis by Sawyer and Moore.)	St. Thomas the Apostle. (Analysis by Bowrey.)	Jamaica Spa. (Analysis by E. Turner.)	Silver Hill Spring. (Analysis by Bowrey.)	Manatee Bay Spring.
	Grains.	Grains.	Grains.	Grains.	Grains.
Carbonate of sodium	.....	0.21	.....	.....	.....
Carbonate of iron	.....	.....	.....	.....	traces.
Carbonate of calcium	.....	.....	0.866	....	2.71
Chloride of potassium	1.44	0.04	.....	.....	.....
Chloride of magnesium	37.68	.....	.....	.....	4.34
Chloride of sodium	186.93	1.48	.....	0.125	52.52
Chloride of calcium	13.50	.....	....	.....	1.31
Chloride of lithium	traces.	.....	.....	.....	.....
Sulphate of sodium	27.93	0.79	.....	0.341	.....
Sulphate of magnesium	.....	.....	2.831	1.745	.....
Sulphate of calcium	.....	0.62	.....	1.234	.....
Sulphate of iron	.....	.....	2.210	0.833	.....
Sulphate of aluminium	.....	.....	4.168	1.360	.....
Phosphate of aluminium	.....	.....	.....	.....	traces.
Iodide of sodium	traces.	.....	.....	.....	.....
Bromide of sodium	traces.	.....	.....	.....	.....
Bromide of potassium	traces.	.....	.....	.....	.....
Bromide of magnesium	traces.	.....	...	... ..	.....
Silicate of sodium	.....	0.45	.....	.....	.....
Silica	traces.	.....	... ..	0.883	.....
Totals	266.88	3.59	10.075	6.521	60.88
Temperature (Fahrenheit)	92°	130°	63°	.....	.....
Sulphuretted hydrogen	.....	Undetermined.	.....	.....	.....

the stomach and intestines, constipation from abdominal plethora, hepatic and other congestions of the abdominal viscera, amenorrhœa, anæmia and chlorosis, various forms of skin diseases, tertiary syphilitic lesions, and chronic malarial affections. The Government has made grants from time to time for the improvement and care of the buildings at these baths, but there is yet much to be desired in the matter of cuisine, bathing facilities, attendance, and other things that contribute to the comfort and entertainment of the invalid. In the absence of these desiderata they still possess the great advantage that they may be visited in the winter season, when the more pretentious and better equipped spas in Europe and the United States are closed.

There are several lines of steamers running between Jamaica and New York, Boston, and Halifax, the voyage from New York being made in from four to six days. During one season steamers plied between Tampa, Fla., and the north shore of Jamaica, and it is probable that this service will be resumed again as soon as the railroad across the island, now nearly completed, is open for travel. There is usually no lack of amusements in Kingston in the way of horse races, yachting, tennis and cricket matches, etc., and there is also a theatre where performances and concerts are given occasionally during the winter. The roads throughout the island are up to the best English standard and the facilities for riding and driving are unsurpassed. A railroad runs from Kingston in a northwesterly direction to Montego Bay, with a branch line to Anatto Bay and Port Antonio, towns on the north shore. Communication with the coast towns is had also by steamers which sail around the island once a week, leaving Kingston every Tuesday. There is frequent mail communication with the United States and Canada, and the island is also connected with this country by cable. Churches of all the leading denominations are found nearly everywhere, and in most of the larger towns are well-appointed clubs, libraries, and social organizations of various sorts.

The best months in which to visit Jamaica are November to April inclusive, as these are the coolest and dryest of the year, but one accustomed to the fierce summer heats of our northern cities would find a grateful change in the hills of Jamaica even in midsummer.

Much valuable information concerning Jamaica as a health resort may be obtained from a work on "The Climate of Jamaica," by the Hon. J. C. Phillippo, M.D., published by T. & A. Churchill, London, and from "The Handbook of Jamaica," published annually in London and Kingston. *Thomas Lathrop Stedman.*

JAMBUL. This is the local name applied to the bark and seeds of *Sizygium Jambolanum* De Candolle (*Eugenia Jambolana* Lamarck), a tree belonging to the natural order Myrtaceæ. It is indigenous to tropical Asia and the neighboring islands, where it grows to a large size and bears a crop of edible fruit in July and August. It is also known as rose apple and Java plum. The *Eugenia pimenta*, the common allspice tree, and *Eugenia caryophyllata*, from which cloves are obtained, are both closely allied species. The fruit varies in size from a cherry to a pigeon's egg, and when ripe is olive-shaped, smooth, juicy, and purplish-black in color. It contains a single seed, which is enclosed in a thin, papery shell. All parts of the tree are astringent, and the bark furnishes a beautiful brown dye. The bark is smooth and whitish, and the cell-structure contains a number of characteristic pitted cells which are visible to the naked eye. The chemical constitution of the plant has not received much attention. It probably contains an alkaloid or glucoside, but none has been separated so far. A white crystalline substance has been obtained, termed jamborine, which is tasteless, insoluble in cold water, soluble in alcohol, ether, and chloroform. It is said to possess the active properties of the seeds, but its composition and properties are uncertain. The following analysis of the seeds has been furnished by Elborne: Essential oil, a trace; chlorophyll and fat, 0.27; resin soluble in alcohol and ether, 0.30; gallic acid, 1.65; albumin, 1.25; coloring matter, 2.70; moisture, 10.0; insoluble residue, 83.73.

The plant is highly esteemed in India for its medicinal properties, and is used by the native physicians in the treatment of many diseases. The sap or juice expressed from the leaves and bark contains the astringent properties of the plant, and when mixed with goat's milk is thought to be particularly beneficent in the intestinal disorders of children. The juice, and an infusion of the bark, are also employed in dysentery, diarrhœa, and in leucorrhœa. A liquor, jambava, is prepared from the fruit by fermentation; it possesses a stimulating and tonic action, and is a favorite beverage of the Hindoos. The most important use of jambul is as a remedy for diabetes, and it is in the treatment of this disease that it has acquired notoriety and attracted the attention of the profession during the past few years. It has long been employed for this purpose in the East, where it has the reputation of producing a rapid and, in many instances, a permanent cure. The quantity of sugar and urine is reduced, the many distressing symptoms relieved, and a return of health and strength is said to follow its administration. This treatment was brought to the notice of the English physicians in 1883, by Banatvala, a medical officer in the service of the Madras government, and has been the subject of numerous clinical and experimental researches.

Von Mehring and Graser[1] performed an important series of experiments to demonstrate its power to check the production and lessen excretion of sugar. They produced artificial diabetes in animals by the administration of phloridzin, and carefully estimated the amount of sugar excreted when phloridzin was given alone, and when it was given in combination with jambul. The diminution was found to be invariable and very decided. The following figures indicate the results in three experiments:

Sugar excreted without jambul	12.2	10	10
Sugar excreted with jambul	2.1	1	1.5

They also proved that it was devoid of any toxic action, as very large quantities were given without producing any ill effects.

Experiments have also been made to show its inhibitory action on saccharine fermentation by adding it to a solution of starch and malt, and it has been clearly shown that the quantity of sugar is reduced in accordance with the amount of jambul present. In one instance it was found

that a solution of rice starch with a definite proportion of malt produced 27.4 parts of sugar; when fifteen grains of jambul were added the amount was reduced to 9.4 parts, and when twenty-five grains were used there was only 1.3 part of sugar formed.

Accompanying this evidence in favor of the drug have been a number of reports of cases treated, and in nearly all it was found that the desired effect was produced in a greater or less degree. Among these are reports by such observers as Kingsbury,[2] Saundly,[3] E. H. Fenwick,[4] Mahomed,[5] Egasse,[6] Villy,[7] Lewaschew,[8] Lawrence,[9] and Britto.[10] In some of the cases in which it was used it failed altogether, in others the sugar reappeared immediately the remedy was discontinued, and frequently it would only lessen the symptoms in a slight degree; but the general tenor of the reports is in favor of the remedy. Villy, who views this treatment more sceptically than any of the others, acknowledges that it is of service "in cases of moderate severity, provided the diet be absolutely restricted."

In reviewing these reports, there is apparent a great deal of uncertainty in the employment of the drug. Some of the cases were treated with small doses and the most satisfactory results were obtained; in other instances the reporters state that in larger quantities only can any benefit be expected. The same variation is observed in the dieting of the patients: some were allowed to eat freely of any food they desired, while others were restricted to a proper diabetic regimen, and in both classes were successes and failures recorded. A more scientific turn has been given to the study of the remedy by the British Medical Association, in empowering its therapeutic committee to inquire into the mode of action. A supply of the fresh seeds was obtained and furnished, with certain directions, to such of its members as desired to make use of them.

How the drug acts, or what are the forms of the disease in which it is indicated, have not been determined. It has been thought to act by simply checking the transformation of starch into sugar, producing the same effect as a carefully prepared diet; but the experiments of Graser would indicate its action to be of a more radical character, and in many of the cases in which its use has been followed by marked benefit, a restricted diet and numerous other remedies had previously been employed. Villy, who studied the drug under the direction of Dujardin-Beaumetz, considers that any beneficial action only accompanies the use of the remedy when starchy food is excluded, and he seems to think that it has very little power in preventing the transformation of starch into sugar. He repeated the experiments with solutions of starch and malt, and found that instead of the diastatic ferment being checked, the conversion of the starch proceeded more rapidly with the jambul added than without its presence.

The seeds and the bark both possess the anti-diabetic action, but the seeds are the more active of the two. A paper presented by Dr. T. Stevenson, of Bombay, to the Pharmaceutical Conference, held at Edinburgh, 1892, states that the fresh seeds, or an extract prepared from the fresh seeds, is the most serviceable and the only certain method of securing the medicinal properties. Under any circumstances, it is recommended that the seeds should be carefully preserved and only reduced to powder as required. Some such variation in the active properties of the drug may account for the uncertainty of its action and the difference in the quantity administered. The usually recommended dose is five to ten grains of the powder, or five to ten minims of the extract, three or four times a day. This, however, appears to be inadequate, and much larger doses are now advised. Dr. Britto, who reports from India his successful treatment of a number of cases, gave it in doses of one drachm of the powder, or one fluid drachm of the extract, three times a day; and Professor Lewaschew, who reports his experience of two years, in which he employed the drug with marked success, advocates it in doses of as much as from twenty to forty grammes (5 to 10 drachms) in the twenty-four hours. The British Association, in their recommendations for its experimental use, state that the dose of the powdered seeds should be from one drachm to one ounce daily. No toxic action follows its use, but instances of nausea and depression have been reported from its continued use.

Beaumont Small.

[1] The Lancet, p. 902, 1889.
[2] British Medical Journal, March, 1887.
[3] The Lancet, October, 1887.
[4] Ibid., October, 1888.
[5] London Practitioner, December, 1888.
[6] Bulletin Général de Thérapeutie, July, 1890.
[7] Ibid., January, 1891.
[8] British Medical Journal, March, 1891.
[9] The Medical News, January, 1893.
[10] The Therapeutic Gazette, February, 1893.

JOINTS, DISEASES OF THE. TREATMENT IN GENERAL.—*Local applications* of all kinds, poulticing, blistering, the cautery, and ice-bags, so much used a few years ago, are no longer employed with the expectation that any effect will be gained upon the disease itself, or that anything more than temporary relief to the superficial symptoms will be attained. The same may be said of compression in tubercular synovitis. Massage and passive motion are not only of no use, but are productive of much harm when used during the course of the disease. After the disease has terminated, they have a certain cosmetic value; they hasten the time when the fullest possible motion and the greatest attainable plumpness are regained, but they accomplish nothing which will not be sooner or later gained by use alone.

Subcutaneous Injections.—Various medicaments have been injected into masses of tubercular tissue and tubercular abscesses, but none have held the confidence of the profession except iodoform in glycerine or olive oil. This is used in ten per cent. strength and carefully sterilized. When injected into tubercular tissue a few drops are deposited here and a few drops there throughout the mass. When used in abscesses, the abscess contents are as completely evacuated as possible, and then from one to four drachms are injected, and moderate compression applied. The cavity usually refills, and the process may have to be repeated many times; or after any one of the injections it may not refill, but gradually close, and the tubercular lining membrane shrink away. If the injection be kept strictly aseptic a cure is effected in much less time than could be had in any other way; but if septic infection does result, the injection proves an injury instead of a benefit. In young children who fear the pain of the injection, the advisability of the procedure may be questioned, it being borne in mind that treatment by brace must in any case be continued for many months.

Fixation and Traction.—The treatment of chronic joint disease by "motion without friction," attained by elastic traction in an ambulatory apparatus, is no longer attempted. All surgeons now agree upon the necessity of fixation during the active stage of the disease. At a somewhat later time many allow motion within the limits of muscular restriction, while others insist upon immobilization until a complete cure appears to have been accomplished.

Traction, or "distraction," is employed either for the fixation which it gives (Judson); or because of the increased area of motion possible during its use (Sayre); or as a means for allaying muscular spasm (Shaffer).

It is obvious that whatever will most quickly allay muscular spasm is of prime importance. The advocates of traction believe that traction is of the first importance, and the best, if not the only, means for satisfactorily doing this. On the other hand, the advocates of pure fixation claim that fixation alone without traction will more quickly allay the spasm than will traction, or fixation combined with traction. The two methods have not been given a fair, unprejudiced trial and comparison. Meantime, the majority of the profession use a more or less perfect, and more or less defective, combination of both principles.

In treating joint diseases in the lower limbs, traction during recumbency and during walking are quite differ-

ent problems, and we feel quite convinced that continuous, uninterrupted traction cannot be had by any splint upon which the patient walks.

HIP DISEASE.—The etiology of the various deformities of hip disease has recently been studied by Dr. A. M. Phelps, of New York, who arrived at the following conclusions:

Abduction always precedes flexion, or is attended by it, in the first stage.

Abduction and outward rotation are always present in the second stage. Flexion is nearly always present, but is absent in a few cases.

When the limb is flexed beyond forty degrees, and frequently at a much lesser degree (twenty degrees), it quite rapidly passes to the deformity of adduction, inward rotation, and flexion, whether the capsule contains fluid or not.

Assuming the work of the glutæus maximus operating in a given triangle with two pounds and a half weight to be fifty pounds, other muscles operating in different triangles of different weights can be accurately estimated as to their comparative strength. Following this rule, it was found that the glutæi muscles were capable of one hundred and thirty-one pounds, whereas the adductors were only capable of one hundred and sixteen pounds, proving that the abductor group was much stronger than the adductor in the subject examined. From clinical observation it was concluded that the reason why the limb went over to the deformity of the third stage of hip-joint disease, was because the actions of these muscles were all changed by the flexion of the limb, or from pathological destruction of the joint changing or annulling the action of the muscles by destroying the leverage.

In the first stage the limb is slightly flexed and abducted to relieve the tension of the capsule. This deformity is increased as the case passes to the second stage by the spasm of the muscles about the hip-joint. The great glutæi, outward rotators, tensor vaginæ femoris, and flexors have the advantage of leverage. As a rule, the deformity of the third stage appears only after flexion to twenty-five degrees has taken place. This is because after the limb has passed to twenty-five degrees of flexion, the adductors to a very great extent become internal rotators; the external rotators almost totally lose their power as external rotators, and become abductors (with the exception of the quadratus femoris and obturator externus), and the tensor vaginæ femoris becomes a powerful inward rotator.

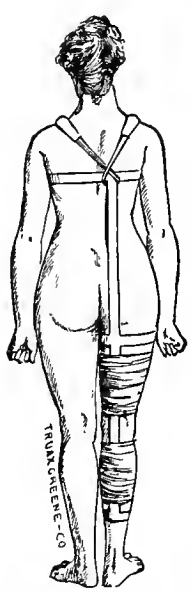

FIG. 368.—The Thomas Hip-splint Applied.

Erratic deformities occur from partial or complete dislocations, and from shortening of the neck of the femur, which destroys the action of the flexors, and often of the adductors, by changing the leverage. Extreme flexion may be accompanied with abduction and outward rotation; or adduction may be accompanied with outward rotation.

The treatment may be by fixation with a plaster-of-Paris splint, or by a brace. If the plaster splint be made use of, it should extend from the ankle to the axilla. It is difficult to apply without favoring increased flexion deformity. Bartow, of Buffalo, partially suspends patients in the conventional suspension apparatus and applies the splint, while the patient bears a part of his weight by the well limb upon a block, the affected limb dangling, or gently pulled downward into the best possible position.

The Thomas hip-splint (Fig. 368) is the only purely fixative splint in general use. The objections which have been raised to it are: (1) That it does not furnish complete fixation; (2) that it does not prevent subluxation; (3) that it does not counteract muscular contraction; (4) that it increases pain because of its leverage action. It is proper to say that these objections are raised by surgeons who have not used a properly constructed splint upon the principles laid down by Mr. Thomas, and the objections are therefore purely theoretical, and based upon an imperfect knowledge.

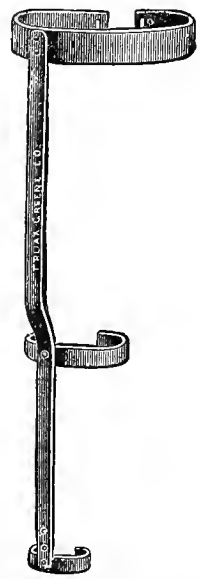

FIG. 369.—The Thomas Hip-splint, as used by the Author.

The persistent deformity of hip disease is flexion. So long as flexion is present, and so long as muscular spasm tending to flexion is present, the splint, by its direct antero-posterior leverage action, if properly applied, absolutely controls antero-posterior motion. Lateral motion, to which there is less tendency, is controlled in the same way, but less efficiently. When there is no longer any deformity, and when the joint has so far recovered that muscular spasm no longer tends to deformity, the fixative power of the splint is greatly lessened; but at that time a certain amount of motion does no harm, as is admitted by those who object to the use of this splint. As to subluxation of the femur during the use of the splint: One such case has been reported, but there is no evidence to show that the reporter of the case knew how properly to use the splint. On the other hand, subluxation now and then happens when the traction-splint is being used, both in walking and recumbent cases. As to muscular spasm: Whatever is able to keep the parts in most perfect quiet, that most quickly relieves the spasm. In my experience the Thomas splint does this; and after using the long traction hip-splint in many hundreds of cases, I have entirely abandoned its use. I am very certain that pulling upon the muscle is not logically, nor is it clinically, the most successful way to abolish the involuntary muscular spasm of joint disease. That which acts to allay the inflammation from which the spasm arises ought to most quickly allay the spasm, and in practice we find that immobilization of the joint does this. As to the increase of pain: It does in many cases increase the pain for the few days during which the deformity is being overcome, but the sum total of pain had better be condensed into two or three days than spread over the days and nights of two or three months. That injury is inflicted by the leverage action which causes the increase of pain has not been proven by any increase in the number of patients having abscesses, stiff joints, or short legs.

The Thomas hip-splint (Fig. 369) consists of a main stem and several bands. The stem is of flat bar iron, from $\frac{3}{16} \times \frac{3}{4}$ to $\frac{1}{4} \times 1\frac{1}{4}$ inch; in length, reaching from the lower angle of the scapula to the lower third of the leg. The size of the bar must be large enough to prevent any bending or tremor. The chest band is of the same width as the main stem, but thin enough to be bent by the hands of the surgeon in fitting it to the chest. In each end is forged a hole three-fourths of an inch in diameter, and at its middle it is riveted to the top of the main stem. It is long enough to surround the chest below the axillæ. The thigh and calf bands are of somewhat lighter iron; the thigh band is riveted to the stem at such a point that it shall be a little below the perineum; and the calf band is at the lower end of the splint. Both are large enough to nearly surround the limb at the points indicated. At times an abduction or an adduction wing is attached to the main stem at a point where it will pass around the flank of the patient above the iliac crest and below the ribs. It is of iron of the same thickness as the chest band.

In the main stem are two bends dividing it into a

straight body portion and a straight leg portion, the lower portion being parallel to and slightly in advance of the upper portion. The lower bend is opposite the glutæo-femoral crease, and the upper one opposite the hip-joint. The splint is applied by opening out the wings of the bands on one side and slipping it under the patient until the stem rests in proper place, when the wings are again bent in to the side of chest and leg. The splint is supported by a strip of broad bandage looped around the main stem beneath the chest band, and carried over each shoulder and down to the holes in the ends of the chest band in front, after the manner of suspenders. The limb is bandaged to the splint by an ordinary roller from the bottom to the thigh band, or by a short piece at the bottom and another above the knee, or by a figure-of-eight around the knee.

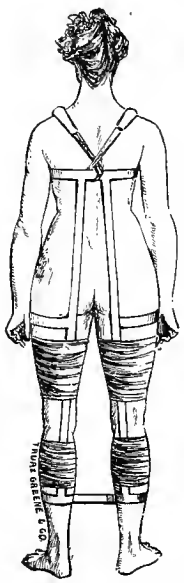

FIG. 370. — The Double Thomas Hip-splint.

If the limb cannot be brought fairly down, the brace may be bent at a point opposite the hip-joint and straightened during the succeeding three or four days; but this should not be done if it can be avoided. If the splint tends to shift to right or left, the wings on the side toward which it moves should be somewhat opened and those on the opposite side drawn closer in to the patient. Abduction and adduction are corrected and prevented by an extra wing attached to the main stem at such a point that it will pass around the flank on the side toward which it is desired to draw the limb. When rapidly straightening a deformity, and in cases where the muscular spasm is intense, the skin underneath the brace should be changed once or twice a day and kept dry and well powdered. In moving a patient with a very sensitive joint, the patient places his well limb across the affected member, while the assistant lifts him by placing one hand under the brace and limb at the back of the knee, and with the other grasps the chest band.

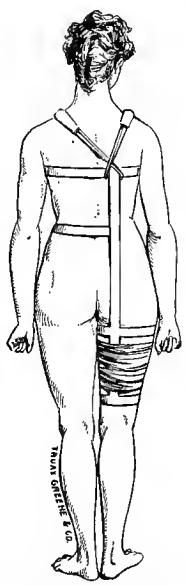

FIG. 371. — The Thomas Hip-splint, shortened for walking during convalescence.

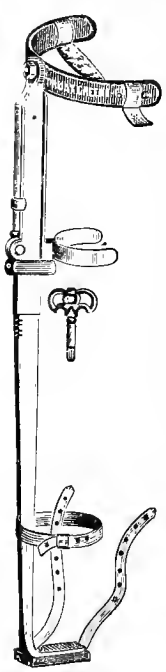
FIG. 372. Judson's Hip-splint.

Judson's splint (Fig. 372) is the most rigid of the long traction hip-splints. The hip band is of heavy steel coated with hard rubber. This is firmly bolted to the head-piece of the side-bar, so that there may be no motion between them. The side-bar and sheath are of steel, about one-quarter of an inch thick, and in width from one-half inch at the bottom to one and a quarter inch at the upper part, where most of the strain must be borne. Adhesive plasters attached to the thigh and leg give means for traction, and a perineal strap gives counter-traction as in the conventional traction hip-splint.

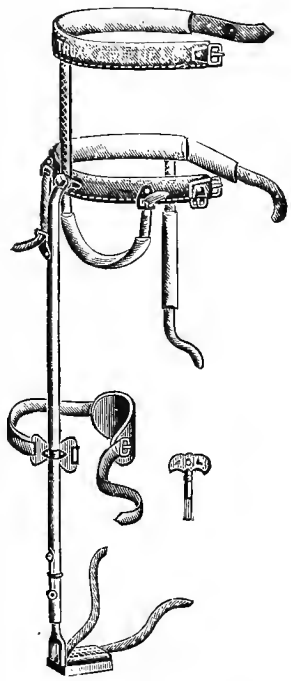
FIG. 373. Ridlon's Traction Hip-splint.

Ridlon's hip-splint (Fig. 373) (no longer used by the author) consists of one of the earlier forms of the Taylor hip-splint to which has been added a side-bar extending up the side of the body to the axilla, and a chest-band surrounding the chest at this point. A strong bolt fastens the chest-piece, the hip-band, and the extension-bar immovably together. Traction and counter-traction are made in the usual way. The advantage of the splint over the usual forms of traction splint is, that the patient cannot voluntarily bend to any extent from foot to axillæ.

Phelps's splint (Figs. 374 and 375) is a combination of the ring of the Thomas knee-splint, the usual extension-bar placed, however, at the inner side of the leg and thereby subjected to less lateral strain, and Ridlon's chest-piece. To these is added a lever to exert lateral traction by pulling outward upon a band passed around the thigh. The splint more rigidly immobilizes than does Ridlon's splint, but has this disadvantage, that it cannot be applied while any considerable deformity is present. The deformity must first be reduced by other means.

Correction of Deformities.— Flexion, abduction, and adduction, when disease is still present, should be corrected as rapidly as possible by leverage action, supplemented or not by traction, as the case may demand. True shortening cannot be remedied, but may be obscured by placing the limb in abduction and slanting the pelvis. Deformities present in cured cases may, if there be any motion present, be corrected by leverage, supplemented or not by section of the shortened soft parts. If there is no motion and no muscular spasm, section of the bone by saw, or preferably by chisel, is indicated, supplemented or not with section of the shortened soft parts. Whatever method is employed to correct the deformity, the limb must be thoroughly immobilized until all pain, tenderness, and muscular spasm have subsided.

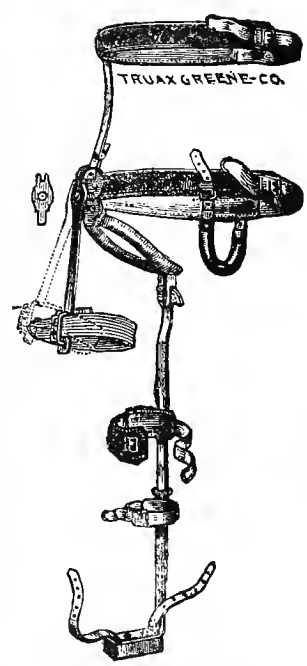

FIG. 374.—Phelps' Hip-splint.

KNEE-JOINT DISEASE.— The same principles govern the treatment of disease at this articulation as at the hip, and need not be rehearsed.

The most effective apparatus is the Thomas knee-splint (Figs. 376 and 377). It is made in two forms: the bed splint and the caliper splint. They differ only in

the manner of termination at the bottom, as will be seen in the description. The splint consists of a thigh-ring and two side-bars; it is made of one-fourth to seven-sixteenths inch iron wire, the ring being welded to the side-bars and sloped from without inward and from before backward. The angle formed by the lateral plane of the ring and the inner bar is about 135 degrees; the posterior angle formed by the plane of the ring and the inner bar is from 55 to 70 degrees, depending upon the thickness of the padding of the ring. The slope of the ring must be sufficient to leave that part of the ring which comes beneath the tuberosity of the ischium a little lower than any other part. The shape of the ring is irregularly ovoid, considerably flattened in the front and drawn out at the inner portion of the back. The shape varies somewhat, depending upon the thickness of padding to be put on.

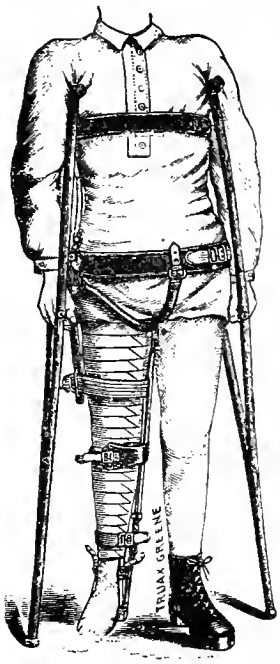

FIG. 375. Phelps's Hip-splint Applied.

The ring is padded firmly with felt and covered with tan sheep-skin put on wet, stretched snugly, and sewed on the outer surface of the ring. When the brace is to be used in bed it is made to extend six or eight inches beyond the foot, and usually is dimpled at the extremity so that the straps from the adhesive plasters will not slip, if they are used to give fixative traction. When it is desired to transform the bed-splint into the caliper, the portion extending beyond the foot is cut off an inch below the sole and an inch of each end bent to a right angle toward the opposite bar. These bent ends are sprung into a hole or tube set transversely through the heel of the shoe. In either splint a sling of leather, from four to six inches wide, is stretched across from one bar to the other at the back of the knee, and another narrower piece at the back of the ankle. A pad is placed over the front of the thigh, close down to the patella, and another over the shin just below the knee-joint, and backward pressure is made by strap or a piece of bandage passed across the pad, beneath each side-bar and back across the pad and fastened. When any backward displacement of the tibia is present, the sling at the back is slipped lower and only the thigh-pad used for backward pressure. In using the caliper splint care must be taken that it shall be long enough to keep the heel clear from the sole of the shoe in walking. The form of Thomas knee-splint extending four inches below the foot and terminating in a patten bottom is no longer used, as it does not give efficient immobilization.

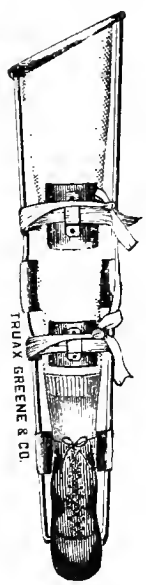

FIG. 376. — The Thomas "Caliper" Knee-splint, for walking.

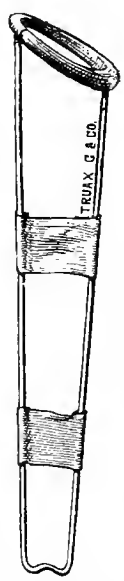

FIG. 377. — The Thomas Knee-splint for use when patient is in bed.

ELBOW-JOINT DISEASE.—This joint can be most effectively immobilized in a very simple manner. A strip of broad bandage is tied about the wrist, the forearm is flexed to such a point as will be most useful in case anchylosis results, the bandage is then carried to the neck and tied, and then around the neck and again tied, so that neither hand nor head can be drawn from their respective loops.

At first sight it would seem that this sort of immobilization would be far from complete, but the contrary is the case. The position which the forearm assumes in relation to the arm in elbow-joint disease is one of extension to about one hundred and sixty degrees, so that if the forearm be held flexed to about seventy-five degrees, the tendency to extension acting in opposition to the restraining influence of the sling gives effective immobilization. The patient does not voluntarily flex the forearm beyond the position of restraint so long as the disease is sufficient to be aggravated by such motion.

In diseases of the other joints nothing worthy of record has been recently advanced. *John Ridlon.*

JOINTS, MOVABLE BODIES IN. There is little, indeed, of unusual moment that can be added now to that which has already been stated in the original article written for the HANDBOOK in 1886. Now, as then, joint derangements are due, not only to the effects of injury and disease on the component parts of the articulation, but also to the presence in them of the products of various histological processes that happen elsewhere in the body, in similar tissues. The semi-lunar cartilages are common seats of injury and disease in the knee, as not only themselves, but also the ligaments connected with them, suffer conjointly and separately, or with interchangeable relationship with each other. The injuries and diseases characteristic of these joint-structures constitute the most important items of affliction incident to the life-history of joints thus provided. The cartilages themselves may be displaced, bruised, crushed, or torn, and the ligaments maintaining them in proper relationship with the articular surfaces and properly attuning their functional movements, may be stretched, bruised, or ruptured. The internal semi-lunar cartilage of the knee-joint and its attachments suffer more frequently than do the external similar structures. The exact reasons for this are somewhat problematical. It may be accounted for by the fact of the greater degree of functional activity that is present during motion at this portion of the joint; for the internal semi-lunar cartilage moves over a greater area of articular surface than the other, in order to meet its functional requirement in connection with the inner condyle of the femur, which condyle passes through the segment of a larger circle than its fellow. Also greater weight is received on the inner condyle than on the outer, and, too, it is more exposed to external violence than is the former. Functional derangement of these cartilages, resulting in their becoming pinched between the moving articular surfaces, is predisposed by any roughening process that hinders the harmony of action necessary for the proper performance of the advancing and retiring movements imposed on them during activity of the articular surfaces between which they are placed. And should this condition be present together with relaxed ligamentous attachments of the cartilages, then, indeed, will the danger of pinching be increased, and even actual displacement be threatened. Especially is this true of the inner cartilage in the presence of an actual extension with supination of the leg. In their normal state these cartilages cannot be broken, although they may be bruised, torn, and twisted. If, however, they have become hardened by morbid processes, then it is not impossible that they may be displaced or broken by severe circumscribed violence directed from without. They may be broken, or their coronary attachments may be ruptured under these circumstances by violence, while the weight

of the body is borne on the extended limb, but they cannot then be displaced. Violence directed against the outer border during the act of flexion of the leg and thigh, may cause them to be torn from their attachments and even ruptured, and then if extension follow quickly and forcibly, they may be overridden by the opposing articular surfaces, and thus held or be forced to the posterior part of the joint cavity. If the joint be already impaired by ligamentous relaxation and other structural changes, then, surely, derangement and displacement of these so-called cartilaginous structures much more readily takes place.

The special indications of semi-lunar involvement relate more especially to modifications of the normal contour of the joint surface at the site of the cartilages, as determined by palpation. With the leg extended, the external rounded borders of these cartilages can be easily felt in the normal state, and it will be noticed that they will recede gradually from the touch as the limb is being flexed, causing instead a marked depression corresponding to their former site. If the cartilage be displaced outward, then undue prominence is noted at that point, which may or may not disappear with flexion of the limb. The semi-lunar cartilages may become displaced outward at other aspects of the joint, but in these instances their mobility is less influenced by the normal movements of the joint than in the first instance. If the displacement be inward toward the centre of the joint, then the degree of extension which may be attainable need not return the cartilage to its normal site, and, therefore, a depression is noted in lieu of the normal contour of the cartilage. If the coronary ligaments be ruptured, these cartilages will recede and advance perceptibly during flexion and extension of the leg, provided the articular surfaces, and those of the adjacent cartilage, are smooth, and properly lubricated, If otherwise, they may be easily pinched and perhaps overridden during extension of the limb. One should judge of the nature and extent of the injury of a joint by carefully comparing its physical and functional characteristics with those of its uninjured fellow.

Treatment.—If the cartilage be displaced, its prompt reduction should be attempted. Various methods of procedure are advised to accomplish this purpose. The chief element of a successful reduction is based on the fact that flexion of the leg relaxes the connecting structures of the joint in direct proportion to the degree of that act. Now, since relaxation loosens joint tension, it follows naturally that loosening of the tension favors the restoration of the displaced cartilage, either by its own inherent elasticity or by direct manipulation, in the best possible manner. For this reason various degrees of extent and rapidity of flexion, combined with supination and pronation of the leg, are advised, for the purpose of reduction. The following, advised by Allingham, is sufficiently comprehensive to suggest, and probably even meets the demands incident to, displacement. "Flex the leg as much as possible on the thigh, drawing upon the tibia as if to separate the articular surfaces from the femur. Then rotate the tibia inward, if the internal cartilage be displaced, and outward, if the external cartilage be displaced. Both movements should be resorted to if the usual one does not succeed. Then extend the leg on the thigh quickly, but not with great violence, at the same time pressing with the thumb upon the projecting cartilage." After reduction, rest and immobility, until the danger of inflammation has subsided, will commonly suffice. If reduction fail of accomplishment, then one of two plans can be pursued :—

1. The employment of massage and passive motion, after the symptoms incident to the injury have subsided. This course will in time restore the function of the joint, although at intervals derangements will ensue, the same as may happen even when the reduction is accomplished at first.

2. The exploration of the joint through a liberal perpendicular or oblique incision made into it at the aspect of the displaced structure, about three-fourths of an inch from the ligamentum patellæ. If the integrity of the cartilage will permit, it should be returned to its proper position, and be stitched there with fine aseptic silk. If this be not allowable, on account of the great extent to which its structure has been damaged, it should be removed entirely. In either instance, finally, the joint should be irrigated with an antiseptic solution and closed by two rows of sutures—the first including only the synovial membrane and its closely adjacent connective tissues; the second, the remaining tissues of the wound. Either silk or catgut can be used, as best suits the wish of the operator. The employment of drainage will depend greatly on the extent of handling to which the structures of the joint-cavity have been subjected. Ordinarily it need not be employed; still, the introduction into the joint of carbolized horse-hair, or a small rubber tube, for drainage purposes, cannot in itself do harm, and should, therefore, be employed when, in the judgment of the operator, such a step is indicated.

The alar structures of a joint may become so elongated or enlarged, as the result of disease, as to be pinched by the articular surfaces. Extravasations of blood within their folds may so change their relations with the joint surfaces as to cause pinching at once, or bring it on at some later date, on account of the formation of fibrinous bodies within them, which remain attached to the borders of these structures, or are eventually disconnected and wander freely in the cavity. Histological changes taking place singly or otherwise in the various tissues constituting a joint, often lead to the presence within it of movable and attached bodies that can be characterized according to the nature of the process causing them, or the structure of the tissues that give them birth. Consequently, they may be described as of fibrinous, fibrous, cartilaginous, fibro-cartilaginous, osteo-cartilaginous, tuberculous, and biform origin, etc. The symptoms of the presence of these morbid bodies are illustrative of joint derangement in the full sense of the term, as compared with those of cartilaginous displacement proper, and little of practical importance can be added now to what has already been stated elsewhere in the Handbook on this subject.

Dr. Robert F. Weir recently called attention (*Medical Record*, July 16, 1892) to an interesting condition causing joint derangement of the knee, which simulated in all essential respects the presence in this joint of a movable body. Exploration of the joint revealed the fact that a duplication of fibrous membrane extended from the under surface of the patella and the adjoining surface of the femur to such a length as to be caught between the articular surfaces during flexion, thus "locking" the joint, and also impeding extension. A grating sound beneath the patella attended the establishment of motion in the two cases of this disease which he had observed. Both were readily cured by removal of this obstructing agent. The treatment for movable bodies relates to the manipulations employed to overcome the joint-locking incident to them, which differs in no essential respect from that used to restore displaced semi-lunar cartilages. Vigorous extension of the leg, during its complete flexion, with or without rotation, will commonly dislodge the troublesome agent and relegate it, for a time at least, to some remote recess of the joint cavity.

The *operative treatment* is the most important, since it offers the only means of prompt and permanent relief, and also because it is attended with an element of risk to the patient which begets at the same time a respectful consideration of the joint cavity on the part of all those responsible for the result of operative measures. The following statement presented by Tuttle will emphasize the operative measure and its dangers much more pointedly than mere words alone can do. It is very important, in-

	Cases.	Cured.	Failures.	Mortality.
		Per cent.	Per cent.	Per cent.
Beamdorf	216	66.2	18.99	14.81
Lorry, 1860	167	68.86	19.76	11.38
Browne, 1884	88	82.95	5.68	14.36
Tuttle	107	97.19	2.81	.....

deed, to note the difference in the results as modified by the recent antiseptic measures, since the results in no uncertain manner impress upon one the fact that the wise use of modern methods relieves nearly all of the afflicted, without causing any of them the loss of life or limb.

Joseph D. Bryant.

KAVA-KAVA. This is the native name of *Piper Methysticum*, a shrub belonging to the natural order Piperaceæ. It is indigenous to the Polynesian Islands. It has acquired a local reputation as a remedy for dropsy and painful affections of the bladder and the urinary tract, but it is chiefly prized as the source of a native national beverage. The plant is reduced to a pulpy mass by mastication and allowed to ferment, until an intoxicating liquor is produced. The primary effect is as a stimulant, but ultimately it causes a peculiar form of intoxication in which the limbs and body are uncontrollable and helpless, while the mental faculties are clear or slightly dazed. The root is the part employed for medicinal purposes, and has been closely investigated by Dr. L. Lewin, of Berlin, who directed attention to its importance as a remedial agent. He analyzed it and obtained an essential oil; two resins, alpha- and beta-resin kava; and a neutral crystalline principle called *kavahin*, or *methysticin*, which is closely allied to *piperine*. The crystalline body exists to the extent of one per cent., but has been found inactive. The alpha-resin, which is obtained by means of alcohol, and is insoluble in water, contains the medicinal properties of the plant, and is thought by Lewin to be the active ingredient. It has, however, been shown that the watery infusion also is useful, and this would indicate that the virtues of the plant are not limited to the resin itself. At present the resin and the fluid extract, not miscible with water, are the preparations employed for medicinal purposes. Kava-Kava has formed the subject of an exhaustive study by Dr. Cerna (*Therapeutic Gazette*, January, 1891) who arrives at the following conclusions regarding its physiological action: Moderate doses produce a stimulating effect, particularly on the central nervous ganglia; in larger quantities it produces general anæsthesia, and diminishes and ultimately abolishes reflex action by influencing the spinal cord, and probably also the spinal centres. The great muscular weakness observed is not due to any action on the higher cerebral centres, as they maintain their normal functional activity. Very large quantities depress the circulatory and respiratory systems, and, in poisonous doses, death is produced by failure of the respiration, or by cardiac paralysis. Placed on the tongue, it at first causes a burning sensation, which is followed by numbness and anæsthesia, which continue for some time and are accompanied by a free flow of saliva. On the cornea and conjunctiva the same effect is produced. The local anæsthetic action is said to be equal to that of cocaine, but its use is restricted by the insolubility of the preparations in water.

Kava-Kava is advocated as a remedy in cystitis, gonorrhœa, and chronic inflammatory conditions of the mucous membrane of the urinary organs. It also possesses a diuretic action, and has been used with success in dropsy. Its tonic and stimulating properties add to the general well-being of the patient, and increase its beneficial action. Its administration should be accompanied by copious draughts of water, which soon promotes a plentiful flow of urine which rapidly moderates the inflammatory action and exerts a remarkably soothing influence. This is followed by a lessening of the purulent and catarrhal discharges. The fluid extract is the most convenient preparation to use, and has been employed with decided success. It may be given in doses of twenty to sixty minims three times a day, and has been combined with sweet spirits of nitre and glycerine when these are indicated. The alpha-resin is given in doses of one to one and a half grain, three times a day. A solid extract is prepared, the dose of which is two to six grains. The principle, kavahin, is not employed, as its therapeutic action and dose are uncertain. *Beaumont Small.*

KILRUSH AND KILKEE. Popular sea-side resorts in County Clare, Ireland. There are a number of ferruginous springs near these places. Kilrush is on the north shore of the estuary of the Shannon, and Kilkee faces the Atlantic Ocean. At the latter place there is a fine sandy beach. The climate of these resorts is on the whole good. It is decidedly bracing, and at times the westerly gales are trying. The amount of rainfall is not greater than the average for Great Britain. The accommodations are rather primitive. There are many opportunities for excursions on land and sea. Scattery Island is only one mile from Kilrush. *Edmund C. Wendt.*

KISSINGEN. The principal features of this important German spa have already been described in Vol. IV. of this Handbook. The writer has had occasion, on his several visits to the place, to gather abundant evidence as to the good results obtained there in suitable cases. It is, however, one of those resorts where it is by no means superfluous to remain under strict medical supervision while taking a course of the waters. Patients acting without professional advice are at times injured by the waters.

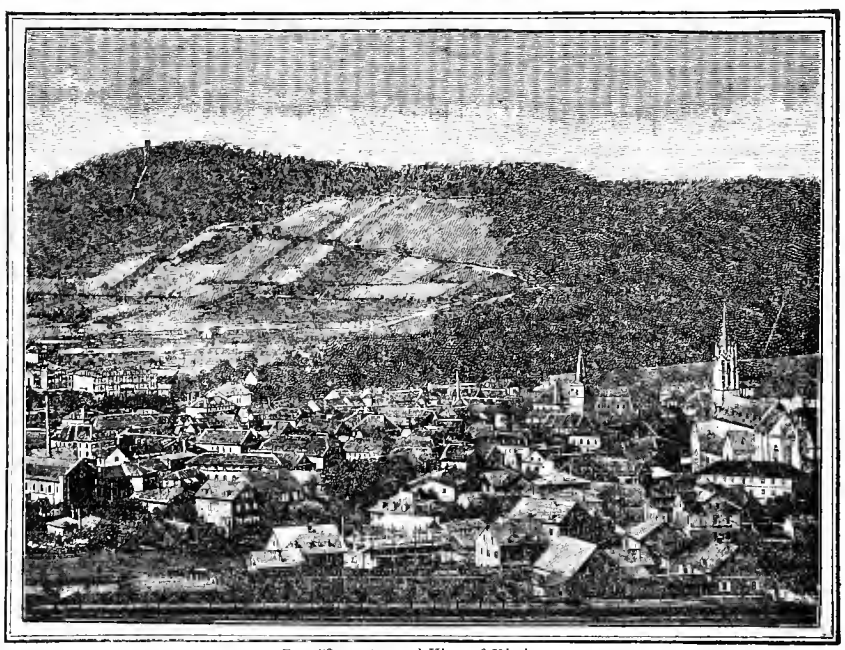

Fig. 378.—General View of Kissingen.

Recently some needed sanitary reforms have been completed at Kissingen. The little town is now well drained and is supplied with good drinking water. It is so pleasant a place to spend a summer in, that many visitors now go there who are not invalids.

Kissingen has excellent facilities for all kinds of baths, inhalations, mechanico-therapeutics, massage, etc. There are also various private medical establishments, under supervision of competent physicians. Dr. v. Sohlern has a special sanitarium for the treatment of gastric disorders, and the results of treatment there are known to be often highly satisfactory.

In regard to the brine baths, Dr. Thomas More Madden, after a recent inspection (*The Provincial Medical Journal*, December 1, 1892), speaks as follows:

"About a mile from the other springs, to the north of the town, rises the Soolensprudel. This well is contained within a handsome square building facing the river. The hall occupies the entire central part of the structure, and is lighted from the dome, while at each side different galleries run round. In the middle of this apartment is a raised structure, somewhat like an immense beehive, with glazed cover, about two feet high, beneath which is the Soolensprudel. The shaft of the well, seen through this cover, is about twenty feet deep by about eight feet in diameter, and seems to be lined with woodwork. Through the bottom of that shaft an artesian well was bored in 1823 to the depth of nearly three hundred feet in the sandstone, and this it is which now supplies the Soolensprudel.

"This source presents a very remarkable phenomenon, namely, it intermits, or ebbs and flows, with great regularity, eight or nine times daily. If we arrive a little before the 'flow,' on looking down the shaft through the thick glass cap we see the well apparently empty of water; we then hear a distant rumbling noise, which gradually becomes louder, and draws nearer, till in about half an hour from the time it was first heard, the water is seen foaming below; it gradually ascends, and in another quarter of an hour reaches within a few inches of the top of the well, covered with white foam, and hissing and seething with great turbulence. Above the water hangs a heavy layer of carbonic acid gas, rising and falling with it. This gas is collected and ingeniously utilized in various forms of gas baths. Indeed, the entire system of vapor, gas, and water baths in the establishment is extremely perfect.

"Internally used this water is strongly purgative, and diluted, as from its strength it could not otherwise be drank, it is employed in the same class of cases as the other springs. It is, however, principally used for bathing, in rheumatic, neuralgic, and cutaneous affections. It acts as a powerful stimulant to the skin, producing redness and considerable irritation of the surface. From its close resemblance to sea water, having, however, in addition, a small proportion of iron and a considerable amount of carbonic acid gas, it might, and perhaps even more advantageously than sea-water, be employed in scrofulous cases. The mother lye, or concentrated saline water of the Soolensprudel, is applied with wonderful results as a local application to scrofulous glandular swellings and similar affections."

Physicians and their families are very courteously treated at this spa, and annually visit Kissingen in large numbers. The hotels are large, and many of them are quite modern in the provision of comforts.

Edmund C. Wendt.

KNOCK-KNEE. In the treatment of knock-knee by mechanical means two essential points must be insisted upon during the period of attempted correction of the deformity, namely, the patient must be kept off his feet, and the mechanical device must be applied with the knee in full extension, and be capable of constantly maintaining that position without motion at the joint. The discredit which has generally fallen upon the mechanical treatment of this deformity, and led to the employment of operative procedures, is due to the use of braces so constructed with a joint at the knee as to allow the patient to walk with a reasonable degree of comfort. Only when the knee is fully extended is the leverage action of any brace effective; as soon as the leg begins to flex, the deformity becomes less, and, before flexion reaches a right angle, entirely disappears, and the feet can be brought together. This is due to the fact that the divergence from the normal relations of the condyles is more a longitudinal than an antero-posterior one. The divergence of the condyles from the normal may be either a shortening of the external, or an elongation of the internal; upon this relation depends the choice between the operations of Ogston and MacEwen in operative cases. If the internal condyle is considerably elongated and the external condyle of normal length, obviously Ogston's operation, which allows the split-off inner condyle to slip upward, is to be preferred to MacEwen's, which practically elongates the outer condyle without shortening the inner, by the gap at the outer side of the lower end of the divided femoral shaft. This deviation of the condyles from the normal should also be taken into consideration in choosing between the operative and the mechanical treatment; otherwise it may be found, when the deformity has been corrected, that one lower extremity is considerably longer than the other, as in Fig. 379, and that the deformity resulting from the treatment is quite as serious as that for which the treatment has been employed. Unlike bow-legs, when the choice between mechanical and operative treatment depends upon the age of the patient and the rigidity of the bones, the choice in knock-knee depends upon the nature and location of the abnormality. In all cases the knock-knee can be corrected by a brace; nevertheless, Ogston's operation is to be preferred if the deformity consists solely of great elongation at the internal condyle, and MacEwen's in those older cases where the shortening at the outer

Fig. 379.—Elongation of Left Limb due to Correction of Knock-knee by a Brace.

condyle equals or exceeds the lengthening at the inner. A description of these operations will be found under their separate headings. The mechanical treatment consists of the application of some rigid splint, a simple form of which is represented in Fig. 380. It consists of a piece of flat bar-iron placed along the outer side of the limb, reaching from the greater trochanter to the sole, forged round at the bottom, bent at a right angle, and passed into a tube or hole in the heel of the shoe; attached to this, at a point just above the malleolus, is a padded band of thin iron reaching two-thirds around the ankle; at the

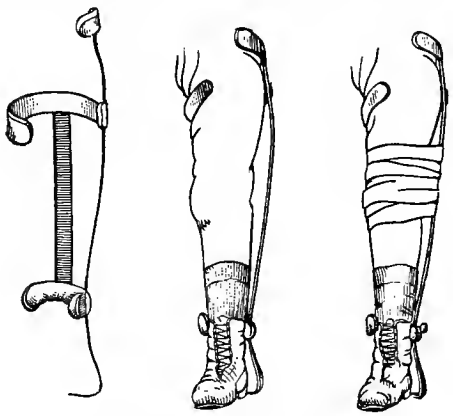

FIG. 380.—The Thomas knock-knee brace.

upper part of the thigh is a like band, and these bands are joined by a light bar of iron placed directly back of the middle line of the limb. At the top of the lateral bar is another padded band reaching about two inches to the front and an equal distance to the back of the lateral bar. The limb is bandaged to the splint by a figure-of-eight bandage, fixing the joint first to the posterior bar, and then laterally by passing the bandage around the limb and both bars. This corrected position is constantly maintained until the deformity is not only corrected, but remains so; then jointed retention braces may be applied and joint motion permitted.

John Ridlon.

KOESEN. A popular spa in the Prussian district of Merseburg, Germany.

LOCATION.—Koesen is very prettily situated about six hundred feet above the level of the sea. The surrounding country is hilly, and the little town is on the river Saale. The climate is mild, the air pure, and the scenery tempting. Season—May to September.

ACCESS.—Koesen is now reached by railroad by way of Naumburg.

ANALYSIS.—The *Johannesquelle* is a strong saline water. There is also a chalybeate spring, the *Mühlbrunnen*. Koesen is, however, chiefly known for the excellence and strength of its brine. Indeed, the principal spring, the *Soolquelle*, supplies so concentrated a brine, that it is necessary to considerably dilute it for bathing purposes.

INDICATIONS.—Rickets and scrofula in all their varied manifestations are principally treated at Koesen. But many women with chlorosis and diseases of the organs of generation, and sufferers from gout and rheumatism, are benefited by the Koesen baths.

ACCOMMODATION.—The hotels are small and only moderately good, but the thermal establishments are equipped with all modern appliances.

Edmund C. Wendt.

KOLA NUT. The seeds of the kola or cola tree, *Cola acuminata R. Br.*, order Sterculaceæ, a native of western tropical Africa. Kola is to the native of Africa what cocoa and maté are to the South American, and marvellous tales are told of the amount of work and fatigue that the African is enabled to endure when supported by the stimulating properties of this nut. It has been held in the greatest esteem from time immemorial, and is now looked upon almost as a vital necessity. It has been naturalized in other countries, and is valued by the inhabitants of the West Indies, Brazil, Mexico, and other tropical countries. In addition to its ordinary use, it has acquired a reputation as a specific in counteracting the depressing and debilitating effects of alcoholic intoxication. Experiments have been made with it in the French army which prove that it has decided stimulating properties, but is in no sense a food, and any benefit derived from its use may be traced to the caffeine which it contains.

The tree grows wild upon the western coast of Africa, from the Sierra Leone to the Congo, and reaches several hundred miles into the interior, where it follows the limits of the palm. It grows to the height of thirty or forty feet, and is said to resemble the chestnut in appearance. The leaves are six or eight inches long, pointed at both ends; the flowers are pale yellow spotted with purple; they are destitute of a corolla, but have a five-cut calyx, the segments spreading like the spokes of a wheel. The flowers are numerous, polygamous, in terminal and axillary cymose pannicles. In the male flower the stamens are united into a very short column, which bears the anthers in a single row, the cells of the anthers spreading apart. In the hermaphrodite flowers the anthers are subsessile in a ring surrounding the base of an oblong five-celled ovary. The ovaries are five in number and cohere together, each having a slender stigma but no style. Ovules are numerous, anatropal, attached in a double row to the ventral suture of each carpel. The fruit consists of two, sometimes more, separate pods or follicles, which split open on the inner side and contain several seeds about the size of horse-chestnuts, weighing from seventy-five grains to an ounce. The covering of the seeds is brownish-yellow in color, the substance is a white mass of cells filled with starch and containing the alkaloids which give to the plant its medicinal properties. The tree commences to yield fruit about the fourth year, and is at its best about the tenth year. The flowering is nearly continuous; and fruit and flowers may be present at the same time. There are two collections during a year, a tree averaging about one hundred and twenty pounds of fruit annually.

Several analyses have been made of the seeds, with slightly varying results, but all point to the caffeine as the principle to which its virtues are to be ascribed. The following table compares its constitution with tea, coffee, and cocoa:

	Cocoa (Mitscherlich).	Coffee (Payen).	Tea		Kola (Heckel).
			Green. (Peligot).	Black	
Fat	53.00	13.00	0.28	....	0.585
Proteid matters	13.00	13.00	3.00	2.80	6.761
Theobromine	1.50	....	....	....	0.023
Caffeine	....	2.25	0.43	0.46	2.348
Essential oil	0.04	0.003	0.79	0.60	undet.
Resin	....	....	2.22	3.64	....
Sugar	0.56	15.50	....	....	2.875
Starch	....				33.754
Gum	....	....	8.58	7.28	3.040
Cellulose	....	34.00	17.08	26.18	29.831
Coloring matters	....	....	17.24	19.20	2.561
Coloring matters	5.00	....	2.22	1.84	1.290
Extractive	....	....	22.80	19.88	....
Tannin	....	....	17.80	12.88	1.618
Ash	3.60	6.697	5.56	5.24	3.395
Water	6.00	12.00	....	....	11.909
	100.00	100.00	100.00	100.00	100.00

The kola nut and its physiological action was treated in a thorough manner by Dr. Monnet in 1884, under the direction of Dr. Dujardin-Beaumetz, and an abstract of his thesis was published in the *Therapeutic Gazette* in the following year. The physiological and therapeutic action he sums up in the following conclusions:

1. Kola, by the caffeine and theobromine which it contains, is a tonic of the heart, whose pulsations it accelerates, while it increases its power and regulates its contractions.

2. A second phase of its action, similar to that of dig-

italine, proves it to be a regulator of the pulse, which revives under its influence, the pulsations becoming fuller and less numerous.

3. In consequence of its action upon arterial tension, diuresis is increased, and, consequently, kola can be employed to good advantage in cases of dropsy with cardiac lesion.

4. It might be deduced from observation that kola, which acts energetically upon cardiac contractions, and upon the contractility of muscles of organic life, would, on the other hand, have a paralyzing influence upon the striated muscles, when it is used in toxic doses.

5. It retards tissue metamorphosis and diminishes the excretion of urea resulting from decomposition of azotic substances, very likely by exerting a special action upon the nervous system.

6. It is a powerful tonic, through the principles which it contains, and its employment is indicated in cases of anæmia, in chronic affections associated with debility, and in convalescence from acute disorders.

7. It favors digestion, either by augmenting the secretion of the gastric juice (eupeptic), or by acting on the smooth fibres of the stomach, which it would render less atonic in cases of dyspepsia. Under its influence rebellious anorexia disappears and the digestive functions become more regular.

8. Finally, it is an excellent anti-diarrhœa remedy, and has rendered great service in chronic diarrhœa or sporadic cholera, although its action could not be explained physiologically.

Further use of the drug indicates that it does not possess any virtue that may not be ascribed to the alkaloids which it contains, and it has not secured a very firm foothold as a remedial agent. Its power to sustain fatigue has received more attention than its therapeutic properties. Among pedestrians and athletes its use has become very popular, and it is thought to prove very satisfactory to those who have used it. It has been suggested that the red substance that remains after the caffeine has been extracted by chloroform is a complex body, and exerts a peculiar stimulant action on the muscular and nervous tissues. A series of experiments have been made by E. Heckel (*Repert. de Pharm.*, October, 1892), to compare the action of caffeine and kola rouge or *kolanine*, from which he concludes that the action of the latter on the heart is more prolonged and due to the presence of caffeine in a "nascent" state. Surgeon R. H. Firth publishes (*Practitioner*, July, 1889) some very practical observations made upon British troops and natives under his control, and concludes that it is in no sense a food, and that its physiological action is explained by the contained alkaloids; when pure and not too old it has a peculiar stimulant action on the nervous system, temporarily strengthens the heart-beat, and increases the arterial tension; taken continuously during times of exertion and fasting, it possesses some power of warding off the sense of mental and physical exhaustion. This power, however, is not so marked as some observers have reported; in the convalescence from long sickness its value is not apparent, and its alleged antagonistic action to alcoholic sequelæ is not capable of proof.

As a therapeutic remedy it is of benefit in strengthening the weak heart, augmenting the general flow of blood and vascular tension, and promoting diuresis. Its tonic effect has also proved of benefit in disturbances of the nervous system and debility of the cerebro-spinal centres, and in the prostration accompanying and following severe fevers and protracted illness. As a remedy for diarrhœa, particularly of an atonic character, it has proved of decided value. The combination of the tannic acid and its tonic principles makes it of great service in this disorder. The preparations advised are the alcoholic tincture, the elixir, and the wine. The tincture is made by exhausting fresh kola with five parts of alcohol, and the wine by macerating the same proportions of kola in wine for a fortnight. The dose is from one to two or three teaspoonfuls three times a day. The elixir is prepared by diluting the alcoholic preparation with equal proportions of syrup. *Beaumont Small.*

KRONTHAL. A small spa in the Taunus district in Nassau, Germany. Kronthal is prettily situated near the wooded hills of the Taunus, not far from Frankfort-on-the-Main. The springs are mild saline, chalybeate ones, and are very agreeable to the taste on account of the large proportion of free carbonic acid. The Kronthal waters are much exported and are quite popular as tonic beverages. The spa is well suited to the milder forms of anæmia, dyspepsia, and neurasthenia. Many invalids go there for a so-called "after-cure." The climate is mild and pleasant. There are good facilities for excursions, promenades, and out-door amusements generally. A fine thermal establishment has been recently erected, in which the usual hydro-therapeutic appliances are found, also baths, massage, sprays, etc. The nearest railroad station is Kronberg, from which town Kronthal is reached in twenty minutes. *Edmund C. Wendt.*

LEPROSY. ETIOLOGY.—During the past five years the etiology of leprosy has received a great deal of attention, and the discussion has assumed somewhat of a public character. Among the most important contributions is that by[1] Zambaco, of Constantinople, who has had during ten years two hundred cases under constant observation. Although he made a careful study into the personal as well as the family history of these cases, he has not been able to establish a single fact which would prove the contagiousness of the disease. He cites a number of cases of individuals who have lived in the closest contact with lepers and have not become affected. He believes that it is contagious in certain localities and in extremely rare cases. He adheres to the theory of hereditary origin.

Dr. Heindiston[2] has cited several instances illustrating the hereditary character of the disease. He mentions the case of a child of a leprous mother, deserted soon after birth, and brought up by perfectly healthy people in a district where leprosy was not known. At ten years of age early symptoms became manifest, and at fourteen she was admitted into the leper hospital.

This case is quoted by Zambaco, and would therefore appear to be one of the best established instances of hereditary origin.

Dr. Danielsen has again affirmed that in his long experience he has never met with a single case of contagion.

Dr. Bevan Rake is doubtful as to the proof which has so far been produced in favor of direct contagion of leprosy. The question in his opinion is narrowed down to this: Can a healthy person more readily derive the bacillus from an infected human being, or from water, or from some host which contains the bacilli or its spores? On the other hand, Hansen, of Bergen, thinks the theory of the hereditary transmission untenable. He made careful personal investigations into the history and condition of the descendants of one hundred and sixty Norwegian lepers who settled in the States of Minnesota, Wisconsin, and Dakota. He traced out the history of the children, grandchildren, and even the great-grandchildren, and was not able to find a single case of leprosy among them. Dr. Phillips, of Jamaica, is of opinion that the disease is communicable by contagion, and Dr. Saunders, of Jamaica, is of the same opinion.

In the "Traité de Médecine," now being published under the direction of Charcot, Bouchard, and Broussais, the following conclusions are given regarding the etiology of leprosy: "The sole cause of leprosy is contagion, that is to say, the transmission of its bacilli by direct contact with a subject affected with ulcerative leprous lesions, or by the medium of different bodies upon which leprous secretions have been deposited."

Mr. Jonathan Hutchinson,[3] in an article on the "Leprosy Problem," arrives at conclusions of which the following are among the more important:

1. Leprosy is a well-specialized disease of which the bacillus of Hansen is the cause.

2. It is not modified by race, and it appears to have no allies.

3. It is not, for practical purposes, contagious.

4. It is endemic and affects both sexes.

5. It may occur at any age.
6. It is possibly hereditary.
7. It may be produced in immigrants or even visitors to leprous districts.
8. The poison which produces the disease gains access to the body in the form of food.
9. The evidence as regards the disease points to fish as being probably the article by which leprosy gains access to the human body.

He gives as a reason for the latter theory that in a very large number of leprous districts fish is one of the principal articles of diet.

To what conclusions may we arrive in view of the foregoing apparently contradictory opinions? Now that there is a general agreement that the disease is produced by the bacilli of Hansen, one might think that we could more easily arrive at a satisfactory conclusion.

The disease being of bacillary origin, must be communicated either by heredity or contagion. If by the latter, the virus must be introduced either by inoculation, in food, or through the atmosphere.

One cannot deny the possibility of hereditary transmission, although no instances have yet been reported which positively prove its hereditary character. The bacilli have never been found in the fœtus or in newly-born children, as has been the case in tuberculosis.

The cases cited by Zambaco and Heindiston are not conclusive, as in them the disease may possibly have originated in some other way. If Hansen in his investigations had discovered a single case in the descendants of the leprous immigrants in the Western States, where the possibilities of contagion were at a minimum, it would have gone a long way to prove that the disease may, at any rate occasionally, be transmitted from parent to child.

There can be no doubt that a tendency to this disease is thus transmitted. It is not at all impossible that the disease may be communicated in articles of food. That this is frequently the case is very doubtful.

The inhabitants of the Hawaiian Islands used the same form of diet after as before the introduction of the disease. If the food or drink then contained the virus, the germs must have accidentally become incorporated with them. Dr. Arning, on a most careful examination of all the surroundings of patients, water, food, soil, etc., was unable to discover the bacilli in any of them. They have never been found in fish or any other article of diet, as the bacilli of tuberculosis have been found in milk and the flesh of animals. In the parishes adjoining Tracadie, in New Brunswick, the inhabitants are of the same race, live under similar conditions as to food and climate, and yet do not suffer from the disease.

It is possible that further investigation into the subject may be rewarded by the discovery of the bacilli in other animals than the human being. The theory of contagion by inoculation, or by prolonged and intimate contact, seems to best satisfy all the facts. By this theory alone can the outbreak in Tracadie or in the Sandwich Islands be understood.

The fact constantly brought forward of individuals living in the closest contact for a lengthened period with lepers, and remaining free from the disease, can be accounted for on the ground of natural immunity. We have instances of individual immunity in as contagious a disease as small-pox.

It is true that leprosy appears to be but slightly contagious, and requires a soil which is only produced by certain modes of living, the use of certain food, and in certain races. It is also true that there are occasional cases of individual susceptibility in the most highly civilized races and in the highest classes of society.

On September 30, 1884, Dr. Arning inoculated a criminal with fresh matter from a leprous tubercle. Local inflammatory action ensued which lasted six months and disappeared. In September, 1887, tubercular leprosy made its appearance, and the patient has since succumbed to the disease.

Dr. Morrow, who visited the Sandwich Islands in 1889, excised some of the tubercles of this patient and found bacilli in them. Dr. Arning does not consider the case a positive proof that the disease originated by inoculation, as there existed other possible channels of infection. So far all attempts to inoculate animals have failed.

Pathology.—Subsequent investigations have confirmed the truth of the discovery of Hansen and Neisser. The bacilli are the active cause of the various lesions peculiar to the disease.

Leloir[4] gives in the following summary the differences between the bacilli of leprosy and those of tuberculosis: "The bacilli of leprosy are especially distinguishable from those of tuberculosis because in the colored sections lepromes always maintain an immense quantity of bacilli, while tuberculomes always contain much fewer, and most usually they are very few in number."

The size of the lepra bacillus is more uniform and more rectilinear than the tubercle bacillus (Cornil). They are shorter, thinner, and less pointed than those of tuberculosis (Hansen). The bacilli of leprosy are also more easily colored than those of tuberculosis. A much longer period is required to decolorize them by nitric acid. The tubercular bacillus colors only in alkaline coloring liquids; that of leprosy takes color in neutral or acid coloring liquids (Neisser). For the purpose of distinguishing, for example, the bacilli of leprosy from those of tuberculosis, if they occur together in an organ, the sections are colored with simple fuchsin for half an hour and decolorized with an acid. By this proceeding the lepra bacilli alone remain colored (Cornil and Babes). Dr. Thin[4] has made a careful study of the question as to whether the bacilli are intra- or extra-cellular, and concludes that there is no evidence that the bacilli can live and multiply outside the cells. He thinks this accounts for the chronicity of the disease and the comparative rarity of contagion.

Boinet[6] arrives at the following conclusions with regard to the existence of giant-cells in leprous tissue: "There exist in the lepromes giant-cells like those of inflammation and tuberculosis. They appear to be the result of an inflammatory process and in this particular case the giant-cells do not seem to exercise any distinctive action on the bacilli of leprosy."[7] Of the various parts of the body the bacilli are most frequently found in the skin. The mucous membranes, except those of the large intestines, are generally exempt. The lymphatic glands are almost invariably affected. They are not found in the brain or spinal cord, but they exist in large numbers in the smaller branches of the nerves.

Dr. Bevan Rake,[5] who has made many valuable contributions to the study of this disease, has published the result of his inquiries into the connection between kidney lesions and the skin changes in leprosy. Out of forty-one cases of nephritis he found bacilli in but two. He also found that cases of kidney lesion ran a more chronic course than those of the other results or complications of leprosy.

Dr. Schultze[8] has published the results of electrical and other examinations into the neuritis of leprous subjects. He found the same alteration of motor power and the same electrical reactions as exist in the neuritis arising from other causes.

Diagnosis.—The diagnosis between leprosy and syringo-myelia was made the subject of a paper read by Dr. Morrow at the meeting of the American Dermatological Association, 1888, and has recently been studied by Marestang.[9]

The latter author has arrived at the following conclusions:

1. Leprosy and syringo-myelia are two distinct diseases.
2. Syringo-myelia is the result of medullary change (chiefly gliomatous), while anæsthetic leprosy is the result of neuritic changes
3. The points of distinction clinically are as follows:

(*a*) In syringo-myelia there is loss of thermo-anæsthesia and analgesia, with integrity of the tactile sensibility. This disassociation of sensory conditions is not found in leprosy.

(*b*) In syringo-myelia the surface muscles of the face are unaffected, there is absence of discolorations on the skin,

and the hair remains normal, but there is deviation of the vertebral column.

In leprosy tactile sensibility is abolished, and there are atrophy and paralysis of the muscles of the face, thickening of the nerve-trunks from infiltration, the presence of light-colored patches on the skin, resorption of the fingers, excessive alteration of the nails, complete or partial loss of hair, and the presence of the bacillus of Hansen in the discharge from the ulcerative lesions.

Zambaco,[1] at the Académie de Medecine, Paris, 1892, expressed the opinion that Morvan's disease is a form of leprosy, as also is one variety of syringo-myelia. The writer could not gather from the discussion that the bacilli of Hansen had been found in either of these diseased conditions.

Prognosis.—Several cases of cure, or rather cessation of the symptoms, have been recently reported: one by Dr. G. H. Fox, which will again be referred to; Sandreczky[9] also mentions a case in which the lesions disappeared; finally, Dr. Kaurin gives the history of two cures, and Dr. Muro, of St. Kitt's, relates the history of one.

The number of apparent cures, however, is small compared with the whole number of cases. The disease has therefore lost little of its dreadful fatality, notwithstanding the many new methods of treatment adopted.

Treatment.—Dr. Unna, of Hamburg, in 1885, published a method of treatment and related one apparently successful case. He made external applications of pyrogallol, chrysarobin, resorcin, and ichthyol, and gave ichthyol internally. From Dr. Thin's work I would infer that Dr. Unna's patient died in South America, whether from leprosy or not is not known.

Dr. Duckman[12] relates an advanced case of disease treated after Unna's method with apparent success. According to Dr. Thin, however, the patient died in 1889, probably from leprosy.

Dr. Duckman used ten per cent. pyrogallol ointment for the forearms and hands, and ten per cent. chrysarobin upon the other parts of the body except the face. On the latter he used a plaster of salicylic acid and creasote. Ichthyol was given internally.

Dr. Blue, of New Orleans,[13] has reported a number of cases treated according to Unna's method. He states that pyrogallol, resorcin, and salicylic acid were not at all satisfactory when applied to the face, but that they were useful on other parts of the body. He gave ichthyol up to six grains a day with negative results.

Dr. G. H. Fox[14] has reported a case of apparent cure in which the principal remedy used was chaulmoogra oil. The patient, a young man of New England parentage, was born in the Sandwich Islands, and symptoms of leprosy having developed, he came to America, and after a time (1883) placed himself under Dr. Fox's care. After other methods of treatment failed he was put on chaulmoogra oil in gradually increasing doses, until he took sixty drops each day. In time the lesions gradually disappeared, and in 1885 he wrote to Dr. Fox from California: "There have been no more symptoms of the disease in any shape. I have enjoyed almost perfect health in every way, and were it not that I still have numbness of the hands I would not believe that there could be anything the matter with me. I take about a hundred drops of the oil daily and it does not disagree with me." In 1887 and 1889 he reported himself as being quite well, and Dr. Fox has recently informed the writer (February, 1893) that the patient is still in good health.

The favorable result, as Dr. Fox states, is largely due in this case to the change of climate as well as to the remedy used.

Dr. Zariago (de Valence) gives chaulmoogra oil in large doses with decidedly beneficial results. He speaks highly of Unna's method of treatment in the early stages of the disease.

Dr. Falcoo[16] gives gynocardic acid in one decigramme pills with bitter extract. He begins with two pills daily and increases the number to twenty. At the same time he uses a pomade of gynocardic acid and vaseline.

Gurjun oil has been used with apparent benefit by some physicians.

The following quotation from the "Journal of the Leprosy Investigation Committee," January, 1890, will give in brief our present knowledge with regard to the action of tuberculin: "The authors consider that these differences (of reaction) prove for us, (*a*) whether an affection is leprosy or tuberculosis, (*b*) whether at the time being leprosy is associated with tuberculosis, and (*c*) whether a suspicious tropho-neurotic disease be leprous or not. They observe that it remains to be seen whether the remedy can cure leprosy, produce a durable improvement, or prevent its further development." Tuberculin does not seem to have any positive effect in the cure of the disease. Dr. Rake has reported the case of a negress, in whom vaccination produced an amelioration of symptoms. Several cases have been recorded where the presence of an intercurrent affection, such as erysipelas, pneumonia, etc., has exerted a favorable influence on the course of the disease.

Prophylaxis.—From a brief survey of the literature one is impressed with the idea that leprosy has made considerable progress during the last five years.

Dr. P. S. Abrahams[18] publishes the following statements with regard to some of the British Dominions: The disease is certainly on the increase at the Cape of Good Hope.

The number of cases has increased in the Trinidad Asylum, as shown by Dr. Bevan Rake.

The total number of cases in the Barbadoes has increased from 96 in 1871 to 120 in 1881.

In New Brunswick there has been a slight diminution.

The disease has appeared in British Columbia, but is limited, as Dr. Milne, of Victoria, informs me, to the Chinese population.

The present number of lepers in the United States is placed at about two hundred, a decided increase.

Zambaco makes the following suggestions as to prophylaxis:

1. All cases of the disease to be placed in a special hospital, where they can receive proper attention and medical treatment.

2. To prevent marriage in all cases where the disease is present or even suspected.

3. To improve the character of the food and surroundings of the people.

4. To carefully inspect and supervise the children of leprous parents.

Dr. Bevan Rake, who, with Zambaco, is still sceptical on the subject of contagion, also recommends isolation.

It will thus be seen that in the prophylaxis of the disease there is a unity of opinion between the contagionists and non-contagionists on the importance of the complete separation of the diseased from the healthy.

During the past five or ten years much progress has been made in this direction.[19] In 1884, the government of the Cape of Good Hope passed a Leprosy Repression Act. In Norway, segregation was made compulsory in 1885.

Under an act to facilitate the segregation of lepers in the Hawaiian Kingdom, 821 lepers had been removed to the asylum, between July 17, 1887, and March 12, 1889. For some years in New South Wales lepers have been kept in a lazaretto near Sidney, and quite recently a bill has been passed by the New South Wales Legislature to empower the authorities to compulsorily segregate lepers.[19] In Sau Francisco also a stringent act has been adopted.

In many parts of the world, however, as Dr. Thin observes, great carelessness is still shown in this matter.

James E. Graham.

[1] Bulletin Acad. de Med., Paris, 1889.
[2] Loc. cit.
[3] Archives of Surgery, 1889.
[4] Dr. Thin: Leprosy. 1892.
[5] British Journal of Dermatology, 1888–89.
[6] De la Cellule géante dans la Lèpre, Revue de Médecine, Paris, 1891, pp. 339, 344.
[7] Van Harlingen: Internation. Clinics, January, 1892.
[8] Deutsche Archiv für klin. Med., xliii., 4 and 5.
[9] Du diagnostic différentiel de la lèpre anæsthésique et de Syringomyélie, Revue de Médecine, 1891, p. 781.
[10] Monats. für prakt. Dermat., 1891.

[11] Ibid.. 1885.
[12] Ibid., 1888.
[13] New York Medical Journal, 1889.
[14] Transactions of the Medical Society of the State of New York, 1890.
[15] International Dermat. Congress, Paris, 1889.
[16] Ibid., 1889.
[17] Zambaco: Le Mercredi Medicale, August, 1892.
[18] London Practitioner, 1889.
[19] Dr. Thin: Leprosy, p. 245.

LEVULOSE ($C_6H_{12}O_6$.). This form of sugar has, within the past year, been advocated as an article of diet for diabetic patients. Its administration does not augment the amount of sugar in the urine, as it is thoroughly oxidized in the system, and acts as food by building up the body and supplying vital energy and strength. A preparation under the name of *Diabetin* has been placed in the market, which is said to be a perfectly pure levulose. It is a dry crystalline powder, easily soluble, and possessed of a remarkably sweet taste.

Levulose exists in honey and in most fruits and vegetables. It may be formed from cane sugar by heating with dilute acids, and is also produced by the action of yeast on pectase, the ferment peculiar to fruits. It is distinguished from the ordinary forms of sugar or dextroglucoses by its property of turning the plane of polarization to the left, lævo-rotation, from which its name is derived. It generally exists with dextro-glucose, and is with difficulty obtained pure. It exhibits the same chemical reactions as other sugar, but is more easily altered by heat and acids. A large percentage of dextro-glucose may be present without altering its rotatory action, as its power of polarization is much greater than that of the dextro-rotatory sugar. *Beaumont Small.*

LIPANIN. A fatty compound formed by the addition of five or six per cent. of oleic acid to fine olive-oil. It has been proposed by Von Mehring as a substitute for cod-liver oil. Its use was suggested by the theory of Buckheim that the beneficial action of cod-liver oil was due to the fatty acids it contained. The proposed substitute is more palatable and is easily retained by the weakest stomach, and when desired may be readily formed into an emulsion. It is freely absorbed, and undoubtedly is a nutrient of some value. No diarrhœa or intestinal disturbance has been traced to its use. The dose for children is one teaspoonful before meals; for adults, one tablespoonful. *Beaumont Small.*

LITHÆMIA. In the treatment of the uric-acid variety of lithæmia, the so-called uric-acid diathesis, as well as in true gout, *piperazine* has been extolled and freely advertised, in 1892, as a specific for that disordered state of the system. The remedy, a whitish powder of pungent taste, is prescribed in five-grain doses dissolved in carbonic-acid water, with or without bicarbonate of soda, and given three or four times in twenty-four hours. I have found it to be a fairly good palliative for an acute attack of gout, but a specific by no means, nor as good as Laville's liqueur antirheumatique, the active principles of which are colchicine and colocyntine. Laville's preparation I have often prescribed for acute attacks of gout, and found that twenty to thirty drops taken every three hours during the day, for a week at most, afford quick relief, and remove all acute symptoms effectually in almost every case. In cases of uric-acid diathesis neither Laville's liqueur nor piperazine is ever indicated, but the plain and cheap *bicarbonate of soda*, with a little lithion and chloride of sodium, is all that is required when the patient needs a mineral water.

Of German observers Dr. E. Pfeiffer, Dr. Mordhorst, of Wiesbaden, and Professor Ebstein, of Göttingen, have studied the question of gout and lithæmia, and the proper diet and medication for those afflicted with these disorders, and have written probably more about it of late than anybody else. The Wiesbaden doctors particularly, who undoubtedly see and treat a great many gouty patients, have apparently proved that *bicarbonate of soda* is the remedy of all others which will promptly dissolve, and effectually keep in solution, the uric acid. They order now their patients to take it, dissolved in a mineral water that goes by the name of "Wiesbaden Gichtwasser" and is prepared by putting extra quantities of bicarbonate of soda and lithion into the natural Wiesbaden Kochbrunnen. The patient takes about a quart of this water per diem, in divided doses, and with excellent results, as has been proved by recent statistics.

The following analysis of the Wiesbaden Gichtwasser has been published: One thousand grammes of the water contain:

Natr. bicarbon	7.560
Natrii muriatic	6.828
Calc. bicarbon	0.266
Magnes. bicarbon	0.177
Lith. chloric	0.023
Potass. chloric	0.182
Carbonic acid	9.296

These are the principal ingredients of the water, and the therapeutic effects of the same are mainly produced by the relatively large amount of the soda and salt, and to only a small extent by the other salts. That an alkaline water thus prepared and drank in sufficiently large doses daily, and for a considerable period, will prove of excellent effect in gout and uric-acid diathesis I am ready to testify to from the observation of a large number of cases of that kind. The well-known Selters, Vichy, and Fachingen waters can readily receive additional quantities of soda and salt to bring them up to the required standard of about 3 ij. of each salt to a quart of water, and will then serve the same purpose as the Wiesbaden water.

Leonard Weber.

LLANDUDNO. A modern and fashionable watering-place in Wales. The climate is good, owing to its sheltered position. It is more of a summer resort and sea-bathing place than a recognized winter station. It is situated under the promontory of the Great Orme's Head, and extends for over a mile along the shore, between the bays of Conway and Llandudno. The sanitary condition of the settlement is good, the rate of mortality being about nineteen per thousand per annum. The winds coming over the water are generally tempered, but violent cold gales at times keep all invalids indoors. Dr. Yeo ("Climate and Health Resorts") speaks of this place as follows:

"Llandudno has pretensions also as a winter resort, especially for invalids who can support a certain amount of windy weather. Its annual rainfall—32.36 inches—is somewhat below the average rainfall of England and Wales, which is 35 inches. The mean humidity of the air in winter is 82°, so that it has a drier winter atmosphere than some of our southwest coast resorts; this is partly due to the porousness of its subsoil, which is mostly gravel and sand.

"During the five winter months (November to March), from observations extending over five years, it would appear that the mean winter temperature is 43.5°; the mean maximum, 48.3°; the mean minimum, 38.8°; the mean daily range, 9.5°; the mean monthly range, 28.3° F. North and east winds blow on 44 days, south and west winds, 107 days. There were 83 rainy days, and a rainfall of 15.96 inches.

"Nothing, perhaps, could show better the character of our (*i.e.*, the English) winter climate than the fact that a place claims to have attractions as a winter resort, where, on an average of five years, there have been eighty-three wet days out of one hundred and fifty-one—more than one-half!"

Llandudno is two hundred and thirty-six miles distant from London.

The hotel accommodation is good, and the usual amusements are provided. The drinking-water is said to be excellent. There is a fine sandy beach.

Edmund C. Wendt.

LOSOPHANE (Tri-iodo-meta-cresylic acid). A new antiseptic preparation, obtained by the action of iodine upon oxy-toluylic acid in the presence of an alkali. Its formula is $C_6HI_3OHCH_3$, and it is said to contain eighty

per cent. of iodine. It forms in white needles, insoluble in water, slightly soluble in alcohol, and readily soluble in ether, benzene, and water. At 140° F. it is freely soluble in fatty oils.

It is particularly recommended in parasitic skin affections. It may be used in tinea tonsurans, scabies, pityriasis versicolor, also in prurigo, in chronic eczema, acne, and sycosis. It is contra-indicated in all acute inflammatory conditions of the skin, as it is liable to increase the irritation and intensify the disease. The remedy may be applied in solution of the strength of one per cent., or in an ointment of one to three per cent.

Beaumont Small.

LOWESTOFT. A popular seaside resort on the Norfolk coast. It is situated on the most easterly point in England, at a distance of about ten miles from Yarmouth. The beach is much used for bathing, although it is only partly sandy and in part shingle. The little town is prettily built on the cliffs overlooking the sea. The air is claimed to be particularly pure and bracing at Lowestoft, but the place does not escape the humidity and abundant rainfall common to English resorts. The drinking-water is good, and the sanitary arrangements satisfactory. The death-rate is about eighteen per thousand. The hotel and boarding-house accommodation is moderately good. *Edmund C. Wendt.*

LUNGS, ANATOMY OF THE. HISTORICAL.—The first account we find of the structure of the lungs is that given by Hippocrates,[1] and is very incomplete. He compares them to a sponge interspaced with numerous small vessels. Aristotle[2] also gives to the lungs a spongy nature, the canals receiving blood from the great vein. Celsus[3] also describes the lungs as being spongy. Galen[4] had but little better idea of their structure; he describes them as being made up of lobes, liver-like in substance, and containing many vessels. Vesalius[5] describes the lungs as being divided into lobes, and says in regard to their structure that "the substance of the lung is soft, spongy, thin, light, airy flesh, as if formed of frothy blood, or bloody froth, and crowded with many branches of vessels."

We now come to the time when Harvey[6] announced his discovery of the circulation of the blood; this had its effect on all anatomical research. Malpighi,[7] profiting by this discovery, proved by means of injections that the air and blood were not contained in the same channels, but had separate systems of vessels, and that these did not communicate with each other, but did communicate among themselves. He also saw the circulation of the blood in the vessels of the lung of a living frog. He recognized the presence of air-vesicles, and described them as opening into the trachea and communicating with one another. He also compares the lung to a sponge. Bartholin[8] defended the views of Malpighi. The next writer of note is Willis.[9] He is wrongly quoted by Williams in Todd's "Cyclopædia;" he places Willis among those who describe the air-vesicles as communicating with one another. What he does say, directly opposite to the view of Malpighi, is, that the bronchial tubes give off numerous small branches which bear on their distal extremity little bladders, thus giving the lung the appearance of a bunch of grapes. Helvetius[10] returned to the older idea and maintained that the lung was spongy in its nature. He denied that the spongy tissue of the lung was formed by the expansion of the bronchial tube, but asserted that the bronchus simply penetrated into the spongy tissue. His description of the lung is not very clear. Soemmering[11] describes the lungs as made up of small, irregular polygonal cells grouped together into lobules. The cells of the lobule communicate, but those of one lobule do not communicate with those of adjoining lobules.

Early in the present century, Reisseissen[12] published a very important paper, in which he advanced views quite opposite to those accepted by the anatomists of his day. His method consisted in pouring mercury into a bronchus and, by applying gentle pressure, forcing it on until it appeared beneath the pleura. He describes the bronchi as dividing into branches which in turn divide quite rapidly, becoming at the same time much smaller, until eventually each small branch ends in a single rounded extremity. This was apparently a revival of the theory of Willis. Magendie[13] wrote two important papers on the lungs. In the first he denies that the bronchi terminate in air-vesicles, but affirms that the air-cells of one lobule communicate with one another, but do not communicate with those of adjoining lobules. In his second paper he states that those grape-like structures described as hanging on to the end of a bronchus do not exist in nature, but are to be found only in books. His conclusion is that the lung is made up of "spongy tissue formed by the arrangement of the vessels, which have between them small spaces into which the air penetrates freely."

In 1832 Bazin[14] wrote supporting the views of Reisseissen, and was followed a few years later by Lereboullet,[15] who in quite a lengthy essay also supported Reisseissen. Addison[16] failed to find "any tubes ending in culs-de-sac; on the contrary, I always saw air-cells communicating with one another in every section I made." He describes the bronchi as dividing, within the lobule, into numerous minute branches which terminate in "branched air-passages and freely communicating air-cells." Huschke,[17] however, writing about the same time, described the bronchi as ending in fine branches, which bore on their free extremity small sacs which did not communicate with one another.

Rainey[18] wrote several excellent memoirs on the lung. He says "they are made up of bronchial tubes, bronchial intercellular passages, and air-cells." These air-cells communicated with one another, and with the bronchi or bronchial intercellular passages, by means of large circular openings. Moleschott[19] published an excellent brochure in which he combats strongly the opinion of those who hold to the communication of one vesicle with another. In no instance did he find the bronchi forming anastomoses; he also distinctly states that the air-vesicle contains no opening except that by which it communicates with its proper bronchial tube.

Rossignol[20] gave us a very valuable treatise on the structure of the lungs. He introduces the term "infundibulum." According to this author the bronchi give off numerous branches which cross each other repeatedly in all directions, but do not communicate; from the ultimate division of the bronchial tube arises a dilatation in the form of a funnel, which he terms "infundibulum." The walls of each infundibulum are lined with numerous air-cells or alveoli. Rossignol compares each infundibulum with its alveoli to the lung of the batrachians, and says: "The human lung looked at from this point of view can be defined as the assemblage or concentration of innumerable small lungs, held together by means of a common bronchial tree." In an inaugural dissertation written by Adriani,[21] he adopts the nomenclature of Rossignol. He also describes alveoli as existing on the walls of the bronchial tubes just before they dilate into infundibula. He takes strong exception to Rossignol's statement that there are no communications between adjoining alveoli, declaring it to be without doubt false, and describes minute openings by which adjoining infundibula communicate.

Kölliker[22] gives quite a valuable description of the finer structure of the air-passages. He considers the term "infundibulum" introduced by Rossignol unnecessary, and says, that "all the vesicles belonging to one lobule open, not into ramifications of the finest bronchial twig going to it, but into a common space from which the air-vessel is afterward developed."

The "Cyclopædia of Anatomy and Physiology"* contains an article on "Respiration" by Williams, in which he has embodied some of his personal investigations. He describes each lobule as being sacculated and receiving a single bronchial tube; this tube gives rise within the lobule to small branches which subdivide to the third or fourth order, and from these latter branches the air-

* The Cyclopædia of Anatomy and Physiology. Supplementary volume. London: Robert B. Todd, editor.

cells arise. He discards the term "infundibulum," and uses in its place that introduced by Rainey, "intercellular passage." Mandl [23] describes the bronchial tubes as ending in terminal cavities which have numerous depressions in their walls, the "vesicles." He compares the terminal cavities and their vesicles to the lung of the frog.

In 1860, Waters [24] published a most excellent essay on "The Human Lung," in which he describes the "ultimate pulmonary tissue" as being made up of elongated air-sacs arranged in groups, called by him "lobulettes," which spring from the enlarged end of a terminal bronchial twig; the air-sacs bear on their sides and ends depressions varying in number, the alveoli. He failed to find any communication between the air-sacs. On this point he says, "I have never found, either in the lungs of man, or of the dog, or cat, or pig, or sheep, or of any other mammal I have examined, any lateral orifice of communication between the different sacs of each lobulette."

Henle,[25] in his systematic work on anatomy, gives a very good article on the lungs. He describes communications between air-cells, but considers them anomalies. He found them in the lungs of old people, and attributed them to the result of atrophy and absorption of the lung-substance. Delafield [26] advocates the theory of communication between air-cells. He says: "The air-passages seem to be made up of a succession of large vesicles which open into each other, or of an irregular larger canal made up of vesicles into which other vesicles open from all sides." He also describes anastomoses between the air-passages. Roosevelt [27] agrees with Delafield in regard to the communication of the air-cells. In other places [28] I have described some of my own researches on the lung.

Besides the authors quoted at length, I will refer the reader to the works of Milne-Edwards,[29] and to that of Ewart.[30] Those who are interested in the development of the lung should not neglect to read the article by His.[35]

General Histology.—For the structure of the trachea I will refer the reader to the text-books on anatomy, mentioning especially Quain (tenth edition).

At the hilus of the lung we find the artery, vein, and bronchus lying in quite close apposition, and it is only at this point that we find them in such close relationship. The arrangement differs on the two sides; on the right side the bronchus lies behind, the artery in the centre, and the vein on the outside; the bronchus occupying a higher level than the other two vessels. On the left side the vessels have the same order, but the artery occupies the higher plane.

Taking up now each set of vessels, we will consider first the bronchus.

About on the level of the fifth dorsal vertebra the trachea bifurcates into the right and left bronchi, which pass to their respective lungs. Of these two bronchi the right is the shorter and wider, and is usually described as having a more horizontal direction than the left. Aeby,[31] in his admirable monograph, has shown, however, that it is the more oblique. The left bronchus is longer, but at the same time smaller in diameter, than the right; its lower termination being about twenty-five millimetres below that of the right bronchus. The shortness of the right bronchus is due to the fact that, just before it penetrates into the depth of the lung, it gives off a branch which supplies the upper lobe of the right lung. This branch is given off above the point where the pulmonary artery crosses the bronchus on its way into the lung. On the left side we find no corresponding branch in man.

Below the point where the pulmonary artery crosses the main bronchus, the arrangement of the bronchi is quite similar on each side. This peculiarity of the bronchi leads to the formation of three lobes for the right lung, but only two for the left lung. Aeby calls those that branch above the point where the artery crosses, eparterial; those below, hyparterial bronchi; he reasons that as the eparterial bronchus is not present on the left side, the lobe to which it is distributed is also absent, and that the upper lobe of the left lung and the middle lobe of the right lung are homologous. Occasionally in man the eparterial branch arises directly from the trachea; this point of origin is constant in sheep and in the ox. Some of the lower animals possess eparterial branches on both sides, and in others no eparterial branches are found. Monkeys have an accessory lobe, termed by Owen [32] the azygos lobe; this is supplied by an accessory bronchus, which arises from the right bronchial trunk near the point where the first branch is given off.

Immediately after penetrating into the lungs the bronchi undergo division, not in a dichotomous manner; neither is the arrangement axial, but rather arborescent. Aeby,[31] by his investigations, proved conclusively that the old idea of dichotomy was erroneous; and while at first I was inclined to the view of an axial arrangement, more careful investigation of the subject satisfied me of the untenableness of this view.

The bronchi, in their finer structure, have the same arrangement as the trachea up to their entrance into the lung. With the division of the bronchi we find changes in the structure. The cartilage which has been in the form of incomplete rings is now found in the form of angular plates, which are placed at longer and longer intervals, until at last it is only found as a small plate at the fork of the smaller branches. Bronchi which have a diameter of one millimetre, and under, have no cartilaginous plates. At the same time that the cartilage begins to disappear, the smooth muscle-fibres which have been in the form of rings gradually spread out into an uniform layer, which diminishes in thickness with the diminution in the calibre of the bronchus. Beyond the terminal bronchus the muscle-fibres are not found. In the larger bronchi the mucosa is arranged in longitudinal folds and consists of at least two layers, the innermost of which is made up of ciliated epithelium and scattered goblet-cells. In the finer bronchi these disappear, and we find in their place a single layer of respiratory epithelium. Outside the cartilage, and extending the whole length of the bronchi, there is found a layer of connective tissue which forms a sheath surrounding the bronchi and contains elastic fibres, and in which the vessels and nerves run.

When the divisions of the bronchus have reached a diameter of about 0.5 mm. they break up into the proper parenchyma of the lung. The last division of the bronchus before this breaking up takes place is called the terminal bronchus, and it forms at the distal extremity a club-shaped cavity.

At this point the structure of the lung changes, and what lies beyond this has been a much disputed point, as I have shown in my account of the history of the subject. As a preliminary description, I will quote the following from a previous paper:[28] "The last division of the bronchus, before breaking up into the parenchyma of the lung, is known as the terminal bronchus, and from this arise a number of passages which widen out into an expansion. From this other passages lead out which open into a central cavity set about with small irregular cells. A good idea of this arrangement may be obtained if we compare it to a Pompeian house. The passage leading off from the terminal bronchus is the 'vestibulum,' which opens into the 'atrium.' From this arises the 'faux' or air-sac passage, which leads into the 'peristylum' or air-sac. This air-sac is set about with 'cubicula' or air-cells.

"From this description it will be seen that the air-sacs do not communicate directly with the terminal bronchus, as is usually described, but between each air-sac and terminal bronchus there is a cavity constant in all parts of the lung, which I shall term atrium. The communication between the atrium and the bronchus I shall call vestibulum; that between the atrium and air-sac, air-sac passage, or, simply sac-passage." (Fig. 381.)

The terminal bronchi do not have a smooth cylindrical surface, but we find projecting from all portions small cells (Fig. 381), the air-cells of the bronchus, which have an average diameter of 0.047 mm. The opening by which these cells communicate with the

bronchus is surrounded by the smooth muscle-fibres lining the bronchus. In a section of the lung the terminal bronchi may be recognized by their diameter, by their walls being thicker than that of the surrounding parenchyma, by the presence of smooth muscle-fibres, and by their having a lining of cylindrical epithelium.

Leading out of the dilated end of the terminal bronchus we find from three to six openings, the vestibules. These are circular in outline, or nearly so; they are surrounded by the muscle-fibres which line the bronchus, and have an average diameter of 0.2 mm. These openings do not all take the same direction; usually one of them appears as if it were a continuation of the bronchus, while the others open out at various angles or may take a course nearly recurrent to that of the bronchus. As these openings are surrounded by smooth muscle, should the section lie in such a plane that we look directly into a vestibule, it will appear as a quite small terminal bronchus, but can be distinguished from one by its size. I have already stated that the smooth

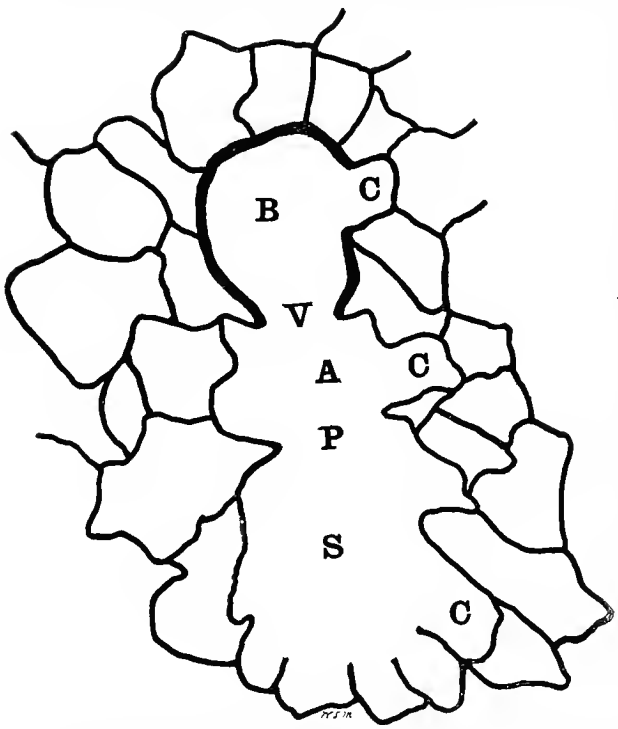

FIG. 381.—Camera Tracing of a Section through the Terminal Bronchus, Atrium, and Air-sac. Enlarged about 65 diameters. *B*, terminal bronchus; *A*, atrium; *S*, air-sac; *V*, vestibule: *P*, sac-passage; *C*, air-cells arising from terminal bronchus, atrium, and air-sac.

muscle-fibres do not extend beyond the terminal bronchus. That this ring surrounding the openings of the vestibules is the last found is shown in sections which lie in such a plane that a vestibule is cut at right angles. In such a section we find the bundles of muscle-fibres cut transversely, lying on either side of the mouth of the vestibule, but not in the least entering into the formation of the walls of the cavity lying beyond.

The cavity into which the vestibule opens I have called the atrium (Figs. 381, 382, 383, 385, *A*). This is irregularly spherical in shape, about half the size of a terminal bronchus, and has leading out from it three to six openings; of these, one is that of the vestibule, and the remaining openings lead into the air-sacs with which it communicates. There are also numerous projections from its surface, the air-cells. The walls of the atrium differ in no respect from those of the air-sacs.

If we make a complete injection of the air-passages with wax and corrode in hydrochloric acid, we shall obtain a mass which cannot be pulled apart; if now we break off a small portion from the completely injected part and pick it to pieces under a dissecting microscope, we may obtain casts of the atria which present several freshly broken surfaces. These indicate the points of attachment of the air-sacs, and also their attachment to the bronchus. The presence of these broken surfaces has been misinterpreted by a recent writer, and used as an argument for the communication between air-sacs. That such is not the case will, I think, be readily understood from the above description.

In Fig. 382, I have represented a terminal bronchus to which are attached five atria. The air-sacs communicating with them have been removed. The specimen was prepared by cutting a small block from the lung of a dog (treated by the corrosion process) into serial sections, and then reconstructing by Born's [33] method a terminal bronchus and the parts attached to it. Two models were made, in one of which the air-spaces were cut out and the plates piled together. This gave an exact model of the air-spaces. At the same time the plates were piled together the pieces cut out were piled also, and I thus obtained the second model—a "corrosion" of the first. It is this corrosion deprived of its air-sacs that is figured. The sections were cut 20 μ thick, and the power used was one hundred diameters.

The air-sac passages connecting the atrium with the air-sacs are somewhat smaller than the vestibule, having an average diameter of 0.143 mm. The air-sac passages (Figs. 382 and 383, *P*) can always be distinguished from the vestibule by the absence of smooth muscle-fibres.

The air-sacs present a great diversity of forms; they are very irregular and adapt themselves to the space they have to occupy. As seen in sections of the lung, they vary in diameter from 0.313 mm. to 0.511 mm. Fig. 383 shows a corrosion model, prepared in the same manner as Fig. 382, of an atrium with a single air-sac attached, the others having been removed.

Fig. 384 shows an air-sac removed from its atrium; the irregularity of form is well shown. Some air-sacs have a deep partition extending into them, nearly dividing them into two. The irregular contour of one air-sac fits into corresponding irregularities in adjoining air-sacs, making it impossible to pull complete wax or Wood's metal corrosions apart. The walls of the air-sacs are quite thin, and are made up principally of the capillary network of the blood-vessels and connective tissue. Mall [35] has shown the presence of "reticulum" in the walls of the air-sacs. In sections of lung lying parallel with, or perpendicular to, the pleura, the large irregular-shaped openings bounded by thin walls are the air-sacs. The small openings grouped about them are the air-cells.

The air-cells are about one-fourth the size of the air-sacs; their walls are thin and have the same structure as those of the air-sacs. Air-cells are found in three situations: arising from the bronchus, from the atrium, and from the air-sacs (Fig. 385, *C*). Those arising from the air-sacs are the more numerous, the entire periphery of the air-sacs being covered with them. The air-cells arising from the air-sacs and atria have the same average diameter of 0.113 mm., while those air-cells which are found on the bronchus are smaller, having an average diameter of 0.047 mm.

It is not uncommon to find in sections made parallel to the pleura that the plane of the section is such that it divides longitudinally as a vestibule opening into an atrium, and in rare instances it may pass through all the parts. Fig. 381 is an example of such a section. Usually, it is quite difficult to determine the atria and air-sacs, unless we have a complete series of sections to examine. I have already mentioned several points of distinction, but for general purposes attention to the following points will help one to decide: The bronchi may be recognized by their containing smooth muscle-fibres, and by their diameter; lying in more or less of a circle about the bronchus may be seen three, four, or five openings, nearly circular in outline and separated from the bronchus by a number of smaller openings; the first are the atria, the

second are air-cells. Lying peripheral to these may be seen large irregular openings, the air-sacs, and grouped around each a number of smaller openings, the air-cells.

A much disputed question in the histology of the lung is whether there exist communications between the air-sacs. As I have shown in my brief account of the History of the subject, the opinion of the older authors was that such communication did exist. For a long time no one doubted the point; then it was denied, and for a considerable period the question was vigorously discussed on both sides; but gradually the view that there were no communications prevailed. The two most recent writers on the subject in this country, however, have returned to the old view of communication. I cannot agree with them on this point, for both comparative study and reconstruction of the mammalian lung show the contrary to be true.

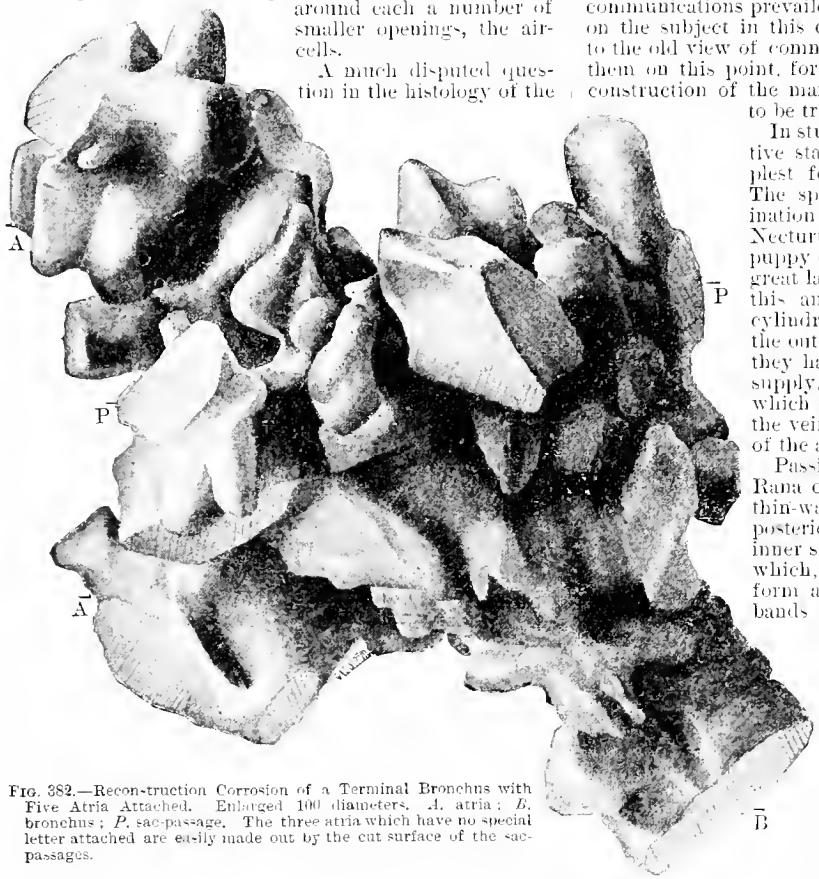

Fig. 382.—Reconstruction Corrosion of a Terminal Bronchus with Five Atria Attached. Enlarged 100 diameters. *A*, atria; *B*, bronchus; *P*, sac-passage. The three atria which have no special letter attached are easily made out by the cut surface of the sac-passages.

In studying the lung from a comparative standpoint, we find that the simplest form is found in the Proteida. The specimens I have used for examination have all been obtained from Necturus maculatus, the common mud-puppy of the Mississippi Valley and the great lakes of the West. The lungs in this animal consist of two elongated, cylindrical-shaped bodies, smooth on the outer and also on the inner surface; they have both an arterial and venous supply, the ultimate distribution of which is so arranged that the course of the vein is nearly at right angles to that of the artery.

Passing on now to Anura, we find in Rana catesbiana that the lungs are two thin-walled ellipsoid sacs, terminating posteriorly in bluntly-pointed ends. The inner surface is crossed by large bands, which, extending into the central cavity, form a coarse network; between these bands smaller bands are found which also form a network, thus giving the lung a honeycombed appearance. Between the lung of Necturus and that of Rana all grades of division of the inner surface may be found.

In Ophidia, the lung (for they possess only one, the right) is much elongated; the posterior two-thirds is perfectly smooth, externally and internally, but the anterior third of the inner surface becomes more and more subdivided, until we find in the anterior sixth that we have the inner surface divided into many small air-sacs, which communicate with the central cavity by a nearly circular opening. If we look down into one of these sacs with a low-power lens, 10–20 diameters, we shall see that each sac is divided into a number of shallow depressions, the air-cells. A careful examination of specimens prepared by cutting open previously blown-up and dried lungs, and sections of hardened specimens, failed to show any communication between neighboring air-sacs.

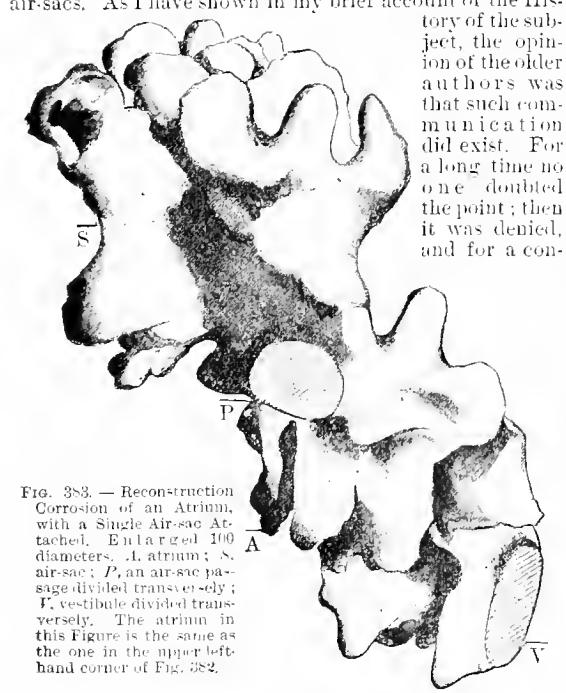

Fig. 383. — Reconstruction Corrosion of an Atrium, with a Single Air-sac Attached. Enlarged 100 diameters. *A*, atrium; *S*, air-sac; *P*, an air-sac passage divided transversely; *V*, vestibule divided transversely. The atrium in this Figure is the same as the one in the upper left-hand corner of Fig. 382.

Thus far the lungs we have examined have consisted of a large central cavity, having its wall either smooth or beset with larger or smaller cavities, which possess a more or less complex structure. The bronchus has entered the anterior end of the lung, but has not extended into its interior. There have been no partitions across the central cavity and extending the entire distance, dividing the lung into independent cavities. In Heloderma suspectum, one of

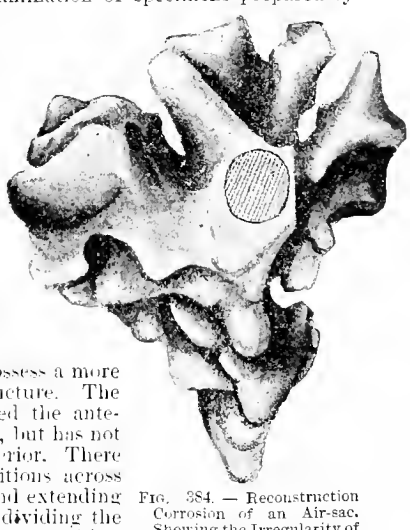

Fig. 384. — Reconstruction Corrosion of an Air-sac. Showing the Irregularity of Form. Enlarged about 50 diameters.

the Lacertilia, we find the central cavity divided by partitions which extend across the entire distance, dividing the lung into larger or smaller cavities, which are in their turn subdivided into smaller spaces, just as we saw in the frog's lung. The surfaces of these partitions are also covered with fine bands which divide them into small cells.

The bronchus enters the lung at the inner and upper sixth, and terminates in the partition which divides the posterior cavity from those in front of it. It occupies very nearly a central position. Lateral openings, more or less oval in shape, are found in the wall of the bronchus; these communicate with the different cavities. This opening is the only one which opens into any single cavity. Nowhere do we find an opening through the partition wall. The only medium of communication between one air-sac and another is that of the bronchus. The posterior sac which occupies the entire posterior third of the lung is much simpler in structure than those situated anterior to it. We shall find, as we continue the comparative study, that this posterior sac is slow to take on the complex structure found in those lying more anterior to it.

The lungs of the Chelonians show beautiful gradations in their division into cavities and in the complex subdivision of these cavities. In many forms the posterior sac is quite simple in structure, resembling the lungs of Necturus and of Rana; but we find the primary divisions extending deeper and deeper into the centre, until, in Macrochelys, we find that it has a similar structure to those lying anterior to it. The bronchus extends centrally to the posterior sac; the openings from the bronchus into the different sacs are nearly circular, and they are the only opening which each sac possesses. We found in Heloderma that there were no openings through the partition walls of the sac; the same is true of all Chelonians. The only means of communication between neighboring air-sacs is through the bronchus.

In Crocodilia the bronchus enters the lung near its centre and on its inner side; it passes somewhat obliquely into the lung, and at the junction of the lower and middle thirds breaks up into six to twelve tubular passages. The point where the bronchus breaks up forms a terminal bronchus; the tubular passages are elongated atria; opening out of them are numerous small air-sacs, which are subdivided into air-cells. There are no communications between one atrium and another, or between adjoining air-sacs. I have used in my study specimens obtained from the crocodile of the Nile, and from our representative of the group, the Florida alligator.

In Aves the type of the lung presents marked differences from that of reptiles on the one hand, and of mammals on the other. The lungs are closely attached to the ribs and their interspaces. The bronchus penetrates into the lung and breaks up into elongated tubular passages, which, in some instances, communicate with each other by means of short branches. These tubular passages are not true bronchi, because their structure shows a marked difference, and they do not give rise to terminal bronchi. They are to be considered as atria, and the alveoli, or true lung structure, arise from them just as we have found to be the case in the lung of the crocodile. By tracing the principal bronchi through the lungs we find that they communicate, by means of openings more or less circular in outline, with large air-bags situated in the abdominal cavity, or with air-spaces in the bones, etc. These air-bags must be considered as a portion of the lung, for they are directly continuous with the bronchi and are developed from them.[35] There are no communications between air-sacs.

The lungs of mammals I have studied by resorting to Born's[33] method of reconstruction.* In no instance have I found any communication between neighboring air-sacs or between one atrium and another. As was seen in the lungs of the lower animals, the only mode of communication was through the bronchus. I have examined carefully specimens taken from the lungs of man, the dog, the cat, and several other mammals, both in adult life, in the growing period, and in fœtal life, but have invariably failed to find any communication.

Blood-vessels.—We have to consider three vessels, the pulmonary artery, the pulmonary vein, and the bronchial artery. The relations of the pulmonary artery and vein before entering the lung can be found in all systematic works on anatomy. The position occupied by the bronchus, artery, and vein at the hilus of the lung has been already stated.

Within the lung the pulmonary artery follows closely the bronchi throughout their entire course. The divisions of the artery correspond to those of the bronchi; so if one knows the number of bronchi in a given lobe, the number of arteries is also known.

With the division of the bronchus into terminal bronchi and their breaking up into the parenchyma of the

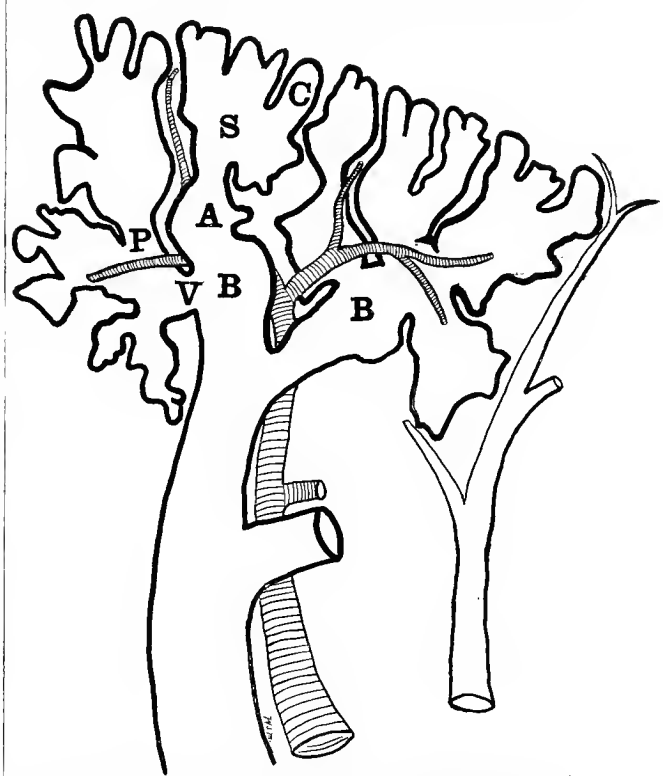

Fig. 385.—Scheme of the Lung Lobule. *B*, terminal bronchus; *A*, atrium; *S*, air-sac; *V*, vestibule; *P*, air-sac passage; *C*, air-cell. The shaded vessel is the artery, the vein is in outline.

lung, changes take place in the distribution of the artery; it penetrates into the centre of the lobule until it reaches a position beyond the terminal bronchus; there it breaks up into as many branches as there are atria, and from these branches are given off which pass to the air-sacs. There are also branches which correspond in size to those given off within the lobule, that arise from the artery just before entering the lobule, and supply the air-sacs which lie close to the terminal bronchus. As a rule, these air-sacs arise from an atrium which has taken a recurrent course.

On reaching the air-sac the artery divides into small radicles which run on the central side of the air-sac in the sulci between the air-cells, and finally are lost in the system of capillaries to which they give rise.

The capillaries anastomose with those of adjoining air-sacs, but the arteries do not anastomose with each other. There is, therefore, but a single system of capillaries in the wall of an air-sac or atrium. The capillaries have a

* Reconstruction methods have, so far as I have been able to learn, been made use of by Born, His, Selenka, Zimmerman, His, Jr., Piersol, Fol, and Mall in the study of embryos, and by Spelteholtz, Mall, and myself in histology.

diameter of about 7 μ, being slightly larger just beneath the pleura and somewhat smaller deeper in the lung. In length they are rather more than twice their diameter, and the space between the capillaries, the mesh, is a trifle more than the diameter of the vessel.

After the capillaries have formed from twenty to twenty-four loops they unite to form small venous radicles which are situated on the peripheral side of the air-sac. These radicles do not lie in the sulci between the air-cells, but run directly over their centre; they eventually form a small vein, several of which, uniting together, form the veins of the lobule. These larger veins run in the interlobular spaces and are situated as far away from the bronchus as possible.

We have therefore an artery on the central side of each air-sac, a vein on the peripheral, and between the two a rich capillary network, thus giving an arterial and venous side to each air-sac.

The bronchial arteries are distributed to the walls of the bronchi and run throughout their entire length; they are also distributed to the areolar tissue of the lung, the walls of the blood-vessels, and the lymphatics.

I have been unable to find any veins accompanying the artery. The bronchial artery forms a long-meshed capillary network that unites to form short veins which open into the pulmonary vein.

The question whether the bronchial artery opens into the pulmonary artery or vein, has been much discussed. I cannot here enter on a full description of my work on the subject, but will give the results.

The bronchial artery is distributed to the bronchus throughout its entire length, to the walls of the blood-vessels, the lymph-vessels, the connective-tissue sheaths and septa.

From the walls of the expanded end of the terminal bronchi two small vessels arise, which are formed by the capillary system, into which the bronchial artery breaks up; these pass out from opposite sides of the bronchus. Each vessel receives a small number of venous radicles from neighboring air-sacs, and in this way a short but quite large vein is formed which empties itself into the nearest pulmonary vein. As these two veins arise from the expanded end of the bronchus, they lie within the lobule, and form an exception to the rule that all veins lie on the periphery, while the arteries occupy the central portion of the lobule. In a few instances I have found small veins coming from the bronchus just before entering into the lobule; in other words, small veins may arise from the walls of the last forked division of the bronchus. They follow the same course as those within the lobule.

W. S. Miller.

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LUNGS, CROUPOUS AND OTHER INFLAMMATIONS OF. Consideration of this subject is here limited mainly to etiology in reference to the agency of microbes.

Weichselbaum (1887) holds that the bacteria found in the different forms of pneumonia are to be regarded as the cause of the inflammation, and taking cold as only a predisposing event. He considers the diplococcus as the most frequent cause.

Perret and Rodet (1887) have together made experiments of injecting microbes (presumably under the epithelial surface of the air-passages), and conclude that pneumonia may be produced by a variety, including those of typhoid fever, measles, scarlatina, etc.

Weichselbaum (1888) found bacteria constantly present in the different forms of pneumonia, and most active and abundant in early stages. In his opinion the virus is not a unity, but the croupous form itself may be due to several different organisms. The distinction of lobar and lobular, croupous and non-croupous, he believes to be anatomical merely—not etiological. Fränkel's diplococcus is the most common microbe found. Friedländer's being rare. This diplococcus (Fränkel's) is found in all the cavities about the nose; also in the brain, spinal cord, pleura, pericardium, interior mucosæ and submucous tissue. The same organisms are sometimes found in endocarditis and suppurative arthritis.

Monti (1888) withdrew the exudation of pneumonia from the lungs during life by means of Koch's syringe, and in twenty instances failed only once in obtaining micro-organisms. Fränkel's diplococcus was always found (Friedländer's never), sometimes associated with other micrococci. Inoculation of rabbits with the sputum always gave positive results, but produced pneumonia only when thrown into the trachea. Under the external skin it caused septicæmia; into the pleura, pleuritis and pericarditis, but never pneumonia; into the dura mater of a dog, after trephining, it caused meningitis.

Netter (1888) holds that pneumonia is transmissible through specific pathogenic micro-organisms, which multiply in the diseased foci, and leave the body chiefly in the sputa. The contagium resists desiccation and retains its activity for a long time outside the body.

The examination (1889) by Prudden and Northrup of seventeen children who died of diphtheria complicated with pneumonia, disclosed similar streptococci in both the diphtheritic membranes and the lungs of all but one of the cases. By using intra-tracheal injections of pure cultures of these streptococci, obtained from the lungs of the children, they uniformly produced lobular or broncho-pneumonia in rabbits.

Netter (1889) reports an infant born of a woman while ill of pneumonia. The child lived five days, and autopsy revealed pneumonia at the apex of the right lung, double pleurisy, suppurative pericarditis, and cerebro-spinal meningitis, associated with microscopic appearance of micrococci. It is presumed that the child was infected by the mother before birth; and similar observations have been made in rabbits, guinea-pigs, and mice.

According to Sternberg, Fränkel's diplococcus (called by him micrococcus Pasteuri) is widely distributed, and is often found in the sputum of healthy persons.

Mosler, of Greifswald (1890), gives a series of cases in one family. The father apparently contracted pneumonia outside and communicated it to the others. The

fluid from the lungs contained bacilli resembling those of septicæmia in the rabbit, but no micrococci of Fränkel nor of Friedländer.

Levy reports, in a Paris journal (1890), a case of congenital fibrinous pneumonia complicated with pleurisy and pericarditis. Sero-purulent fluid aspirated from the chest gave cultures of the diplococcus of Fränkel and Weichselbaum, and inoculations of the same proved their potency. The child was born thirty-six hours before the mother's death, and died, two days after birth, of broncho- and lobar fibrinous pneumonia combined. Fluid was drawn from the left ventricle of the heart and right lung, and cultures from the same gave Fränkel's diplococcus. This microbe was also found abundantly in the blood.

Platini (1890) found that inhalation of the pneumococcus failed to cause pneumonia, while the mucous surface of the respiratory tract maintained its integrity. After traumatism through the thoracic walls, or inhalation of ammonia or hydrochloric acid, infection took place. It was found that the animals after inoculation had more elevated temperature and more extensive pneumonic lesions, and succumbed more rapidly when subjected to refrigeration, than other animals similarly inoculated but not exposed to cold. On the other hand, exposure to cold without the inoculations failed to induce pneumonia.

Debove (1890) reports having found pneumococci in a case of meningitis complicated with peritonitis, but there was no pneumonia.

Netter observes that pneumococci are rare in peritonitis, but occur in most cases of meningitis. Cultures of pneumococcus have been made from the fluids of cerebral and spinal meningitis and encephalitis; also from those of pleurisy and empyema, both independently of pneumonia and complicating it.

Devoto, in many examinations of those dead from pneumonia, never found Fränkel's diplococcus in the kidneys. Luccatello generally found the blood free of them. But Canfield, at the pathological laboratory of Johns Hopkins Hospital, has found them in the blood and tissues of rabbits killed with Sternberg's sputa and with the prune-juice expectoration of pneumonia. Bozzolo reports the discovery of diplococci in the milk of a woman ill of pneumonia.

Several French physicians (Mosny, Laboullière, Strauss, and Brouardel) report fatal cases of pneumonia, in which they attribute the infection to the streptococcus of erysipelas solely. In like manner pneumonia coexisting with typhoid fever, scarlatina, small-pox, influenza, or dysentery, might be referred to the action of the microbes of one of these diseases on the lungs.

Assuming the correctness of the above observations, the following conclusions seem to be justified:

1. The most prevalent forms of pulmonary inflammation hitherto enumerated (croupous or lobar, and catarrhal or lobular) differ in degree and extent rather than in nature and cause.

2. Pulmonary inflammation is always accompanied by micro-organisms, and may be regarded as directly dependent on their action. The most common is the diplococcus of Fränkel, but several others are found operating singly or mixed.

3. The same micro-organisms affect other anatomical parts, producing inflammation in all instances. Various parts may suffer at the same time from the same kind of bacteria. Several species of bacteria may be found in the lungs at the same time, all concerned in the inflammatory process. Pneumonia, therefore, is not a specific disease, in the usual sense of the word *specific*.

4. A solution of continuity in the mucous surface of the respiratory tract is a necessary antecedent. Bronchial catarrh with cough is the most common predisposing cause; inhalation of an irritating vapor, gas, or dust, and violent injury of the pulmonary structure in any manner, are efficient causes also.

5. The common atmosphere near the ground habitually carries in suspension the necessary micro-organisms to excite inflammation in lungs susceptible to their action, and such susceptibility is most usual in the seasons of coughs and colds. One or more cases of pneumonia in a dense population, where colds and coughs are prevalent, may then light up an epidemic of this disease.

6. That condition of the respiratory tract which renders a person liable to pneumonia, probably exposes one to the infection of pulmonary consumption, wherever the bacillus tuberculosis may be present in atmospheric dust; and this accords with the frequent sequence of phthisis to pneumonia, the bacillus tuberculosis being slower in propagation and growth than most other disease germs.

As to treatment, intra-pulmonary injections of solutions of corrosive sublimate, potassium iodide, sodium benzoate, and iodoform have been tried, but the results have not been encouraging. Petresco claims extraordinary success from large doses of digitalis—the disease aborting in two or three days, and the physical signs disappearing altogether in three days. In some cases he avers that the subject has resumed work in twenty-four hours. A reasonable explanation is, the drug strengthens the heart's action and thus promotes the removal of the products of inflammation by the blood-current. Blisters over the chest may be supposed to increase the flow of blood through the parenchyma of the lungs, and so produce the same effect. In this view the earliest application is the most efficient, and such has been the experience of the present writer. *S. S. Herrick.*

LUXEUIL. This "almost unique" spa, situated in the Vosges region of France, has already been briefly referred to in Vol. IV. of the HANDBOOK. Owing to its importance, the following additional information may be found useful. The ancient town wears a picturesque aspect, and if the thermal establishment and casino are not so pretentious as are those of the more fashionable resorts, they are nevertheless supplied with all essentials for the cure of invalids. The chalybeate waters being freely "digestible," are taken with impunity by delicate women and even children. It is claimed that the surprisingly good results obtained in the treatment of anæmia at Luxeuil are due to the admixture of arsenic and manganese with the iron compounds. Of the eighteen springs found at this spa, fifteen are exploited. Bathing and drinking go hand in hand at this resort, few patients being subjected to only one kind of treatment. A so-called "crisis" is commonly produced by a course of Luxeuil waters. Mr. Wolff ("The Watering-places of the Vosges") describes this phenomenon as follows: "Even the saline waters produce this—a combination of all sorts of unpleasant sensations, describable and indescribable—insomnia, debility, palpitations, constipation (aggravation of constipation is a very usual first effect), cutaneous eruption, sometimes, and in acute cases even fever. When the water taken is the chalybeate, the 'crisis' appears in an aggravated form. However, all this does not last very long, and the doctors rather like to see it, on the principle that it shows the waters to be doing good. Sometimes, however, there is a recurrence of the same symptoms in the third or fourth week. Whenever that happens it is held to show that the treatment has been carried far enough and should be discontinued. On its cessation the unpleasant symptoms subside almost at once, and give place to an improvement which in some cases is described as really astonishing."

The same author also states that "the marked difference in the Luxeuil waters is attributed to the difference in the triassic strata from which they spring. There are, first, the rather warm springs, ranging from 95° to 132° F., which are alkaline and saline, but of rather slight mineralization, the total of solid matter in the litre not exceeding 1.17 gramme. These resemble, generally speaking, the Plombières waters, and are of course considered useful for much the same classes of cases—rheumatism, liver complaints, dyspepsia, diabetes, affections of the respiratory organs, and some female maladies. They share with the waters of Plombières the peculiarity that, however hot they be, flowers (or other vegetable matter) thrown into them do not at once shrivel up and fade, but rather assume at first a brighter coloring. Secondly, there are the chalybeate waters,

which are less warm, indicating from 72° to 86° F., even less mineralized—having but 0.9 gramme of solids in the litre—but remarkable for holding their iron in combination with a strong dose of manganese. (This really applies to the saline waters as well, only the quantity of iron is much smaller). The chalybeate waters, as might be expected, contain a very much larger proportion of free carbonic acid—it is said about six times the quantity. In both varieties of waters there occurs a fair amount of nitrogen, and some arsenic. It is the ferruginous water which makes Luxeuil almost unique, and so wonderfully effective in women's and children's anæmia, hypochondria, the *malaria urbana*, rheumatism—articular, muscular, or fibrous, more particularly rheumatism in the intestines,—neuralgia, uterine complaints, anæmia (*prétendue*), palpitations, scrofula, etc. The water is held to be contra-indicated only where anæmia arises from organic degeneration."

Analysis.—The subjoined table gives a fair average of the different springs. In one thousand parts there are contained :

Sources Thermales.	Parts.	Sources Hyperthermales.	Parts.
Silica	0.0360	Silica	0.0988
Phosphate of iron	0.0037	Carbonate of lime	0.0732
Carbonate of iron	0.1093	Carbonate of magnesia	0.0075
Carbonate of manganese	0.1074	Carbonate of maganese	0.0023
Carbonate of magnesia	0.0136	Carbonate of iron	0.0036
Carbonate of lime	0.0810	Sulphate of soda	0.1646
Chloride of sodium	0.0369	Chloride of sodium	0.7512
Chloride of potassium	0.0240	Chloride of potassium	0.0585
Chloride of magnesium	0.0240	Chloride of lithium	0.0096
Chloride of calcium	0.0296	Carbonate of soda	0.0216
Salts of arsenic	traces	Arseniate of soda	0.0006
Organic matter and loss	0.4469	Boracic acid, fluorine	traces
		Organic matter and loss	0.0757
Total of solids	0.9005	Total of solids	1.1684
Temperature 70° to 86° Fahrenheit.		Temperature 95° to 133° Fahrenheit.	

Accommodation.—The hotels and boarding-houses of Luxeuil are not in all respects first-class. Nevertheless most patients can be made tolerably comfortable for the few weeks time which the "cure" calls for. The people of the place are very obliging to foreigners.

Edmund C. Wendt.

LYSOL. This is a proprietary preparation of cresol introduced to supersede creolin, the best known solution of this valuable disinfectant. Since the discovery of the active antiseptic properties of cresol various methods have been adopted to secure a solution suitable for practical purposes, and numerous patented preparations have been supplied to the profession. Many disadvantages attend these solutions, the most common being a precipitation of the constituents when added to water, which produces turbid mixtures, and an annoying soapiness that renders the instruments and the hands of the operator slippery and unpleasant. The advantages claimed for lysol over the other cresol compounds are that it forms a clear solution when mixed with water, contains a greater amount of cresol, and is perfectly free from injurious qualities. It is said to be prepared by dissolving the cresols, which distil between 190° C. and 200° C., in fatty matter and subsequently saponifying by the addition of alcohol. It is a brown, oily-looking, clear liquid, with a feeble, aromatic, creasote-like odor. It is said to contain fifty per cent. of cresol. Its solution forms a soapy, frothing fluid, which only becomes turbid when mixed with hard water, the extent depending upon the quantity of lime-salt present; this turbidity increases upon standing for some time. Lysol mixes freely with alcohol, glycerine, chloroform, and benzene. The saponaceous character is claimed as an advantage, as it facilitates cleansing and disinfecting the site of the operation and the hands of the operator. It acts in a manner equal to the best soap, and readily removes all dirt, fat, and resinous matter. In order to avoid the annoyance of the soapy instruments and to facilitate the tying of sutures, the hands and instruments may be rinsed in sterilized water to remove the lysol solution.

The disinfectant and deodorizing properties are undoubted. They are such as would be expected from a solution of cresol of such a strength, and experiments have shown that a 0.3 per cent. solution is capable of arresting the growth of the staphylococcus pyogenes aureus. It is also perfectly harmless and devoid of any toxic action.

For surgical purposes it is used in different degrees of strength. For disinfecting the hands and cleansing the body of the patient a five per cent. solution is used by rubbing into the parts thoroughly, and then washing it off in a solution of one or two per cent. For disinfecting instruments and for irrigation during an operation a one or two per cent. solution is prepared, and for gynæcological and obstetrical purposes a solution of one-half per cent. is sufficient.

Lysol is indicated and may be used in all forms of inflamed and ulcerated surfaces in which a disinfectant is required. On mucous surfaces, when used in stronger solution than two per cent., it causes a burning and painful sensation which lasts for some time, but otherwise is perfectly unirritating.

Lysol has recently been administered internally (*Therapeutic Gazette*, November, 1892), in the treatment of scarlet fever. In doses of three to ten drops, of a mixture of lysol one part to two parts of sherry wine, three times a day, the temperature of the patient was rapidly lowered, the albumin disappeared from the urine, and the general condition of the patient improved. In dysentery and choleraic diarrhœa it was serviceable when used as a clyster in the strength of a one per cent. solution. From the satisfactory results thus obtained it is suggested as a remedy in Asiatic cholera, by giving immediately 2.5 grammes of lysol mixed with a stimulant, and thoroughly washing out the intestines with a one per cent. solution. *Beaumont Small.*

MAGNETO-THERAPY. Magnetism is known to be a remarkable force, and it is not strange that from time to time the occult power of magnets has been brought to bear upon certain disorders by physicians in the hope, and often with the belief, that it would be efficient as a remedial agent. We need not seek far in medical literature for matter relating to magneto-therapy. For instance, Roberts Bartholow, in the third edition of his work on "Medical Electricity," published in 1887, says: "We know that a current circulates in a magnet. If a powerful magnet is brought near to the skin, opposite electricities are attracted to the poles and currents are induced. About the point of application, therefore, the skin will be acted on directly by the magnetic current and by an induced current. The production of physiological effects, which can be recognized, is therefore merely a question of magnetic strength." He then quotes Dr. Vansant, as assuming the body to be diamagnetic: "By applying north and south polarity to different parts, very extensive subjective impressions are experienced; they are of two classes of heightened organic activity and the opposite condition."

He then adds: "That impressions of a very decided kind are produced by the application of strong magnets is evident in the experience of Dr. Proust and Dr. Ballet, who continued a course of investigation begun by Charcot at Salpêtrière." They ascertained that magnets could not be applied with impunity, for, if applications were prolonged, pains were felt in the epigastrium and thorax, making respiration painful, digestion was disordered, and boulimia brought on. These results were so uniform that there seemed to be no doubt of their genuineness in the minds of the investigators.

Under the heading "Therapeutical Application of Magnets," Dr. Bartholow quotes Dr. Hammond as preferring a horseshoe magnet, and advising that several of the same size be kept, so that by clamping them together more power can be obtained. The author adds: "Hammond insists on the necessity for the application of both poles in many cases, and therefore uses the horseshoe magnet."

"Hammond has used magnets in nine cases of chorea, in two 'complete cures being produced in a few minutes.'"

"In two cases of hemiplegia with hemianæsthesia Hammond had very surprising results from the application of horseshoe magnets, the sensibility returning immediately, and in one the hemiplegia was recovered from in a few hours."

Professor Benedikt, of Vienna, who has made much use of the magnet in nervous affections, has taught that erethitic forms of hysteria are better treated by the magnet than by electricity, hydrotherapy, or drugs. A magnet being applied to the sensitive vertebræ, without removal of the dress, the irritable patient soon becomes quiet and even quasi-paralyzed. The magnet, therefore, "increases the resistance to conduction in the motor nerves." The muscles gradually relax, the respiration becomes sighing, consciousness slowly disappears; the resistance to conduction in motor nerves "could easily become absolute." The two poles have different effects. Sometimes one pole to a hyperæsthetic ovary fails to relieve pain, whereas a change of the poles causes its speedy disappearance. According to him the magnet must be employed with due caution, since patients may be injured by it.

Of late years Luys has in Paris brought to the attention of the profession some of the marvellous effects of magnets upon the human body, but it is plain that Luys has been carried away by his own imagination as well as by the imposition and simulation of his patients. Where not directly due to feigning, the facts in his experiments can readily be explained by the phenomena of suggestion.

The magnets made use of by physicians are generally those of a horseshoe shape, varying in length from a few inches to a foot. They are the so-called permanent magnets.

They exert a traction force equivalent to several ounces and in some instances to as much as three or four pounds. But electro-magnets may be made infinitely more powerful. Some may sustain two hundred pounds to each square inch, or fourteen kilogrammes to the square centimetre of active surface on either pole, that is to say, twenty-eight kilogrammes to the square of active surface on either pole if both poles are alike and share the load.

A propos of the effects of the magnet upon the human body, some experiments were recently made by Dr. Frederick Peterson and Mr. A. E. Kennelly, at the Edison Laboratory at Orange, N. J. ("Some Physiological Experiments with Magnets at the Edison Laboratory," New York *Medical Journal*, December 31, 1892). Several of the largest magnets known to modern science were made use of by the experimenters. In one of them the intensity of the magnetic field between the poles was about five thousand centimetre-gramme-second lines to the square centimetre, a field twenty-seven thousand seven hundred and seventy-eight times that of the earth's horizontal component that aligns the compass needle. A microscope was properly arranged so that substances might be examined when exposed to the operation of this force. Iron by hydrogen, dry or placed in water, was observed to act as do iron-filings when similarly treated.

Dry powdered hæmoglobin exposed to this magnetic field was not visibly affected by it.

Human and frog blood-corpuscles similarly examined showed not the feeblest traces of polarization, movement, or vibration.

Living ciliated epithelium from the pharynx of a frog was absolutely unaffected by the magnet as it was magnetized and demagnetized by the making and breaking of a one hundred and twenty volt current in the huge coils. The delicate ciliary movement continued without change of any kind.

The circulation of the blood in the web of the foot of a curarized frog was observed under the microscope in the same way, and it was demonstrated that the magnet had not the faintest influence upon the blood or its movement.

A small dog was placed in the cylinder of a set of idle field magnets and kept for five hours exposed to a magnetic field with an intensity of 1,000 to 2,000 c.g.s.* lines to the square centimetre, and not the slightest visible effect was produced upon the animal.

The next experiments were directed to studying the influence of magnetic fields on the human brain. The machine employed for the purpose converts about 70 horse-power at full load. The armature and one journal were removed, leaving the space between the pole-pieces free. This cavity is 35 ctm. (fourteen inches) in diameter and 60 ctm. deep. The weight of this electro-magnet is over five thousand pounds, and the intensity of the magnetic field produced within the polar cavity after removal of the armature, though not uniform, may be estimated at a mean of 2,500 c.g.s. lines to the square centimetre. A long board was placed upon the base plate leading into this polar cavity, and the subject experimented upon lay on his back upon the board with his head and shoulders in the cavity between the poles, and exposed thus to the full influence of the magnetic field. There would be comparatively feeble residual magnetism with no current in the coils. A switch so nearly silent in action as to be inaudible to the subject was arranged to close and open the exciting current circuit through the field coils. On closing the switch nearly the full magnetic intensity would be active and permeate the head within one second, and on opening the switch the whole intensity would disappear in one second.

Five men, the authors being among the number, were subjected to trial, and the following description of one case serves for all, since the results were precisely the same:

The subject lay back upon the board and concentrated his attention upon his sensations. His right wrist was extended and was grasped by one observer, who took sphygmographic tracings of the pulse. A second observer placed a hand on his chest to observe any irregularity that might occur in respiration. A third observer, in view of these two, but unseen by the subject of the experiment, opened and closed the switch that excited and relaxed the field, signalling to the first two observers as he did so. The strong magnetic influence was therefore turned on or off at will and without the knowledge of the subject. Several sphygmographic tracings were taken in each of our subjects, and in one the knee-jerk was tested continuously.

The sphygmographic tracings taken continuously during the *séance* show no change in regularity, in spite of the making and breaking of the enormous magnetic influence during its registration. The respirations were not changed in the least. The knee-jerk also presented absolutely no change. As to common sensations, there were none that could be attributed to the magnetic influence, and the subject could not discover when or whether the field had been excited. The testimony of all five subjects was alike. In one experiment the subject held a steel screw in his mouth, and was then able to tell when the poles were magnetized or demagnetized, but only by the pulling of the screw to one side or another, not by any peculiar sensation or taste.

Experiments were then made with reversed magnetism. A huge coil of stout, cotton-covered copper wire, about 30 ctm. high and 25 ctm. internal diameter, weighing 70 kilogrammes and composed of nearly 2,000 turns, was so arranged that the head of the subject could be freely introduced within the coil. Its resistance was 10 ohms, and an alternating current of 1,200 volts, making 280 alternations per second, was passed through this coil. The magnetic field would thus be reversed 280 times per second. Each of the authors acted as subject in this experiment. No appreciable effect of any kind was produced when the head was introduced.

The authors concluded that the most powerful magnets known at the present time have no effect whatever upon the organism, neither upon the iron of the blood, upon the circulation, upon ciliary or protoplastic movements, upon the sensory or motor nerves, nor upon the brain.

* c.g.s. = centimetre, gramme, second.

The ordinary magnets used in medicine by Hammond, Benedikt, Charcot, Luys, and others have a purely suggestive or psychic effect and would be quite as useful if made of wood. *Frederick Peterson.*

MALFORMATIONS, PRODUCTION OF. Among the invaluable services of embryology in adding to the general fund of biological knowledge none have been more signal than the removal of developmental anomalies from the domain of fanciful speculation and the establishment of a rational teratology based upon the laws of development. Not only has embryology indicated the lines along which the production of anomalous development progresses, but, likewise, it has indicated the broader morphological significance which in many cases exists, emphasizing especially the fact that not infrequently deviations in the higher types correspond to the normal and usual condition of lower forms.

Notwithstanding the advances in the comprehension of the true significance of variations which the progress and increased accuracy of our knowledge of the course of normal development have rendered possible, there are still numerous deficiencies in our understanding of the primary causes producing malformations—breaks which renewed investigations and further observations alone can supply. The most rational teratological classification, it is evident, would be that in which malformations were grouped according to the various methods of their production; unfortunately, however, with the present limitations and uncertainty of our knowledge of these processes all attempts at such grouping must be imperfect and provisional.

Defects arising from the mechanical effects induced by diseased and unusual conditions of the fœtus, as accumulations of fluid in abnormal quantity within the body-cavities or the undue size of organs, which may, in an adverse manner, directly influence the development of surrounding parts, must be distinguished from those distortions resulting from inflammatory processes, these latter falling under the category of pathological changes rather than of developmental deviations.

A few words concerning the much-vexed question as to the responsibility of maternal impressions in the production of malformations may here, at the beginning of the consideration of our subject, find place. While fully appreciating the sincere convictions of not a few in the belief of the sufficiency of such impressions, and in the sometimes apparently convincing testimony adduced in support of such views, the writer must confess his inability to attach much importance to these influences. In this connection attention must once more be called to the significant fact that in the majority of cases the affected parts are already well advanced in their development before the supposed impression takes place; in fact, not infrequently the developmental deviations necessary in the production of the malformation attributed to the maternal impression take place before the existence of pregnancy is even suspected. While it may be conceived that certain defects may result from nutritive changes induced as the consequence of profound nervous impressions on the mother, yet to those familiar with the embryological significance of malformations the basis of the popular belief in the potency of maternal impressions will appear as depending more upon the very natural disposition to find an explanation for otherwise uniutelligible misfortunes in coincidental circumstances, rather than upon well-established or accurately observed phenomena.

The various headings here introduced make no pretence to systematic arrangement, but are simply provisional, as affording convenient groups for the consideration of nearly-related forms of deviation. Bearing these limitations in mind, malformations may be classed, with regard to their mode of production, into:

I. Those produced by variations in nutrition and growth—either excessive or arrested.

II. Those produced by defective union of component embryonic parts.

III. Those produced by cleavage—either partial or complete—of the primary embryonic cell-mass.

I. *Malformations produced by variations of growth.*

a. The manifestations of *excessive* growth may be present in all parts, resulting in a general increase of the entire organism, or they may be limited to some particular region, as half of the body, a simple extremity, or a special finger or toe. While slight deviations from the normal average length (50.5 ctm. or about twenty inches) and weight (3,250 grammes, or about 7.2 pounds) of the newborn infant constantly occur, yet well substantiated instances where these figures are exceeded to any marked extent are by no means frequent. A height of over 200 ctm. may properly be considered as gigantic.

It is worthy of note that individuals conspicuous by reason of their extraordinary proportions quite usually were children of ordinary size, whose parents, likewise, were of average stature. The case reported by Beach[1] is a striking exception, since the father measured seven feet seven inches, and the mother seven feet nine inches. Their first child, immediately after birth, was twenty-four inches long and weighed eighteen pounds, while the second measured thirty inches and weighed twenty-three and three-fourths pounds. The assumption of an excessive amount of formative material, in the attempt to find an explanation of these instances of unusual growth, must be unsatisfactory when it is remembered that in some cases almost ten years have elapsed before the child evinced any disposition to excessive size. It must be admitted that our knowledge extends little beyond surmise as to the cause of these cases.

Equally uncertain are the causes leading to the curious excessive growth limited to some particular part of the body, as when one extremity, a hand, or even a single finger, attains inordinate dimensions without participation of the adjacent parts. It is evident that such instances of excessive growth must be carefully distinguished from enlargement the result of inflammatory processes or other pathological conditions. As with the instances of general increase, so here, also, the affected parts may for some time after birth present no unusual characteristic, the tendency to extraordinary growth first becoming noticeable at a later day. The subcutaneous connective tissues share with the osseous, vascular, and lymphatic tissues in the participation of the changes in question.

b. Variations due to *defective* growth may be grouped into: 1, those in which a general decrease in size is accompanied by uninterrupted development; 2, those in which the diminution is dependent upon arrested or anomalous development.

The first group is represented by true dwarfs, in which physical development has taken place to completion although the resulting organism is of unusually small dimensions, owing to insufficient growth. Individuals greatly reduced in size, and, at the same time, completely developed, are of rare occurrence; concerning their etiology nothing is known. True dwarfs are, of course, to be carefully distinguished from the not infrequent cases where the diminished size depends upon the effect of pathological processes, as caries or inherited constitutional vices. Heredity plays as unimportant a rôle in the production of dwarfs as in that of giants, since, generally, the parents are of normal size; and, further, not infrequently the dwarfs during early infancy differ but slightly, if at all, from other children of similar age, the diminutive size, which later renders them conspicuous, attracting attention only as age advances.

The second group, including those diminutions dependent upon arrested development and subsequent atrophy, embraces malformations varying greatly in degree, from a rudimentary finger to a shapeless acardiacus. The impaired nutrition, to which the production of these malformations is due, may be the expression of general causes affecting the development of the entire organism and resulting in general atrophy, or of but local causes exerting their unfavorable influence within a very limited area; in these latter cases they may be mechanically induced as the result of undue pressure, either from without or from within the embryo. The investigations of Kollmann[2] and His[3] render it highly probable that general malnu-

trition of the embryo in its earliest stages, resulting in the production of the "abortive" forms, to which the last-named author has recently again called attention,[4] is much more frequent than is generally supposed. These abortive embryos, which may be either nodular, cylindrical, or contorted in outward form, may remain stationary in their development within their membranes for weeks or even months without decomposition or absorption. This fact affords the explanation for the not unusual, apparently irreconcilably small size of the product of conception and the length of time during which pregnancy has existed. These stunted embryos are often the seat of a peculiar proliferation of wandering cells, which invade the entire organism and obscure its histological details.

The group of "acardiac" monsters, likewise, furnishes conspicuous examples of interrupted development brought about by impaired general nutrition. In such cases an atrophic fœtus frequently is associated with a well-developed, and possibly entirely normal, mate, a common placenta, with double cords, being generally shared by the two.

Regarding the manner in which these malformations are produced opinions are by no means in accord. The older view of Claudius[5] attributes the atrophic changes primarily to the reversal and impairment of the circulation, brought about by the overpowering vigor of the stronger fœtus. This doctrine has been warmly defended and further elaborated by Ahlfeld,[6] according to whom the production of an acardiac monster is largely accidental.

The development of an ovum containing two embryonic areas ordinarily results in the formation of "homologous" twins, in which great physical similarity is very pronounced. In any event the development progresses with regularity until the formation of the allantois at about the twelfth to thirteenth day; if the growth of this organ proceeds with equal pace in both embryos the available space for attachment offered by the false amnion will be equally shared, and both embryos will be provided with allantoic, and later placental, circulations fully sufficient for their nutrition. The slight communication between the circulations, established by the anastomosis of the allantoic capillaries, which is usually found in such homologous twins, exerts no untoward influence on either embryo, both being born, at the close of gestation, fully capable of maintaining post-embryonic life.

When, on the other hand, the connection between the two circulations involves large vessels, unequal propelling forces in the two embryos may lead to the gradual suppression of the normal blood-current of the weaker fœtus, resulting in its death, followed by the subsequent disappearance of the amniotic fluid and cavity, and the pressing of the unfortunate fœtus against the uterine walls, where, by the continuous pressure exerted by the increasing bulk of the stronger surviving fœtus, the dead product is reduced to the thickness of stout parchment, producing an atrophic mass to which the term *fœtus papyraceus* is sometimes applied. In those cases where the allantois grows with unequal rapidity in the two embryos the fate of the weaker embryo is somewhat different. The allantois of the more vigorous attaches itself to the partial or complete exclusion of the less fortunate embryo, the latter being thus compelled to seek attachment for its allantois in the remaining unappropriated part of the area destined to form the placental attachment or chorion frondosum.

Where, however, all of the placental area is already secured by the allantois of the first embryo, a secondary attachment to the united allantois of the first embryo is all that remains for the second fœtus to secure. Embracing this last source of nutrition, the weaker fœtus forms anastomoses with the allantoic or placental circulation of the stronger, and thus becomes directly dependent for its nutrition upon the circulation of the latter, constituting an *allantoic parasite* (Ahlfeld).

Owing to this dependence, according to the views of the followers of Claudius, a reversal of the blood-current within the vessels of the weaker fœtus takes place, and is the prime factor in the production of omphalositic monsters, with the accompanying imperfections in many organs. The heart, naturally, is greatly affected by the changed conditions of circulation, becoming, in numerous instances, reduced in function to constitute but a part of the vascular channel. The atrophy and frequent disappearance of the heart was formerly regarded as an almost constant characteristic of these malformations, as expressed by the commonly applied term "acardiac;" that such condition, however, need not necessarily be present has been pointed out by Ahlfeld, who has collected fourteen cases where "acardiac" monsters possessed more or less developed hearts. The young organ may adapt itself to the reversed blood-current to an extent sufficient to enable it to take part in the propulsion of the stream. The quite usual relatively much better developed condition of the posterior, lower, or caudal half of the fœtus, is generally attributed by the supporters of Claudius to the more favorable situation of these parts to secure nutrition sufficing for at least partial development, while the upper portions of the fœtus are denied nutrition adequate to prevent the atrophy and disappearance so commonly observed. That sometimes, however, the reverse may occur is shown in the case recorded by G. W. Koch,[7] in which the neck, trunk, and upper extremities were well developed without even a trace of a heart being present. In those instances where the available blood-supply is insufficient for the nutrition of even the lower part of the fœtus the entire organism becomes converted into a shapeless mass, retaining but little resemblance to the human form, and representing the so-called *amorphous acardiac* monsters.

Opposed to the foregoing views, ably supported by Ahlfeld, are those of Dareste,[8] Panum,[9] Perls,[10] Breus,[11] Koch, and others, who maintain that the reversed blood-current and accompanying changes are secondary and dependent upon an inherent primary defect in the embryo of so grave a nature that development beyond a certain stage becomes impossible. The destruction, which otherwise would be the inevitable fate of such embryo, is partially averted by the opportune assistance derived from the anastomosis of its allantoic circulation with that of its more fortunate companion, from whose more vigorous circulation a donation is received capable of maintaining the partial nutrition of a larger or smaller portion of the affected embryo.

The view advanced by Cleland[12] as to the origin of acephalic and other lowly developed types of monstrosities corresponding to the acardiaci, opposes that of Claudius, and refers the origin of these forms to changes which follow primary posterior or "abcaudal" fission. According to this author, in the cases in question, one of the two segments resulting from such division develops with less vigor than the other, and, in consequence of the unequal growth of the segments and their external allantoic attachments, becomes subjected to greater and greater stretching, until finally separation takes place. One part of the weaker embryo remains attached to, and often within the stronger, while the other portion becomes free, and, where the allantoic circulation is established, capable of maintaining an imperfect existence, resulting in the well-known types of acardiac monsters. Should the weaker embryonic segment fail to form external attachments, it remains connected with the more robust mate, and probably becomes one of the more or less pronounced parasitic forms of double monsters.

Whatever be accepted as the detail of the immediate process by which these highly aborted forms of malformation are produced, it seems certain that their origin depends on a primary impairment of vitality of one of the embryos, as the result of which tardiness in securing adequate allantoic attachments, and failure in maintaining a successful and independent circulation follow. Weighed by the standard of our present knowledge, the changes observed in the circulation of such malformations can no longer be regarded as of the same primary significance as claimed for them by Claudius and his supporters, but rather as secondary phenomena, depending upon more deeply lying fundamental causes.

In seeking the interpretation of those examples of arrested development and incomplete differentiation af-

fecting the lower extremities in various degrees, from the suppression of a single digit to the rudimentary development and fusion of both lower limbs, as in *sirenomelus*, it is difficult to determine to what extent such developmental arrest depends upon external mechanical influences as contrasted with deficiencies of formative material and force.

Perls, Dareste, Gebhard,[13] and others concur in ascribing to an abnormally narrow amnion the principal rôle in the production of such arrests of development. Admitting, as we must, that important modifications may undoubtedly be referred to the direct limitations of the enveloping membranes, yet the symmetry frequently observed in the defects under consideration, together with the fact that sometimes, as in phocomelus, those parts most directly and continuously exposed to external pressure are much better developed than those which are more deeply placed and less exposed, strongly emphasizes the inadequacy of referring to merely mechanical influences the production of such anomalies, and renders imperative the assumption of the presence of a much more deeply seated cause of the arrest of development encountered.

II. *Malformations produced by the defective union of component embryonic parts.*

The limits of the second group of malformations, depending upon the imperfect union or fusion of parts originally distinct but normally uniting in the course of development, are very wide, and include an extended series of defects, which vary in their significance from slight inconvenience, as simple harelip, to great deficiencies incompatible with life, as extensive spina bifida.

These defects naturally fall under two heads: *a*, those arising from imperfect union of embryonal parts, originally separated; *b*, those resulting from incomplete closure of fœtal passages.

In connection with the anomalies embraced within the first sub-group, the early embryonic relations and processes must be recalled, especially the fact that the embryo largely develops by the fusion of two symmetrical halves. These halves, at first lateral tracts, differentiate into two sets of folds—dorsal and ventral. The former unite above the embryonic axis, as defined by the notochord, to form a dorsal tube, the neural canal; the ventral folds join below the axis to form an imperfectly defined primitive digestive tube, whose ventral wall, throughout a variable distance, is incomplete for a time, opening directly into the umbilical vesicle or its duct, the last trace of this connection usually disappearing only at birth. The lateral parts of the dorsal or neural folds are continued into the marked duplications forming the amniotic folds, which gradually cover in, at first the dorsal, later, the ventral surface of the embryo. By the elongation ventrally of the root of the primary amniotic folds, the tissues embraced within the latter (the ectoderm and the parietal layer of the mesoderm) gradually encompass the primitive digestive tube and form the ventral body-walls, the umbilicus marking the position where the last communications between the cavities of the fœtus and external structures exist; likewise, at the umbilicus, the embryonic parietes and the amnion are continuous.

On comparing the normal union of the dorsal and ventral folds it will be seen that while the dorsal line of fusion is unbroken the ventral line of closure is incomplete, being interrupted by the mouth and umbilicus primarily, and by the genito-urinary and anal openings secondarily. As is to be anticipated from these relations, malformations due to defective union along the anterior or ventral line of closure exceed in frequency those of the posterior or dorsal surface.

Without entering into a detailed account of the mode of production of the numerous defects included within the first of the above sub-groups, a brief consideration of the most important of such defects may claim attention.

The region of the face and neck is a favorite seat of such imperfect unions, a tendency readily appreciated when we recall the manner in which these parts are so largely derived from the tissue supplied by the visceral arches, together with the adjoining portions of the head. The most frequently observed defect of this group, the lateral labial cleft or harelip, results from the faulty union of the central naso-frontal, or intermaxillary, process with the superior maxillary or upper division of the first visceral arch. Harelip may be uni- or bi-lateral, and may be associated with defective development of the adjacent bony structures, as maxillary and palatal cleavage. When unilateral, harelip is more frequently limited to the left side, in explanation of which the tendency of the embryo to lie upon the left side in its early stages has been assumed to predispose to the formation of disturbing amniotic folds. Conspicuous anomalies are produced when the intermaxillary process fails to develop, the space between the ends of the superior maxillary processes appearing as a wide central labial cleft. Open naso-lachrymal ducts and oblique facial clefts are other forms depending upon defective union of the margins of corresponding embryonic furrows, while fissures of the cheeks, clefts, fistulæ, and cysts of the lower lip and defective inferior maxilla are further instances of imperfect fusion, or of insufficient formative material. The visceral furrows, as is to be anticipated, offer a productive field for defects of this class, as illustrated in the deviations about the external ear resulting from the imperfect development of the first outer visceral furrow and its secondary tubercles. Persistence of the lower visceral furrows gives rise to the laterally situated cervical fistula, those occupying the median plane resulting from the imperfect fusion of the visceral arches at their inner ends. The question as to the existence of a delicate epithelial partition separating the external furrow from the corresponding inner pharyngeal pouch is still a subject of non-agreement. A number of authors agree with His[14] in denying the existence of a free communication between the outer and inner furrows, unless artifically produced, while many others hold that secondary rupture of the epithelial partition takes place spontaneously and without violence after a variable length of time. Notwithstanding the retention of the epithelial septum during embryonic life, which condition the writer must continue to regard as the usual one before birth, there seems to be no reason why this delicate partition may not disappear subsequently, especially when viewed in the evidence of such cases as those recorded by Sutton[15, 16].

The production of a complete median cervical fistula has been attributed by Marshall[17] to the persistence of a rudiment of the median portion of the thyroid body, the thyro-glossal duct, which enlarges and subsequently opens on the free cutaneous surface. As opposed to this view, Kostanecki and Mielecki[18], Kanthack[19, 20], and others refer the fistula in question to a breaking through of the pharyngeal pouches into the still present remains of the *sinus cervicalis*. Diverticula and cysts also arise within the pharyngeal walls as vestiges of the visceral pouches.

Imperfect approximation and fusion of the parietal plates, to which the ventral body-wall owes its origin, results in defects varying from slight sternal clefts to gaps involving the entire line of ventral union. The causes leading to these defects are various and by no means free from complexity; in addition to the more mechanical influences opposing the normal union, as the disturbing presence of intruding amniotic folds or of the unusual interposition of excessively enlarged, displaced, or abnormally adherent viscera, the effects of insufficiency or distortion of formative material, together with developmental inertia, must likewise be recognized as active factors in causing the arrested unions.

Excessive size of the heart is frequently the cause of imperfect closure of the thoracic walls, cardiac ectopia being sometimes associated with these defects. Likewise abnormal adhesions may limit the development of the ribs, forming lateral clefts through which a pulmonary hernia may appear. The same influences which prevent the perfect union of the anterior thoracic walls may affect the diaphragm to the extent of permitting the formation of diaphragmatic hernia, which may include the migration of a large part of the intestinal tract.

While the thoracic clefts not infrequently are prolonged into the upper portion of the abdomen, it is in the lower or caudad part of the line of ventral union that the defects of closure occur with greatest readiness, a tendency finding its stimulus in the passage through the body-wall, at the umbilicus, of the several structures connecting the fœtus with its external attachments. The normal conditions thus favoring incomplete union, the supervention of causes retarding closure, as amniotic adhesions or excessive bulk or abnormal position of the abdominal viscera, may readily prevent the approximation of the abdominal walls and produce permanent fissures through which more or less extensive extrusion of the viscera may take place.

Such imperfections of slight degree, involving only the umbilical ring, are of frequent occurrence; especially related to the patulous condition of the umbilical ring are the protrusions of the gut, either as the result of abnormal retention within the cord of that part of the intestine which, until the tenth week of fœtal life, lies without the abdominal cavity, but subsequently is drawn within, or, more seldom, as the result of later secondary protrusion of the gut through the still open ring. A familiar example of the persistence of these fœtal relations, to a slight and imperfect degree, is presented in the occurrence of Meckel's diverticula, where the retention of the lumen of the proximal end of the vitelline or umbilical duct may establish a communication extending between the lower portion of the ileum and the free surface at the umbilicus. In the majority of such cases, however, the diverticulum ends before reaching the umbilicus, being continued to the parietes as an impervious fibrous cord. The production of the various forms of funicular hernia probably follows the abnormal attachments of the vitelline duct, which then, as pointed out by Ahlfeld, induces a continuous drag upon the loops of intestine within the cord, thereby preventing its retirement within the abdominal cavity.

Closely associated with an abnormal position and consequent downward traction of the umbilical cord, clefts of the lower part of the abdominal wall, and even pelvic bones, may occur. Ectopia of the urinary bladder, resulting from the rupture of the allantois, due to overdistention, following the obstructed exit of the accumulated excretions owing to closure of the urachus without the formation of the usually substituted cloacal passages, is connected with these abdominal lesions, the vesical defect being frequently associated with abnormal adhesion of the gut.

The altered relations of the parts involved in these malformations exert widely extended impressions, resulting in secondary anomalies. Among such induced malformations are obstructed fusions of the Müllerian ducts due to the interposition of a gut attached to the bladder or of a distended allantoic stalk, and resulting in double uteri and vaginæ in all grades of separation, from the mere suggestion of division, as expressed by a cleft uterine fundus, to completely isolated tubes extending from the oviducts to the vaginal orifice; cleft pubes, with the attendant faulty development of the external genitalia, also follows the lesions in question. Imperfect union of the parts going to form these organs may produce the various fissures, as epi- or hypo-spadia, divided scrotum, etc., from which arise the conspicuous forms simulating hermaphrodites. Displacements of the abdominal viscera and even abnormal curvature of the vertebral column, which latter may induce modifications in the formation and position of the lower extremities, are, likewise members of the train of misfortunes referable to the clefts of the lower abdominal wall.

Interruptions in the closure of the neural canal along the dorsal line of fusion occur, as already stated, less frequently than along the corresponding ventral line. Two localities—the cervical and lumbar regions—exhibit an inherent weakness in the walls of the neural tube, being the points at which union is last completed and at which, therefore, the tissues are least capable of resisting undue pressure from within; the sharp flexures which occur at these positions of the canal are probably, as pointed out by His, responsible for the tardy closure and accompanying weakness. Corresponding with this predisposition, spinæ bifidæ are more frequently observed in these particular portions of the neural canal than elsewhere, those occupying the lumbar region, moreover, preponderating. Where the protrusion is small in size, the stretched and thinned out integument still suffices to invest the tumor; with the enormous increase in the dimensions of the latter sometimes seen, the skin no longer is capable of covering the protruding tumor, the sac in such cases being composed of the distended membranes of the cord alone.

Concerning the mode of formation of spina bifida opinions vary; the older and widely accepted view regards augmented intra-spinal pressure, referable to primary hydrops, as the active factor, and the ununited arches and protruding sac as results of a process of displacement largely mechanical. Other observers, on the contrary, regard these defects as the expressions of arrested development which owes its origin to deeply seated causes affecting the skeletal axis. The symmetry of the vertebral defects shows that they must originate at an early period of fœtal life when formative processes were active in the differentiation of the primary material. The experimental investigations of Richter,[21] likewise, do not support the view that the spinal dropsy or amniotic pressure is to be regarded as the fundamental cause of spina bifida.

The malformations involving the cephalic expansions of the neural tube are also the subject of divergent opinions. The older view, supported by Dareste, Marchand, Perls, and others, attributes to the amnion, as the result of the pressure and obstruction caused by its abnormal adhesions and constriction, the most important rôle in the arrest of development. Ahlfeld, on the other hand, considers that the primary condition is one of abnormal intracranial pressure which results in the rupture of the very early cerebral vesicles, followed by the absorption and disappearance of the ragged edges of ruptured sac, so that later, when these cases usually first come under observation, the cranial basis lies exposed and the original conditions are masked.

Opposed to these non-mechanical theories as to the mode of these malformations are the views of Ackermann,[22] Quicken,[23] and others, who regard these imperfect cephalic developments rather as the results of defective formative energy and insufficiency of formative material than as secondary defects induced by pressure. In view of the frequent association of these cephalic defects with those of the neural canal, it is highly probable that similar forces are responsible in both localities for the arrested development. As consequences of the imperfectly expanded cranial base, and the not infrequently associated vertebral defects, the proportions of the face and the direction of its axis are materially changed, thereby producing the striking "frog-headed" physiognomy so characteristic of an encephalic monster.

Closely related to these deviations in the cephalic developmental processes stand the variations in the closure of the anterior end of the neural tube which produce the conspicuous series of cyclocephalic monsters, whose brief consideration may here find place. Both the view that cyclocephali result from the fusion of two eyes originally distinct, and that ascribing them to failure of differentiation of the two eyes from a condition of primary unity, have been superseded by the more recent explanation by Dareste,[24] by whom the cyclopian features are regarded as directly dependent upon the primary imperfect development of the anterior cerebral vesicle.

The differentiation of the lateral diverticula, or optic vesicles, which under normal conditions are formed, is but partially accomplished, owing to the imperfect development of the anterior cerebral vesicle in consequence of the premature closure of the neural plates forming this portion of the nervous tube. As a result of this closure, an insufficient involution of ectoderm takes place whereby the amount of material available in the formation of the optic vesicles is greatly reduced. When this closure of the cerebral vesicle occurs very early but a single me-

dium optic vesicle is formed, resulting in the production of the characteristic feature of these monsters. In cases where the closure takes place later, affording greater opportunity for advanced development, two imperfectly differentiated optic vesicles are present, from which two eyeballs, more or less closely approximated, arise, the degrees of proximity and fusion depending upon the completeness of the differentiation of the optic vesicles as separate sacs. The cause of the primary arrest of development affecting the anterior cerebral vesicle, Dareste is disposed to attribute to anomalous growth of the amnion, in consequence of which the expansion of the brain vesicle is unable to proceed to the usual extent.

As secondary defects, dependent upon the abnormally situated central optic vesicle and the faulty development of the anterior cerebral sac, deviations and displacements of the naso-frontal process take place with corresponding conspicuous changes in the face. The absence of the central process allows the approximation of the superior maxillary divisions of the first visceral arch, by whose fusion the oval opening assumes a characteristic triangular form. Immediately above the mouth the closely approximated, or single, visual organs take up their position, the displaced naso-frontal process lying higher and often resulting in the development of the characteristic proboscis.

The anomalies owing their production to the abnormal persistence of canals whose function ceases before or at the time of birth are usually inconspicuous, but, at the same time, may induce conditions incompatible with post-fœtal life. The peculiarities of the fœtal circulation are not infrequently retained as a patulous foramen ovale or pervious ductus arteriosus. Variations in the plan of suppression among the aortic arches of embryonic life give rise to the conspicuous anomalies of the great vessels near the heart; not only are transposed aortæ, double aortæ, and deviations in the origin of the subclavian and carotid arteries to be referred to deviations from the usual fate of the embryonic aortic bows, but, likewise, the transposition of the associated viscera. Instances of the retention of the embryonic arrangement of the venous system are also occasionally seen, as in many anomalies of the great veins near the heart. The presence of Meckel's diverticula, and, in extreme cases, the formation of an artificial anus, find their explanation in the persistence of the lumen of the vitelline duct. Likewise, the retention of the allantoic stalk in a pervious condition, instead of the usual transformation into the fibrous urachus, may establish an unnatural exit for the contents of the urinary bladder; such conditions are usually induced by obstruction, during fœtal life, of the more usual channels. Partial retention of the lumen of the allantoic stalk may result in the formation of cysts. Imperfect obliteration of the thyro-glossal duct may contribute to the production of cervical fistulæ.

III. *Malformations produced by fission, either partial or complete*—

a. Of the primary embryonal cell-mass;

b. Of the partially differentiated individual organs.

The malformations comprising the third group—those derived by fission—include the most conspicuous results of developmental deviation, forming a series beginning with the limited fission implicating a single digit, and ending with the extreme division presented by those double monsters in which union is alone maintained by the limited isthmus of attachment, as between the sternum, pelvis, or head.

The production of double monsters has long been a subject of diligent study and ingenious speculation, and even at present it constitutes a biological problem regarding many details of which there is still much difference of opinion.

The once generally accepted and brilliantly supported theory, that double monsters result from the fusion of two separate and independent embryos, may be regarded as now entirely obsolete, modern embryologists agreeing, at least so far, that multiple monsters arise from a single ovum.

Regarding the further question, however, as to whether these monsters originate by the union of two originally distinct embryonic areas upon a single ovum, or whether they result by the cleavage of a single blastoderm, opinions still fail to accord. The former supposition recognizes primitive duality, followed by fusion, the latter primitive unity undergoing subsequent fission.

In addition to the older authorities upholding the fusion theory, B. Schultze, Panum, and especially Dareste, have given this view their support, while Rauber, Gerlach, and others accept it with more or less important modifications. Dareste, while accepting the doctrine of primitive duality, insists that union can only take place in the very earliest stages, and then only as the expression of a special inherent predisposition.

The supporters of the fission theory number many of the most distinguished older investigators, and probably the majority of the embryologists of to-day. The fission theory, as presented by Ahlfeld, one of its most ardent advocates, suffices for the explanation of all forms of double monsters. The primitive undifferentiated embryonic cell-mass may undergo cleavage, in the direction of the future embryonic axis, in varying degrees. When the division is complete, the two resulting halves lie at first parallel, and are capable, under favorable conditions, of developing into homologous twins; when incomplete, the divided parts may subsequently separate, while the attached portions constitute the common bond of union, either anterior, posterior, or middle, as illustrated in the accompanying drawings (Figs. 386 to 389) of actual double monsters of different types of fission observed in the development of avian ova. By the variations in the intensity of these forces all degrees of deflection, from a position of almost parallelism to one of extreme divergence, as head to head, is possible. Ahlfeld regards the fission theory as sufficient for the explanation of all forms of double monsters, and does not admit the necessity of seeking aid from other theories.

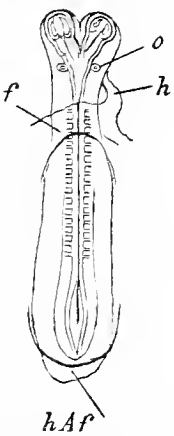

Fig. 386.—Chick Embryo of about Forty Hours, showing limited anterior cleavage. (Dareste.) *rAf*, *hAf*, cephalic and caudal folds of amnion; *h*, heart; *o*, primary otic vesicles.

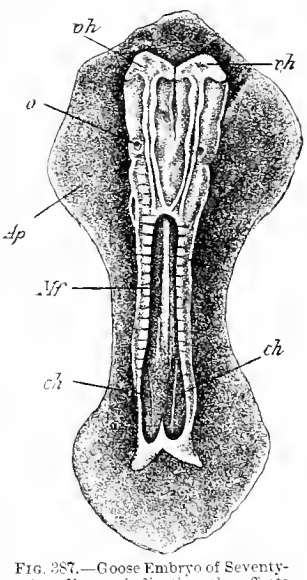

Fig. 387.—Goose Embryo of Seventy-two Hours, indicating the effects of coincident anterior and posterior cleavage; the two resulting divisions are connected by the isthmus of undivided tissue. (Reichert.) *Ap*, area pellucida; *vh*, anterior brain vesicles; *o*, primary otic vesicles; *Mf*, medullary folds; *ch*, chordæ of the divided parts.

Gerlach[25] regards the production of double monsters as far more variable, and opposes the passive cleavage ascribed to the embryonic cell-mass by Ahlfeld, attributing, on the contrary, to the embryonic trace an active participation in the division, the controlling predisposition to which must reside within the cells even before differentiation. This "bifurcation" Gerlach considers especially active in producing anterior or cephalic duplications; the corresponding posterior or caudal cleavage is referred by this author to the partial union or "copulation" of separate but converging traces proceeding from the posterior margin of the germinal

area. Debierre [26] and Klaussner [27] also hold the fission theory as inadequate to account for all forms of double monsters; the former concludes that both fission and fusion may take part, while Klaussner declares that the genesis of such monsters depends upon primary plurality of the embryonic area, and upon fission with post-generation.

The inadequate observations on early mammalian double monsters, together with the fact that the youngest human double monster was already four weeks old (Ahlfeld), still farther adds to the uncertainty of conclusions regarding man and the higher types. Notwithstanding the incompleteness of our knowledge in many points concerning these interesting questions, it must be admitted, we believe, that to fission of the primary embryonic trace must be referred the origin of the great majority of the double monsters encountered, and that, in the present state of our knowledge, we are warranted in

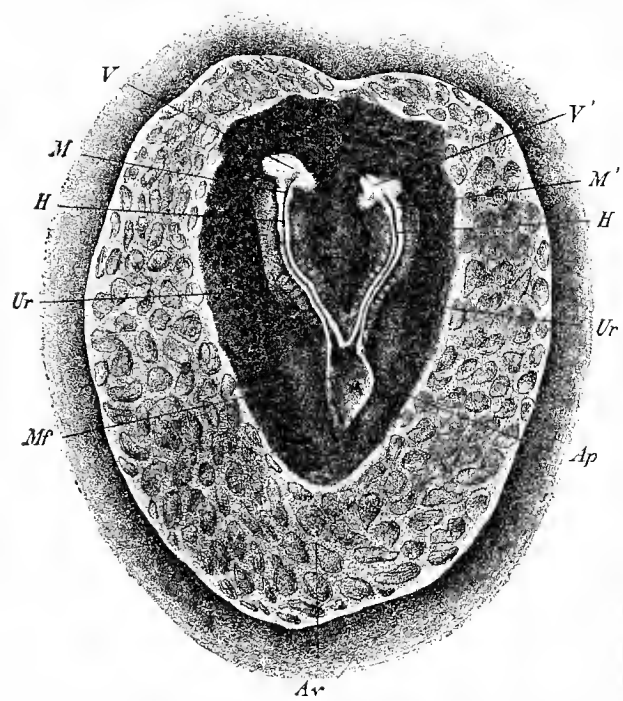

FIG. 388.—Double Chick Monster of Forty-eight Hours. Marked anterior cleavage has taken place, with subsequent divergence. (Gerlach.) *Ap*, area pellucida; *Av*, area vasculosa; *V*, *V'*, *M*, *M'*, *H*, *H'*, respectively the anterior, middle, and posterior primary brain-vesicles; *Mf*, the still widely open medullary folds; *Ur*, the somites or primary segments.

accepting, provisionally at least, the explanations offered by this theory.

The most pronounced effect of the cleavage forces results in the complete division of the cell-mass into two separated portions. Each of these may undergo independent development, the two, under favorable conditions, developing into *homologous twins*, characterized by remarkable physical similarity and the same sex.

In those cases, however, where the cleavage forces effect but partial division of the original embryonic mass, the production of the conspicuous double monsters takes place. The degree of the duplication varies from the slight splitting of the cephalic end of the notochord, the resulting condition presenting no external evidences of its existence and being only accidentally discoverable, to the almost unrestricted separation resulting from the coincident anterior and posterior cleavage where, as in xiphopagus, a narrow bridge of remaining tissue alone establishes continuity.

As an extremely rare occurrence, a repetition of the cleavage may take place in one of the separated embryonic segments, thereby producing a third, which, in the case of complete fission, would form one of the group of homologous triplets; partial cleavage of one of the segments would produce a composite monster of the triple type. Such cases must, obviously, belong to the rarest of anomalies, and when occurring would be prone to unequal development with the suppression of the weaker embryos. Multiple human monsters in excess of triplets have never been observed. When the almost entirely separated embryonic segments undergo equal development and growth, the resulting individuals may be capable of maintaining an almost independent existence, as in the case of the celebrated Siamese twins; not infrequently, however, the segments are affected by unequal development and growth, the disparity becoming more marked with time. From a condition of equality, the weaker embryo becomes more and more dependent upon its stronger mate, until the relations become pronounced as some form of parasitic monster. In the observation of the later stages of growth, when the condition of inequality is already well emphasized, sight must not be lost of the fact that at an earlier period both embryos were of equal dignity, although the possible presence of a shapeless acardiacus attached to a moderately well-developed fœtus at first glance seems little in accord with such condition.

The explanation of the series of obscure parasitic monsters, represented by the different "inclusions," is found in the assumption of duplications, either posterior or anterior, where, as pointed out by Cleland, the two segments are primarily united at a point variably distant from the upper end of the vertebral column. With the subsequent unequal growth of the two embryos, the less developed finally comes to lie within the body of the stronger to an extent dependent upon the position of the primary union, and upon the stage of development and growth to which the weaker part attains. Where the "parasite" remains relatively free and well nourished, the relations between the two may approach those presented by the classic example of the Genoese Colloredo, and by the young Hindoo, Laloo, now living and about twenty years of age. These "inclusions" present their extreme in the obscure tumors attached to some part of the head, as the hard palate (epignathus), lower jaw (polygnathus), orbit, and other parts of the cranium, in which cases the union of the two embryonic segments is situated at the anterior extremity of the vertebral axis, and the weaker segment has, either from the first undergone but slight development, or, as advocated by Cleland, suffered a separation. The part remaining attached to the main stem becomes enveloped within the tissues of the stronger embryo to constitute the contents of the tumor, the position of whose external attachments determines the designation which it receives. In the case of the "congenital sacral" tumors a somewhat modified process must be recognized, since, as held by Cleland, the bony parts within these tumors are the remains of the fused adjoining lower limbs of, at one stage, double sets of extremities, resulting from fission involving the embryo as far as the sacrum. The adjacent left and right limbs of the duplications remain undifferentiated and fused, and, undergoing subsequent atrophy, remain as the contents of the sacral tumor; it follows, therefore, that the limbs which develop really represent the right and

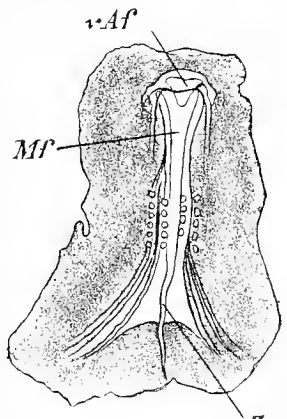

FIG. 389. — Chick Embryo of Thirty-six Hours, showing posterior or caudal cleavage. (Ahlfeld.) *Mf*, medullary furrow divided toward its caudal extremity into the diverging grooves, separated by the median fold (amniotic (?)); *Zw*; *v.Af*, anterior or head fold of amnion.

left members, not of the same, but of two pairs of extremities.

The included fœtus ordinarily lies enclosed within a sac closely united with the surrounding organs; from these latter blood-vessels form communications which supply the nutrition requisite for the existence of the parasite. Should the remaining parts of the included embryo come to rest upon the actively growing tissues destined to form the sexual glands, these parasitic structures become surrounded by the tissues of the future testicle or ovary, and later give rise to inclusions within these organs. These rare conditions must be clearly distinguished from the relatively frequent dermoid cysts occurring within the testicle and ovary: while in the former cases the remains are parts of the atrophic supernumerary embryonic segments, arranged with, at least, a suggestion of order, the contents of the dermoid cysts represent heterogeneous, isolated, and usually ectodermic, tissues of limited variety.

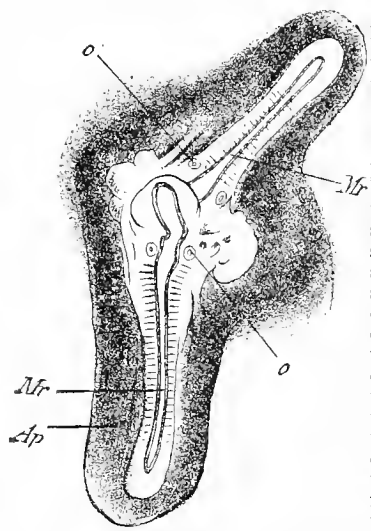

FIG. 390.—Double Chick Monster Resulting from Posterior Cleavage and Subsequent Great Deflection of the Separated Segments. (Rauber.) Such monsters suggest to some authorities the assumption of the possible occurrence of the fusion of at first isolated embryos. *Mr*, medullary furrows; *o*, primary otic vesicles; *Ap*, area pellucida.

Contrasted with the foregoing results of complete or partial dichotomy involving the entire embryonic cell-mass stand the limited duplications arising from the fission of the cell-areas forming the individual organs. Such duplications affect almost every important viscus in the body.

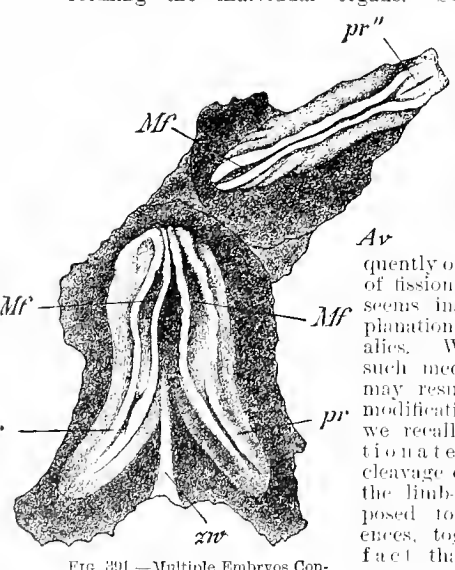

FIG. 391.—Multiple Embryos Contained within two Closely Approximated Area Pellucidæ Occurring in Chicken's Ovum, after sixty Hours' Incubation. The smaller area contains a single embryo, the larger an embryo which has undergone complete posterior cleavage. (Rauber.) *Mf*, medullary furrows; *pr*, *pr'*, *pr''*, primitive streaks; *zw*, median ridge; *Av*, area vasculosa.

The assumption that the obstruction caused by the folds of an abnormally adherent amnion is chiefly responsible for the frequently observed examples of fission in polydactylism seems insufficient in explanation of these anomalies. While, no doubt, such mechanical forces may result in important modifications, yet when we recall the disproportionate infrequency of cleavage of those paris of the limb-buds most exposed to external influences, together with the fact that numerous instances of polydactylism occur among the anamniota, as the amphibians, and the conspicuous transmission of such anomalies by heredity, through several generations, it is evident that the production of these anomalies lies in a much more deeply seated and less local cause. As observed by Pott,[29] the conditions producing polydactylism, adactylism and syndactylism are closely related, being the variously modified expressions of the same inherent differential forces that, under usual conditions, result in the separation of the common cell-area into the normal number of well-defined digits. Where these forces of differentiation and separation, which seem to be possessed by all parts of the embryo during some stage of embryonic life, are stimulated as by excessive presence of formative materials, their action may be exerted far beyond the usual limits, resulting in repeated and extensive more or less perfect cleavage. These divisions commonly are limited to the distal segment of the embryonic limb, producing the frequently encountered supernumerary digits, fingers or toes; much less frequent are divisions implicating the remaining segments, duplications of the entire arms and legs being extremely rare. A remarkable example of cleavage of the upper extremity is recorded by Burnett,[28] where the entire arm has suffered repeated partial division.

Excessive activity of the differentiating forces results in the cleavage of the cell-areas destined to become various parts of the body; examples of such excessive action are particularly noticeable in the formation of such series as the ribs and vertebræ, as well as the muscles, vessels, and nerves, their production supplying the "variations" of the anatomical text-books. Many organs occasionally present more or less complete duplications, either as the result of early fission of the primary cell-mass, or of secondary division induced by encroachments of neighboring tissues. Among the organs occasionally undergoing such cleavage are the tongue, uvula, epiglottis, bronchiæ, pulmonary lobes, stomach, intestines, liver, gall-sac, pancreas, spleen, kidney, ureter, urinary bladder, sexual glands, and mammæ. In connection with the production of supernumerary mammary glands, the recent investigations of O. Schultze[30] are very suggestive, since it is shown that special embryonic areas, or "milk-lines," extend on either side as far as the groin, the permanent glands resulting as the development of certain limited areas along these tracts. While the occurrence of mammary glands on the anterior surface of the body thus finds suggestive embryonal conditions, the instances of mammæ situated on the thigh being also readily regarded as extensions of the primary milk-lines, the occurrence of supernumerary glands on the back, as sometimes observed, seems to call for further explanation. The assumed transplantation of the divided original gland-area seems less plausible than to regard the appearance of these glands in such unusual positions as the expression of perverted differentiation of widely distributed epidermal structures, the mamma arising as but the higher specialization of the ectodermal tissue producing sebaceous glands. Supernumerary mammary glands occur in men with far greater frequency than is usually supposed, as shown by the examinations by Bardeleben[31]; the apparently greater frequency in women arises from the fact that the secretion of milk within these structures, after childbirth, calls attention to the existence of anomalies never before suspected.

The Artificial Production of Malformations. — The origin of double and other monsters has always presented so much of interest, but at the same time of uncertainty, that the hope of adding to our understanding of the methods and conditions of their production long ago induced observers to undertake the artificial production of such malformations. For evident reasons, these attempts at experimental investigations have been limited to the lower forms. While the results of such investigations cannot be directly applied to man, yet they are of value in pointing out facts which possess a probable bearing upon similar processes taking place in the higher mammalian types. In applying the deductions derived from experiments with the lower classes of vertebrates, the inherent differences in the processes as affecting the totally segmenting alecithal mammalian ovum and the partially segmenting telolecithal eggs of the fishes and birds, must not be forgotten.

The possible causes influencing the production of malformations may be arranged in three groups:

I. Anomalous conditions of the sexual elements:

a, Of the female element—the ovum; *b*, of the male element—the spermatozoön; *c*, of the union of sexual elements, resulting in abnormal fecundation and segmentation.

II. Direct mechanical impressions.

III. Anomalous conditions of environment of the embryo, including thermic and respiratory changes.

It is evident that the experimenter has little control over the modifying conditions embraced in the first group, and that these, for the purposes of his attempts at artificially inducing the production of malformations, must be largely ignored. Of interest are the observations of Born [32] on fish eggs, since the fact seems established that the ova of certain females showed especial tendency to yield double monsters, the predisposition remaining practically constant and unchanged notwithstanding variations in the source of the fertilizing male elements. The segmentation of these ova appeared to be normal.

So far, there is no reliable evidence pointing to anomalous conditions of the male sexual elements as being responsible for abnormal development. The double-headed spermatic filaments not infrequently seen, and to which the production of double monsters has sometimes been attributed, are to be regarded as variations in the development of the spermatic elements themselves, rather than as cells endowed with unusual powers of fertilization.

The connection between the entrance of more than a single spermatozoön into the ovum at the time of fertilization, and the induction of abnormal segmentation and subsequent maldevelopment, has been maintained by Fol,[33] and formerly also by O. Hertwig; the more recent investigations of the Hertwig Brothers,[34] however, do not support the supposition that polyspermia produces double monsters. The relation between double spermatozoa and the imperfect expulsion of the second polar body as anticipating the formation of double monsters, as suggested by Windle,[35] lacks further confirmation; and so does, likewise, the hypothesis advanced by Dareste,[36] that multiple pronuclei follow the penetration of more than one spermatic element.

The possibility of influencing development by the application of mechanical impressions early invited the consideration of experimenters. These mechanical influences, brought to bear upon the ovum with a view of modifying development, have been:

a, Abnormal position; *b*, disturbed equilibrium; *c*, direct mechanical injury.

The elder Geoffroy Saint-Hilaire, by his success in producing malformations by incubating eggs placed in abnormal positions, has merited the distinction of being regarded as the founder of experimental teratology.

Thirty years later, Liharzik [37] succeeded in distinctly modifying chick embryos by change of position during the latter half of incubation, when the chick normally lies with its axis corresponding with the longer diameter of the egg, the head usually occupying the broader end of the egg. Recognizing this normal relation, Liharzik placed the eggs vertically, in some cases with the larger end uppermost, in others with this extremity down. The increased nutrition affecting those parts, whether head or tail, which were dependent and, therefore, aided by gravity, was manifested by the distinctly recognizable increase in size of those portions which had occupied the lower end of the egg. Dareste [38] also obtained positive evidence of influenced development by adopting the vertical position, while, more recently, Strahl and Gasser [39] fixed the yolk so that development proceeded while the germinal area lay beneath, and thereby produced a partial inversion of the viscera which, apparently, depended upon the abnormal position for its cause.

The disturbing influences of violent agitation have long been known and successfully applied to the production of malformations by Valentin, Knoch, both the elder and younger Geoffroy Saint-Hilaire, Lombardini, and Dareste. The latter experimenter observed that when eggs are incubated immediately after violent agitation, as after railroad transport, they usually soon die, while, on the contrary, if a period of rest intervene before incubation development proceeds normally. Eggs violently shaken by a machine for some twenty minutes before incubation gave rise to many malformations, including exencephalus, cyclocephalus, spina bifida, etc. Some eggs, however, notwithstanding their maltreatment, passed through the cycle of normal growth.

Attempts at still more profoundly influencing the course of development have been made by the direct injury or mutilation of the early embryonic cell-mass. Schrohe [40] incised and punctured the germinal area with the hope of producing double monsters, but with the results of inducing but single deformities. Rauber's attempts at causing the formation of double monsters by division were also negative; his conclusions, that it is not possible to produce such malformations by mechanical injuries, are endorsed by Panum and Dareste. In this connection the quite recent experimental investigations of Driesch [41] on the segmentating ova of echinus, and, still later, of Wilson [42] on the earliest stages of amphioxus, are extremely suggestive. In these experiments, by the separation of the blastomeres of the earliest stages of segmentation, it was possible to obtain multiple embryos, either as isolated individuals, or, as often happened in the experiments on amphioxus, as double monsters in various stages of separation. These investigations are important as emphasizing the primary differential equality of the early blastomeres, a single segmental element, in some cases observed by Driesch, sufficing to produce a perfect individual of diminished size.

Further attempts to produce anomalous embryos have been carried out by Warynski and Fol, who applied the thermo-cautery to embryos, and concluded that cœlosomia and symelia are the only malformations directly referable to the amnion; Gerlach [43] also cauterized the anterior end of embryos with the view of producing exencephalus, but with only partially satisfactory results. Electricity in various forms has been employed by Lombardini, Maggiovani, Windle, and others, but this agent seems capricious and uncertain in its results.

The experiments whereby the supply of heat and oxygen has been affected have yielded the most important results. As long ago established by Réaumur, the most favorable temperature for incubation is about 40° C. By keeping eggs at a temperature of 41° to 42° C., Dareste was able to obtain in twenty-four to thirty hours, embryos which had attained a development corresponding to that usually reached only at the third day; on the other hand, a reduction to 30° C. retarded development fully one-half. Variations in the form and development of the germinal, and especially the vascular, area seem frequent accompaniments to these thermal changes. A continuous slight elevation above the normal temperature hastens development but retards growth, and often results in the production of dwarfs. Out of seventy-eight eggs incubated at a reduced temperature, Richter [44] obtained five malformations, three spinæ bifidæ with exencephalus, and two exencephali alone.

Modifications in the amount of oxygen having access to the egg have been carefully studied by a number of experimenters. While the effect of an abnormally abundant supply of oxygen must be regarded as still undetermined, the deleterious influences of a diminished supply are conclusively established. In the experiments affecting the respiratory interchange of gases, advantage has usually been taken of the fact that through the porous egg-shell the air gains access to the ovum. Various devices for rendering the shell more or less impervious to gases have been employed, the favorite method being the application of varnish. Dareste has called attention to the precaution of coating freshly-laid eggs, since after the formation of the air-space the contained oxygen suffices for development for a certain length of time. The elaborate experiments of this author confirmed the investigations of the earlier observers as to the efficiency of these methods of influencing development, especially the

development of the vascular area and the blood-corpuscles, thereby establishing an anæmic condition. Dareste concluded, moreover, that the restricted supply of air bore no direct relation to the malformations.

The methods adopted by Gerlach in his experimental investigations are of especial interest from the fact that the results are more nearly positive than those of any former experimenter. Recognizing that the growth and proliferation of cells are always influenced by the supply of oxygen, Gerlach assumed that by restricting the interchange of gases to a **V**- or **Y**-shaped area, so placed that it would correspond to the anterior part of the germinal area, it might be possible to alter the arrangement of the cells, by compelling a new disposition in their search after oxygen, to the extent of producing an anterior bifurcation. Of sixty eggs so treated, nineteen exhibited variations which Gerlach attributed directly to the modified conditions of respiration. Of these deviations, two were unmistakable anterior duplications. It is to be remembered, however, that such malformations probably occur, under ordinary conditions, more frequently than supposed, and the direct causal relation between the two fissions and the especial treatment of the eggs is by no means beyond question.

Gerlach and Koch,[45] and later Koch,[46] studied the connection between restriction of air and the production of dwarfs, but they conclude that the retarded growth consequent upon such conditions results not in true dwarfs, but only in poorly developed embryos.

Review of the foregoing experiments in the artificial production of malformations emphasizes the fact that certain disturbing influences, as violent agitation, marked thermic variations, and restricted supply of oxygen, are all forces capable of profoundly impressing the early embryonic cell-mass, and of secondarily inducing more or less conspicuous malformations. And further, as pointed out by Dareste, and more recently emphasized by Windle,[47] that there is no definite relation between the nature of the disturbing influence and the character of the resulting malformation, the same anomalies being produced by various methods. On the other hand, notwithstanding a wide variation in the nature of the disturbing agents, the deviations of development are largely those referable to impaired nutrition, as expressed by the defective development of the vascular system.

Whatever may be the success of future investigators in producing at will certain types of malformations, it must be admitted that at present, at least, experimental teratology is capable of yielding results which are suggestive rather than definite. *George A. Piersol.*

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MALT (*Maltum*, U. S. Ph., 1880). The official directions given in the United States Pharmacopœia for the preparation of this product are as follows :

"Malt, in coarse powder, not finer than No. 12, one hundred (100)parts ; water, a sufficient quantity. Upon the powder, contained in a suitable vessel, pour one hundred (100) parts of water and macerate for six hours. Then add four hundred (400) parts of water, heated to about 30° C. (86° F.), and digest for an hour at a temperature not exceeding 55° C. (131° F.). Strain the mixture with strong expression. Finally, by means of a water-bath, or vacuum-apparatus, at a temperature not exceeding 55° C. (131° F.), evaporate the strained liquid rapidly to the consistence of thick honey. Keep the product in well-corked vessels in a cool place."

The historical references, detailed description of the processes of manufacture and peculiarities of the finished product, as given by Professor Bolles (REFERENCE HANDBOOK OF THE MEDICAL SCIENCES, Vol. IV., 1887, p. 637), are sufficiently full for our present purpose, and need not therefore be touched upon. The almost universal employment of malt preparations, especially liquid malt-extracts, by physicians and by the laity, however, seems to warrant a critical study of their value from a therapeutic standpoint. This naturally implies an investigation of the composition of malt, its properties as a food-substance from a physiological point of view, and finally, an estimate of its virtues alone, or combined with other medicaments, in the treatment of disease. And, inasmuch as there is a popular demand for these products, some reference should also be made to adulteration, and the addition of foreign substances—principally antiseptics, to prevent fermentation.

COMPOSITION.—The manufacture of malt consists essentially of four different processes, viz. : *Steeping*, *couching*, *flooring*, and *kiln-drying*, which result in decreasing the weight of the grain (about 20 per cent.), but are attended with an increase in bulk (3 to 8 per cent.). The entire manipulation should be considered as succes-

sive steps of the same operation, since the malt contains, in somewhat altered arrangement, the substances found in the grain; malting merely effects the transformation of these substances, through the influence of heat, moisture and the amylolytic action of *diastase*, an unformed ferment (*enzyme*) which is a constituent of malt to the extent of from one to two per cent. (Hagar). Through the action of diastase—manifested within an hour after grain is put to steep—whose properties are similar to that of *ptyalin* from the saliva and *amylopsin* from the pancreas, the insoluble starch of barley is converted into dextrin and glucose — sometimes called grape-sugar. Thus, the outline of Proust (*loc. cit.*) shows that malt contains nineteen per cent. less starch and cellulose than barley, ten per cent. more sugar, eleven per cent. more dextrin, while the amount of gluten is lessened by two per cent. It should be stated in this connection that, while the object of "malting" is to produce the maximum of sugar by the action of diastase, it is not desirable that this action should be entirely exhausted, and therefore, at a certain stage of the operation, this process is arrested by kiln-drying; under favorable circumstances —heat and moisture—this fermentation is re-kindled.

Qualitative tests for *diastatic activity* are extremely simple. A quantity of malt is added to hot water and dissolved by constant stirring; then a small portion of starch is added in like manner, and in the course of a few minutes the iodine test is applied.

The *soluble extract* in a good malt suitable for brewers' use, is, according to Ure, 66.8 per cent.; it contains in addition, insoluble matter, 26.7, and moisture, 6.5 per cent. To determine the proportion of *insoluble matter*, a definite quantity is measured by weight and dried by heat from boiling water; the remaining powder is then put in cold water and heated. The soluble extract is then decanted off and the residue dried and weighed and the percentage calculated.

The process of diastatic fermentation is by hydration (Hoppe-Seyler), as will appear later on. The amylolytic power of diastase is about the same as the proteolytic power of a good pepsin; that is, diastase will convert starch into glucose in the proportion of 1 to 2,000, while pepsin converts albumin into peptone in the same proportion, although recent improvements in the manufacture of pepsin enable manufacturers to produce a much more concentrated article (1 to 6,000).

Liquid malt-extracts are simply weak solutions of ordinary malt, very much like beer, and usually contain a variable proportion of alcohol, a small percentage of carbonic acid, with more or less solid extract, but for none of them can be claimed any distinct diastatic property. These preparations hold in solution the products of diastatic activity, dextrin and sugar, which renders them "sweet" and palatable, while the alcohol is not in sufficient amount to interfere materially with the proper performance of the digestive functions; indeed, in the case of elderly persons, it may prove a decided benefit. Carbonic acid is also acceptable to the stomach; but the percentage of "*solid extracts*" in these products furnishes no criterion as to their intrinsic value, as will be shown presently.

From an examination and analysis of thirteen different samples of liquid malt-extracts, Leffmann (*Medical News*, January 28, 1893) found that all save one contained alcohol in small proportion—none as high as eight per cent., and that the solid extract ranged from 5.1 grammes to 16.06 grammes for each 100 c.c. Moreover, three of the samples contained appreciable amounts of salicylic acid.

Adulteration.—The temptation to sophisticate malt arises from the great care required in the process of malting; if the diastatic power be destroyed by excessive heat, the malt possesses no nutritive or digestive value. Again, in sections of the country where malting is extensively carried on, manufacturers may employ "ungerminated" grain, *i. e.*, grain that has been subjected to "heating," and has thus lost its vitality. As a result of wet seasons, therefore, malt may be of a very inferior quality — possessing but slight diastatic power, yet showing a large percentage of insoluble matter.

Most serious objections are urged against the employment of salicylic acid as an antiseptic, since it is harmful if taken in too large quantities or too long continued, and besides, like all other antiseptics, it arrests or suspends diastatic activity. Now, while this is true in general, it may not apply uniformly to malt-takers and beer-drinkers, because we know that even in the absence of diastatic power this class generally present a rotund, florid, sometimes a bloated appearance—due to the deposit of fat from the absorption of sugar—and frequently suffer from rheumatic affections; hence the introduction of salicylic acid free from impurities may possess negative value, (1) by enacting the rôle of an antiseptic in the alimentary canal, (2) by lessening the diastatic activity, thereby preventing the rapid conversion of starch, and (3) by its influence upon the rheumatic diathesis. This leaves, then, for the liquid malt-extracts containing salicylic acid, nothing of special value except the converted sugar and a small proportion of alcohol.

Incompatibles.—The following table (after Hermann Meyer and Brunton) is introduced to show the strength in watery solution of the different drugs which arrest the action of diastase, from which it will be observed that, while chloroform and creasote, even in saturated solution, have very little or no deleterious effect, corrosive sublimate in a solution so weak as 1 to 50,000 destroys the ferment. Thus salicylic acid in the proportion of one grain to ten ounces (approximately) is sufficient to arrest the action of diastase:

Alcohol, 1 to 3.	Corrosive sublimate, 1 to 50,000.
Benzoate of soda, 1 to 100.	Creasote, no action in sat. sol.
Benzoic acid, 1 to 1,025.	Eucalyptus oil, acted only in excess.
Borax, 1 to 100.	Glycerine, 1 to 2.
Bromine, 1 to 5,070.	Iodine, 1 to 4,125.
Carbolic acid, 1 to 30.	Mustard oil, only lessens action in sat. sol.
Chloride of lime, 1 to 6,613.	Salicylic acid, 1 to 5,100.
Chlorine, 1 to 7,411.	Sulphurous acid, 1 to 8,600.
Chloroform, slight action in sat. sol.	Thymol, slight action in sat. sol.
Copper sulphate, 1 to 6,500.	

Physiological Action.—From the preceding remarks it will be apparent that there is comparatively little to add in regard to the physiological action of malt, either from the standpoint of the clinician or from that of the physiologist; and yet that little is of paramount importance. Malt performs a twofold action in that it is a digestive and nutrient, its virtues being augmented by hydration. Digestibility is the prime element in all food-stuffs, but concentration may seriously interfere with absorption; hence the importance of dilution by water, which is the most efficient medium for the transmission of pabulum through the secreting structures of the alimentary tract (endosmosis). Thus, while concentration is an important factor entering into questions relating to the manufacture and transportation of food products, the very opposite is essential to insure rapid absorption and easy assimilation. But the increased consumption of carbohydrates, while it increases the amount of fat, is at the expense of muscular structures which require nitrogenous material for the maintenance of their integrity, and therefore, too much dependence must not be placed upon the apparent gain secured by the administration of malt and predigested foods of this character. Indications of their unfavorable effects will be manifested by acidity, hepatic and cardiac derangements, and constipation, along with mental hebetude and other evidences of imperfect metabolism.

Contra-indications to the employment of malt preparations in the treatment of children's diseases, more especially those peculiar to summer and autumn, should be noticed, viz.: evidences of fermentation in the stools. When this condition is present, carbohydrates must be omitted and nitrogenous food substituted.

The dangers arising from the small percentage of *alcohol* in the liquid malt-extracts have been unduly magnified, as we have ample evidence of its value as a reconstructive. In suitable amounts—*with meals*—alcohol improves the

appetite, favors digestion, lessens the elimination of phosphorus and promotes the excretion of urea, thus enhancing muscular capacity; but we must bear in mind, also, that alcohol *lessens oxidation*—a conservative process in certain wasting diseases—although an effect to be avoided in health. Its obtunding influence upon the nervous system is likewise of medicinal importance, and in the administration of malt preparations we should never lose sight of the physiological functions of the organism, our sole object being to restore and maintain its integrity by the exhibition of remedies adapted to its wants.

There is still another important factor to be considered in connection with the physiological functions of malt. For example, a considerable percentage of cod-liver oil can be incorporated with it in such a manner that the compound is tolerably stable while freely miscible with water, and, therefore, readily assimilable by the digestive apparatus. Now, bearing in mind that malt contains more or less gluten, perhaps a little dextrin, together with some unconverted starch and *insoluble extract*, it is not unreasonable to believe that under normal conditions the contents of the intestine may approach the type of a mucilaginous substance, possessing cohesive properties, and whose viscosity will prove of value in preventing the absorption of poisonous products from the alimentary tract. Physicians readily appreciate the value of starch enemata in irritable conditions of the lower bowel, although but few understand the *modus operandi* by which these benefits are secured. Starch enemata are of service, not merely because they have a quieting effect upon the terminal filaments of sensory nerves in the mucous structures, but rather on account of their adhesive qualities, which enable them to lay hold of poisonous substances in the course of elimination, thus preventing them from coming into contact with the delicate and inflamed tissues. While the old idea has long been accepted as a clinical fact, it was nothing more than a temporary hypothesis or make-shift, and is promptly set aside to make room for the scientific fact upon which it depends.

And just here should be pointed out the marked similarity or analogy between the conditions which obtain in the small intestine when malt is administered and that of the lower bowel when a starch enema is introduced. This explanation not only sheds new light upon the incidental physiological action of malt, but it puts the entire theory of the therapeutic action of emulsions upon a scientific basis, in keeping with the results of clinical observation. Heretofore the causes which were actually responsible for the wonderful improvement following the exhibition of comparatively small quantities of malt, cod-liver and petroleum oils, as well as other remedies in the form of emulsion, have been scarcely realized, because the physiological functions of the emulsionizing agents were overlooked, or but imperfectly understood. Notwithstanding the fact of its being a negative virtue, it is, nevertheless, a factor of material significance.

THERAPY.—The most important therapeutic application of malt consists in its employment for the relief of *intestinal affections* dependent upon imperfect intestinal digestion of starchy foods and subsequent fermentation. In this class of cases the carbohydrates should be restricted, bread only being allowed, and the patient instructed to masticate it thoroughly in order to incorporate with it the *ptyalin* of the saliva, which serves to break up the starch granules before entering the stomach. Occasionally *amylopsin* may be added with benefit. This method of treatment will be found available in a very large number of cases of intestinal indigestion associated with *chronic disease*, especially *pulmonary affections*, because, as has already been shown, carbohydrates are fat-producers. They do not, however, increase the capacity of the muscular system, and may, therefore, do harm by lessening oxidation and obstructing elimination. Shortness of breath, cardiac weakness, or hepatic insufficiency with acidity of the stomach and diminished urinary excretion demand their prompt discontinuance and a complete re-arrangement of the dietary.

Malt enjoys deserved popularity as an adjuvant in *convalescence* from protracted illness, as an auxiliary and digestive in the case of *nursing women*, and to a limited extent in the treatment of all *debilitated conditions* of the system, but its continuous or indiscriminate use will eventually result disastrously. Like all other remedial agents, its medicinal employment requires the discriminating judgment of the conscientious and intelligent physician.

In the treatment of *summer diseases*, in both adults and children, malt possesses a high degree of utility, but it is only adapted to the cases in which the stools are putrid and foul-smelling. Where the stools are sour-smelling, due to starchy fermentation, malt and malted products are of secondary importance, as they have no influence upon the micro-organisms or other poisons associated with the intestinal disorder. Indeed, there is good reason to believe that the popular method of treating this class of affections by the exhibition of "*barley-water*" has been productive of greater mortality rates than would have occurred had all treatment been abandoned. Science absolutely condemns the practice, and clinical observation emphatically indorses her teachings. The personal experience of Dr. Benjamin Ward Richardson, published in the *Æsclepiad* about a year ago, covering the untoward effects of oatmeal and barley-water, should be critically studied by every general practitioner.

ADMINISTRATION.—Malt (U. S. Ph.) may be given in doses of *one or two drachms*, either with meals or two hours later. Liquid malt-extract should be given *with meals*—one or two wineglassfuls.

To meet special demands in the case of malnutrition, malt may be combined with a number of reconstructive medicaments, as follows: Malt with quinine, iron, and strychnine; malt with hypophosphites; malt with peptone; malt with cod-liver oil—but not to exceed the proportion of *ten per cent.* *John Aulde.*

MALVERN. A spa of ancient repute in Worcestershire, England.

LOCATION.—Malvern is prettily situated in a beautiful part of Worcestershire, at an elevation of five hundred and twenty feet above the sea. Bradshaw says that the town of Malvern is beautifully situated on the slopes of the Malvern Hills, which rise to the height of fifteen hundred feet above the sea-level. These hills are traversed by roads and paths easy of ascent. From their summit a succession of the grandest and most picturesque views in the United Kingdom, embracing twelve different counties, can be obtained.

The town consists of Great and Little Malvern, which are about three miles apart. The picturesqueness of the site and surroundings of Malvern have been celebrated in prose and verse by Byron, Walpole, Southey, Browning, and Macaulay.

The Malvern air is dry and bracing, the climate tonic and stimulating, and the temperature equable. The drinking-water is of absolute purity and softness. The death-rate is low, being only 18.85 per 1,000. The sanitary arrangements are based on the best scientific principles. Over fifty thousand persons visit this spa during the season, which lasts from May to October.

ACCESS.—Malvern is one hundred and twenty-nine miles from London, and can be reached in about three hours by rail.

ANALYSIS.—The Malvern waters are faintly alkaline and earthy. Its brine baths are famous. The two springs of Malvern are St. Anne's and the Holy Well.

INDICATIONS.—The waters and saline baths of Malvern find their chief employment in cases of rheumatic gout and rheumatism, and their various sequelæ and complications; also in scrofulous disorders, neuralgia, sciatica, lumbago, etc.; swellings of the joints, contractions and anchylosis, paralysis, morbus Brightii, bronchial affections and chest complaints, skin diseases, old wounds, and ulcerations. *Edmund C. Wendt.*

MARGATE. One of the best known and most popular seaside resorts in England. Margate was once fashionable, but Ramsgate has outstripped this city by the sea in

that particular. Margate is in Kent. It begins in a valley and stretches up the slope of a hill. It has a famous pier, and in many other respects resembles our own Coney Island. Though quite open and exposed to trying winds, Margate is a healthy place, and the air there is remarkably keen and bracing. The famous Clifton baths, formed out of a cliff, are one of the main attractions of the beach, which is a fine sandy one. Margate is only two hours by rail from London, and about four hours by river steamer. Dr. Yeo speaks of Margate as follows ("Climate and Health Resorts"):

"Although often associated in men's minds with the neighboring resorts on the south coast, it must not be forgotten, in estimating the special qualities of the climate of Margate, that its aspect is not to the south, nor to the east, but to the north or northeast. Whoever will take the trouble to look at a map of this part of the coast of the Isle of Thanet will see that Margate has a decidedly northerly or northeasterly aspect. In this respect it differs entirely from the neighboring coast town of Ramsgate, which is so placed in an indentation of the coastline as to look southeast. From this difference of aspect it not infrequently happens that the local weather differs considerably in these two places, only a few miles apart, for a storm may be raging at Margate which is scarcely felt at Ramsgate. It happens also from this northerly or northeastely aspect of Margate that during the prevalence of the northeasterly winds of spring it is one of the very few conveniently accessible seaside resorts where, during that season, pure sea-air can be obtained. For the prevailing northeast winds blow directly over the North Sea and the northern portion of the British Channel on to Margate and the line of coast of which it forms a part, whereas during the same season the prevailing winds at the resorts on the southern coast are land winds and blow off the land out to sea, driving off, as it were, the sea air —hence, I take it, the great value which Margate air is known to possess in scrofulous affections.

"It has a chalk subsoil, and the ground quickly becomes dry after rain. The water supply is abundant and pure.

"The best residential part of the town is on the Cliff, where the Cliftonville Hotel stands; but the cheaper hotels and lodging-houses are on the lower ground, near the harbor and pier.

"The drainage of the higher ground is better than that of the lower level, which is not all that could be wished.

"Margate is too windy for cases of chest disease, except in the summer months, but it is especially beneficial to cases of scrofulous disease in children and to those of convalescence after surgical operations. This fact has led to the establishment there of that excellent institution, 'The Royal Sea-bathing Infirmary, or Royal National Hospital for Scrofula.'

"The air of Margate is excellent for promoting the progress of slowly healing wounds and ulcers, and it is valuable in cases of debility from inherited feebleness of constitution. It is also said, from its dryness, to be good for rheumatism.

"Its autumn climate is often very fine. In November, when London is foggy and the country damp, Margate rejoices in a clear, bright, and dry atmosphere.

"Margate is celebrated for its sands, which are very extensive, owing to the shallowness of the water. They are therefore the delight of children and those who do not care for a plunge into the deeper sea."

Edmund C. Wendt.

MARTIGNY-LES-BAINS. A spa in the Vosges Mountains, France, which has recently acquired an excellent reputation.

LOCATION.—Martigny is a village situated in a pleasant valley surrounded by wooded slopes. It is not far from the spas of Contrexéville, Bourbonne-les-Bains, and Vittel. Although its growing reputation as a watering-place is of recent origin, the place itself is said to date back to the times of the Druids, and there are seen to this day remains of undoubted Celtic origin.

The two principal springs of Martigny supply a chalybeate water rich in lithia. The waters are cold, clear, and slightly astringent to the taste. The climate is pleasant and bracing.

ACCESS.—Martigny-les-Bains (not to be confounded with Martigny in Switzerland) is a station on the Eastern Railway of France. It lies on the road from Contrexéville to Bourbonne-les-Bains.

ANALYSIS.—According to Wilm, one thousand parts contain:

	Parts.
Bicarbonates of lime, of magnesia, and of iron	0.3918
Sulphates of lime, of magnesia, and of lithia	0.8641
Chloride of magnesium	0.0071
Silicates of magnesia, of soda, and of potash	0.1383
Silica	0.0018
Organic matter and loss	0.0250
Total	2.3281

The more complete analysis of M. Jacquemin is as follows: One thousand parts contain:

	Source No. I. Parts.	Source No. II. Parts.
Bicarbonate of soda	0.0160	0.0120
Bicarbonate of magnesia	0.1750	0.1800
Bicarbonate of lime	0.1620	0.1580
Bicarbonate of lithia	0.0320	0.0190
Bicarbonate of iron	0.0090	0.0310
Sulphate of soda	0.2290	0.2360
Sulphate of magnesia	0.3300	0.3340
Sulphate of lime	1.4240	1.4400
Chloride of sodium	0.0950	0.1050
Chloride of potassium	0.0120	0.0140
Phosphate of lime	0.0028	0.0019
Silicate of soda	0.0532	0.0456
Silicate of lime	0.0029	0.0014
Fluorine, arseniate of lime, borates of soda, of manganese, of alumina	traces	traces
Organic matter	0.1141	0.0681
Totals	2.6570	2.6400

According to Mr. Wolff ("The Watering-places of the Vosges") there is now a large new hotel with good appointments, which includes the thermal establishment. But although baths are much used "the main use of the water is for drinking. The hours are the same as at Contrexéville and Vittel, and so is the number of glasses taken, generally from eight to ten. There are grounds adjoining, covering something like twenty-five acres, and very prettily laid out. One very useful feature is the large covered *Promenoir*, in which are housed the two springs, and which affords shelter alike for walking after drinking, and for pretty free exercise in wet weather."

The older chalybeate spring is not much used now, and lies outside of the village.

INDICATIONS.—The lithia springs of Martigny are employed for the relief of gout, gravel, diseases of the bladder, hepatic congestion, and the various manifestations of the uric-acid diathesis. But dyspepsia, anæmia, and chlorosis, gastralgia, diabetes, and some forms of rheumatism and neuralgia are also said to be treated with advantage there. Those in search of a quiet watering-place, devoid of all the excitements of fashionable spa life, will find comforts that they will appreciate, amid surroundings that are interesting and agreeable at Martigny.

ACCOMMODATION.—In addition to the large modern hotel already mentioned there are a number of unpretentious establishments, with fairly neat and clean rooms and a modest bill of fare at decidedly reasonable rates.

Edmund C. Wendt.

MASSAGE. PHYSIOLOGICAL.—Experience has taught us that massage is a powerful tonic to the muscular system. But Professor Maggiora, of the University of Turin, has recently demonstrated this much more fully by a series of careful and pretty experiments, showing the rapidly restorative effects of massage upon muscles weakened from various causes (*Archives Italiennes de Biologie*, tome xvi., 1891).

1. The action of massage upon muscles in a state of repose was first studied. For this purpose the fatigue curves of the right and left middle fingers in voluntary flexion with a weight of three kilos (6.6 pounds) every two seconds were taken at 8 and 11 A.M., at 2 and 5 P.M., and the following day the fatigue curves of the same muscles, with the same weight and rhythm, were taken at the same times of day after massage for three minutes.* The average result showed that the muscles did almost twice as much work after massage as they did before. The average for the left middle finger was 4,252 kilos without massage; after massage, 8,019 kilos before extreme fatigue prevented further contractions. The right medius behaved similarly. Another series of experiments was made in which the same muscles were fatigued by the electric current applied to them or to the median nerve, and the same results were obtained as in the previous experiments, and showed that it takes much longer to fatigue muscles by electrical irritation after massage than before.

2. The next experiments were undertaken in order to ascertain whether the beneficial effects of mixed massage (friction, percussion, and kneading) increased in proportion to its duration. At 8 A.M. the normal fatigue curves were taken, then every two and a quarter hours after this they were also taken, having been preceded by two, five, ten, and fifteen minutes of massage of the right and left middle fingers. Ten tracings were thus obtained, and the result showed that five minutes of massage produced almost all the useful effect possible. When the massage was continued longer, for ten and fifteen minutes there were slight variations in the amount of work shown, above and below that after five minutes. The same results were obtained when electrical irritations were used to fatigue the muscles or applied through the median nerve.

3. The third series of experiments were employed with a view to determine the effects of the main procedures of massage—friction, percussion, and *pétrissage*. The methods were as before: first the normal fatigue curve was taken, then every two hours during the day fatigue tracings were taken after five minutes of friction, after five minutes of percussion, and after five minutes of *pétrissage* or kneading, and finally after five minutes of these three manœuvres alternating. There was little difference in the amount of work that could be done after five minutes of friction as compared with that after five minutes of percussion. There was a great increase in the force and duration of the contractions after *pétrissage*, but the best effects were obtained after an alternation of all three. Like results followed when the contractions were produced by electricity, and these three procedures of massage employed separately and alternately.

4. The effect of massage upon muscles weakened by fasting was such as to restore them temporarily to a normal condition, so that they gave tracings of fatigue equal to normal tracings not preceded by fasting. The same result followed when the electrical current was applied either directly to the muscles or to the nerve supplying them in place of voluntary contractions.

5. The effect of massage upon muscles fatigued in an indirect manner, or as the result of general fatigue, was also studied. After a walk of ten miles, Professor Maggiora took tracings of voluntary flexion of his right and left middle fingers. The amount of work of which they were capable was only about one-fourth of what they could do when there was no general fatigue. After massage for ten minutes they did nearly a normal amount of work, which, of course, was temporary. It has been found that the muscles of the fingers, fatigued in the manner mentioned by Professor Maggiora, by contractions with three kilos every two seconds, required two hours' rest in order that they might produce normal tracings of fatigue. (The massage was applied in this instance half an hour after the fatigue tracing was taken, so that making allowance for this extra work the inference would be fair that ten minutes of massage brought about more recuperation than two hours of rest. When there was no general fatigue, five minutes of massage to the finger would then equal two hours of rest, as in the other experiments.—D. G.)

6. After the loss of a night's sleep the fatigue curve was found to be very small, about one-fourth normal, but after ten minutes of massage it was temporarily restored to a natural curve, a result that was not obtained by nourishment nor by nerve tonics. In fatigue of muscles from fasting, rest alone will not restore them, and in muscular fatigue from wakefulness, food alone affords no appreciable relief.

7. The effect of massage upon muscles weakened by excessive intellectual work was also noted. After the final examination of twenty students, which took five hours, Professor Maggiora was much exhausted, and then took fatigue tracings of both middle fingers. These represented only one-fifth of a normal amount of work. Half an hour later, after ten minutes of massage, the amount of work was little less than natural, and probably would have been natural but for the extra work half an hour before.

8. After a slight attack of fever of ten hours' duration, the muscles were weak the whole of the following day. The influence of massage upon the flexors of the fingers increased their aptitude for work so that they gave a tracing of fatigue nearly normal.

9. Professor Maggiora showed that anæmia of a few minutes produced phenomena in muscles similar to fatigue. His brachial artery was compressed for three minutes, and a fatigue tracing was taken and found to be very small. Two hours later the brachial artery was again compressed for three minutes, and at the same time the forearm was subjected to mixed massage. Then another tracing was taken while the anæmia was kept up, and it was less than the previous one, showing that massage has no effect upon muscles when their blood-supply is shut off.

In comparing this last experiment with the preceding ones, it is evident that the effect of massage consists essentially in reawakening the phenomena of the local circulation, in bringing to the muscles a greater quantity of material necessary for their contraction, and in removing the retrograde products of muscular work.

Muscular Rheumatism almost invariably yields quickly to massage, and the result shows a fivefold influence: 1. Thermal: From equalized and increased circulation and warmth imparted by the hands of the manipulator. 2. Electrical: The muscles contract much more vigorously and agreeably to a faradic current after massage in these cases than before. 3. Neural: Pain disappears, which is brought about by, 4, the mechanical changes produced by massage, which dispels the muscular rigidity and the partial and irregular contractions of the muscular fasciculi, breaks up minute adhesions between muscular fibres, and thus restores flexibility and suppleness to the muscles, and removes pressure and pulling from terminal nerve filaments. Kühne has shown that the contractile substance of muscle is semi-fluid. The pathology of muscular rheumatism coming on suddenly is considered by Professor Busch to be a partial coagulation of the contractile muscular substance. The difference in the firmness of muscles lies not so much in the muscular substance as in the fascia that surrounds it. Where the fascia is thick the muscles seem hard; where thin, the reverse. Ludwig has shown the fascia to be a pump-like arrangement by which lymph is sucked out of the muscles and propelled onward into the lymphatics. Between the two layers of fascia are lymph spaces terminating in lymphatics. When the muscles contract, the inner layer is pressed against the outer and forces the fluid onward into the lymphatic vessels. When the muscles relax the inner layer falls away from the outer, and the lymph finds its way into it. Muscular contraction thus favors the removal of waste products. When muscles cannot contract without pain, as in muscular rheumatism, massage will more than make up for

* The ergograph of Professor Morse was used to take the muscular curves.

the loss of contraction. The intermittent pressure of massage has been demonstrated to increase the flow of lymph in a remarkable manner (see my "Treatise on Massage," pp. 72–75). In this connection a very practical hint is afforded us by those adhesions of the pleura which are frequently loosened by the rubbing together of the two membranes in respiration. 5. As to the chemical influence of massage in muscular rheumatism: It is pretty generally conceded that when a muscle or joint is impaired from fatigue, cold, injury, or rheumatism in the system, a deposit of uric acid takes place at the affected part. Therefore, when this gets well under massage, it may be reasonably inferred that the uric acid, or other *materies morbi*, has been got rid of. Further observations in this direction would be desirable.

I think that massage may be of some value in the diagnosis of doubtful cases of muscular rheumatism from neuritis. As ordinarily understood, muscular rheumatism is distinguished by rigidity of muscle, pain on motion, and ease when at rest. The immediate effect of massage in such is apt to be painful, but speedy relief follows. But there are many cases of what, I think, are erroneously called "muscular rheumatism," where the patients are much more comfortable when up and moving about, in which there is no perceptible muscular rigidity, but, on the contrary, there may be some flabbiness and slight atrophy of muscle, affecting either a single group of muscles or the same groups on each side of the body, and accompanied with some stiffness of motion, and in which pain is much aggravated after the patient has been warm and at rest in bed for some hours. In all probability these are cases of neuritis of the terminal nerve filaments supplying muscle, and the occasional appearance of neuritis affecting a distinct nerve-trunk in such cases would strengthen such a view. But be they what they may, the relief afforded by judicious massage is great and immediate, but not so lasting as in the previous class of cases. They quickly lose nearly all the comfort felt during massage, and it takes long to benefit them; thus in every particular differing from what we have hitherto understood by muscular rheumatism. The recent epidemics of influenza or grippe left a legacy of these neuro-muscular disturbances.

Pleuritic Effusions.—Ten cases of primary pleuritic exudations have been treated with massage of the chest by Dr. Poliakow (*Wien. Med. Presse*). Seven of these were purely serous, three sero-fibrinous. The manipulations were made in the direction of the lymphatics of the affected region. The treatment was begun with light stroking and soon brisk, deep massage was used, and this was followed by percussion, all occupying from ten to twenty minutes daily. The exudations disappeared in from eight to twenty days, and the other symptoms in from nine to thirty-five days. The chest pains were relieved, the muscles invigorated, and the respiratory movements increased in volume, and thus a marked influence on the absorption of the exudation and the distention of the compressed lung was obtained. Dr. Emil Schlegel has also reported several cases of pleuritic effusion where the absorption of the fluid seemed to be accelerated by means of massage. This was used in the form of percussion only, with the ulnar border of the hand striking at the rate of two blows a second, or six hundred in five minutes, which made a sitting, and two of these were given daily. Dr. Schlegel's enthusiasm carries him a little too far, for he believes that percussion might be quite as useful for promoting absorption in the intra-cranial cavity, the spinal canal, etc., forgetting that the blows would have to be so hard, in order to be effectual, that the patient would have reason to object.

Neuritis.—Massage is becoming more generally accepted as one of the proper measures to employ in cases of neuritis. In the early stages it may be used to push the blood out of the distended vessels and to create a free circulation in the adjacent tissues; in the later, to promote absorption of inflammatory products by spreading these over greater space, and for the relief of minute adhesions and thickening of the nerve-sheath. But the sentiment largely prevails throughout the profession that cases of fully developed neuritis ought not to have massage. Nevertheless, testimony is accumulating that even here it may be beneficial. I have recently had two cases of acute neuritis of the sciatic nerve in previously healthy people, in which the result was all that could be desired. In one, massage was used in conjunction with galvanism and tonics; in the other both medical and electrical means had been exhausted. It was the patient's third attack, the first having lasted for three months, then, after an interval of several years, came the second attack, which lasted for six months, and at this rate of increase we feared that the patient was in for a year of it with his third attack, which appeared several years after the second. But under massage alone the whole aspect of the case was speedily changed, and in the course of a few weeks the patient resumed his arduous professional duties.

Dr. A. Symons Eccles, of London, has reported in detail three cases of highly acute neuritis[1] of the sciatic nerve in previously well people, which he treated successfully with rest, position, and massage (*effleurage*, kneading, and percussion). In the intervals between the massage, the leg was suspended in a Salter's swing. It was contrary to all expectation that percussion could be used to advantage in such cases, but experience proved the value of it. In six other cases of sciatica that occurred in patients of an anæmic type the sciatic affection was evidently a concomitant of the general condition. In these general massage of the body, with frequent meals and the avoidance of all pressure upon the nerve-trunk, were kept up from four to ten weeks, with the result that not only was the sciatic pain removed but the patients all improved in appetite, weight, and strength.

Local Neurasthenia.—Neurasthenia, as I understand it, may be either general or local, affecting the nerves or nerve-cells of all or any part of the cerebro-spinal or sympathetic system. Its manifestations are those of exhaustion or too easy exhaustibility of nerve-force; and its pathology, malnutrition of the nerve-cells involved, with concomitant instability of their circulation in the form of anæmia or hyperæmia, or alternations of these. It predisposes to, it accompanies, it results from disease; the nervous shock and the tedious recovery from injuries point to other sources, and it may be caused by overwork, worry, or sheer laziness. The agreeable fatigue after a satisfactory day's work that insures sound sleep may be regarded as a healthy form of neurasthenia, if the Hibernianism may be pardoned.

It is a matter of common observation that those who are compelled to hard manual labor seldom suffer from nervous prostration, and among the more fortunate who may be predisposed to neurasthenia, those who are deeply interested in some hobby or occupation that keeps mind and body active, have found the best means of prophylaxis. The same means that serve for its prevention also supply us with a clue to one of the most valuable agents that can be employed for its relief or recovery. Exercise keeps the circulation active, but requires effort of brain, spinal cord, and nerves, as well as muscles, at a time when our object may be to afford rest to one or all of these parts of an overtaxed nervous system. Massage supplies this want, and will keep the circulation going with a minimum or no expenditure of nerve-force from the patient, and deep massage without friction will lessen the beats of the heart and afford it rest also. Nay, more, for it is getting to be the fashion not only among the laity, but also with some physicians, to say that massage imparts energy to the patient, though I confess I do not exactly understand what this means. Certainly many who submit to massage feel much more vigorous, light, and supple after even the first application than they did before it. But may not this rather be owing to the rousing of their latent energies and restoring the equilibrium of their forces by facilitating the circulation of blood and the flow of lymph and the transmission of nerve-force?

I have previously stated elsewhere that in cerebral exhaustion the relative value of massage was almost *nil*, and that out-of-door exercise was of paramount impor-

tance; but I have since found reason to modify this in favor of more massage and less exercise. In such cases, massage of the head alone daily, or every other day, is better than applying it all over the patient, unless there be a rare idiosyncrasy that will not allow the head to be manipulated.

There are people, not a few, who, when using their brains, suffer from uneasy sensations in the lumbar or dorsal region, and these discomforts continue after the cessation of study, causing wakefulness. Generally, there is also some spinal irritation in the region affected. In such cases massage of the back alone will often induce sound sleep, and next day the patient feels inspired with faith, hope, and courage, in place of doubt, dread, and fear of meeting appointments. With these cases a much more marked effect is produced by local than by general massage, except when the tenderness of the muscles and spinal irritation are extreme, unfitting them for every kind of work, and then the massage should be general, omitting the back at the first *séances*, but gradually approaching it at subsequent ones.

If space permitted I could give details of cases which would seem to justify the following conclusions:

1. That massage induces sleep.

2. That even when massage is applied in the forenoon its soporific effects may not disappear before bedtime, though in general the later in the day massage is used for promoting sleep the better.

3. Disagreeable feelings of drowsiness and languor do not necessarily intervene between massage in the forenoon and sound sleep at bedtime. Aptitude for rest or work generally follows massage. The mind is clearer, the mental faculties work easier and longer, the muscles are more supple, and do not tire so soon.

4. When people are wakeful after massage they may not be restless nor feel the loss of sleep on the following day. Generally they do not.

5. Spinal irritation is relieved or disappears under massage.

6. For local neurasthenia there is no need of general massage unless the whole system be secondarily affected.

7. When affections have come to a standstill under massage, improvement may yet go on after massage has been discontinued.

8. For improving the nutrition of nerves and muscles, restoring natural sensation and motion, massage may succeed when other means have failed.

9. Deep massage without friction has proved of more value in my hands than all other forms of massage put together.

10. Massage can be overdone, producing opposite effects from a moderate application.

11. Besides massage, carefully graduated exercises at regular times are valuable accessories in the restoration of motion.

12. Massage is not the only means of treatment for neurasthenia. Its selection is usually decided upon after the failure or exhaustion of every other means; in the same manner that the shrewd old divine decided that it was not wise to let the devil have all the good tunes to himself.

Diabetes.—Massage under the water, or *douche-massage*, constitutes the peculiar mode of administering the warm hydro-sulphuretted water of Aix-les-Bains, where it has been in use from time immemorial. The water is too feebly mineralized to be rationally employed in any other way than externally, which is thought to favor the absorption of sulphuretted hydrogen by the skin.

Dr. H. Forestier, physician at Aix-les-Bains, has employed this treatment in seven cases of saccharine diabetes in fat people, with the interesting result that there was an enormous decrease of the glycosuria without the intervention of any change in the alimentary regimen or the administration of any medicine.[2] The patients lived *à la table d'hôte*, eating a mixed diet of meats, sweets, fruits, and amylaceous substances. They followed their ordinary habits of exercise. The *douche-massage* was used with the patients seated or lying, while two *masseurs* occupied themselves, the one with the limbs, the other with the trunk, adroitly directing a jet from a nozzle under the arm, douching with both hands and *masséing* at the same time. This occupied ten or fifteen minutes. The temperature of the water was from 37° to 40° C. (98.6° to 104° F.).

The patients thus treated were classified as belonging to the clinical form of diabetes known as *diabète gras* of Lancereaux, or the slow diabetes of the English. All seven presented very similar features—age fifty to sixty years—*embonpoint* or confirmed obesity, extreme thirst, passage of excessive quantities of urine, and great muscular fatigue on slight exertion. These symptoms were overshadowed in four of the cases by arthropathies, and in two by neuralgia which had been mistaken for chronic rheumatism; and in one of them this diabetic neuralgia seemed like that of tabes, affecting the crural and sciatic nerves. In those patients with a large quantity of sugar in their urine, as well as in those with a small quantity, there resulted the same modification in the excretion of urea. Before the *douche-massage* this was less than normal, but under this treatment it increased, thus demonstrating increased oxidation and acceleration of retarded nutrition. The decrease in the sugar was great. In the first case, from 24 grammes in twenty-four hours to 1⅘ grain after the twentieth massage, in twenty days. In the second case, from 117 grammes in twenty-four hours to 66 grains after the twenty-fifth massage, in twenty-five days. In the third, from 87 grammes to 18 grammes after twenty massages, in twenty-two days. In the fourth, from 319 grammes to 101 grammes after nineteen massages. In the fifth, from 42 grammes to 5 grammes after twenty massages. In the sixth, from 30¾ grammes to 11⅔ grammes after twenty massages, in twenty-four days. In the seventh, from 291 grammes to 80 grammes after twelve massages.

The quantity of urine also decreased. The general condition of the patients improved, appetite and sleep were also made better. The pain and stiffness of those whose joints were thus affected were greatly benefited, but the neuralgia affecting the crural and sciatic nerves in one patient was still troublesome, though his general condition had become excellent.

The *douche-massage* would thus seem to be one of the most powerful means of hygienic therapeutics for fat diabetics, and can be used at the same time with other treatment, such as the internal use of the waters of Carlsbad and Vichy and Brides. But these are probably better adapted for diabetics with hepatic troubles and large livers, whereas the hygienic treatment of the *douche-massage* is rather indicated for cases where there is no appreciable trouble of the liver and where the general condition alone seems to be at fault. As to the duration of improvement after massage, but little is said except in two cases: in the one that had 319 grammes of sugar in twenty-four hours, after nineteen massages, this was 101 grammes; and at the end of eight months at home, on modified diet, this had still further decreased to 2 grammes. The following year he went to Vichy, and two months after he had left there the urine had 53 grammes every twenty-four hours. In another case that had been at Vichy for several years, the glycosuria had always increased to the same degree in the intervals between the seasons. After twenty massages, it decreased from 42 to 5 grammes, but how long it remained thus we are not told. The results must probably have been more favorable if the diet had been restricted, but in order not to obscure the results of the *douche-massage*, a full mixed diet was allowed. This might be a good course to pursue when the physician is obliged to use milder treatment than that of special diet, in order not to discourage the patient.

Professor Finkler has tried general muscle-kneading in fourteen cases of diabetes. The patients were at first masséed daily, and later, morning and evening for twenty minutes, over all the muscles of their bodies. The diet at the same time was mixed. A few of the patients were confined to bed, others were able to go about, and some did severe manual labor. The result, on the whole, was favorable, as shown by decrease in the quantity of urine

and of the sugar contained in the same, diminution of thirst, return of perspiration, and increase of body weight. After three months' treatment of one patient the sugar entirely disappeared from the urine, and this remained absent for three months after the last massage, then the sugar reappeared (Schmidt's "Jahrbücher," Bds. 2 and 3, p. 318).

As there was no external application used with the massage in Professor Finkler's cases, the result would probably have been as good in Dr. Forestier's cases without the douching with the waters of Aix.

Intermittent Fever.—Dr. Feroykövy, in the *Internationale klinische Rundschau*, states that in the Austrian army about one thousand soldiers were treated for intermittent fever annually. One of these cases was that of a soldier in whom neither the hot nor the cold stage was observed. He suffered only from severe vomiting, which quinine alone could check. Another case was characterized by severe sciatica. On one occasion when no quinine could be obtained, Dr. Feroykövy ordered these patients to be rubbed on the back with simple ointment. This was done twice in one day, and at the visit next day he found that the attack of fever which had previously occurred regularly had not made its appearance. The massage was later carried out in seventy patients suffering from intermittent fever without the use of quinine, and in sixty cases of quotidian fever the attack did not recur any more, but in ten cases of tertian fever massage had no effect. The same treatment was then tried in over one hundred cases, and in the "vast majority" the result was satisfactory.

Massage of the Heart.—Massage of the heart is very much overestimated. General massage is of great aid to the peripheral circulation, lessens the work of the heart, tranquillizes the nervous system, and induces sleep, even in the worst cases of heart disease. In a recent work Oertel places altogether too much importance upon the mechanical effect of massage of the heart over the chest-walls. In order that massage might act upon the heart in the same way that it does upon the muscles of the extremities (which he claims), it would be necessary to remove the chest-walls, a procedure that would hardly be justifiable. While the patient is standing he directs that gliding pressure should be made upon the chest-walls, downward and inward from the axillary line, the benefits of which he states are not only referable to its influence in perfecting expiration, but also to the direct pressure upon the heart, influencing its nutrition precisely as massage benefits the muscles of the extremities. It is indicated, he says:

1. When the heart-muscle is weak from deficient nutrition, anæmia, or corpulence.

2. When the arterial system is imperfectly filled and there is passive congestion as a result of insufficiency of the myocardium.

3. When there are valvular lesions or obstruction to the circulation, the pressure of tumors, or constriction of the pulmonary orifice. Emphysema and curvature of the spine increase the demands of the heart.

4. As an accompaniment of treatment of the heart by mountain climbing.

It is contra-indicated in acute or recurring endocarditis or pericarditis, in acute or subacute myocarditis, the result of sclerosis of the coronary arteries, and in general arterio-sclerosis.

But the great authority in this matter, according to Dr. Sarah E. Post, is the renowned pugilist, John L. Sullivan, of whom she says: "It is idle to fight with facts when a man like the great Sullivan insists upon being rubbed down and not up. . . . Horses, too, are rubbed down and not up" (*Massage Primer*, p. 27). The horses know as much about this as Sullivan. A moment's reflection will show that rubbing down would tend to produce engorgement of the venous and lymphatic systems.

Myxœdema.—I had never heard of massage being used in myxœdema prior to May, 1885, when Professor Robert T. Edes sent me a case. It was that of a man fifty-six years of age, who had suffered from the usual symptoms of myxœdema for four years. The result of a course of general massage every other day was most satisfactory. The boggy, brawny, waxy condition of the tissues gave place to suppleness and elasticity, freedom of motion, improved mental tone, and better hearing. Seven years have elapsed and the improvement has continued. Since then several cases have been reported much improved or cured by means of massage and hypodermic injections of an extract of the thyroid gland of a sheep. A most interesting case of this kind has recently been published in the *British Medical Journal* by Dr. Wallace Beaty. The patient, a lady forty-five years of age, had for five or six years become more and more easily tired, speech had become slow, memory impaired, temper irritable, walking difficult, constipation increased, susceptible to cold, etc. Her face was swollen, waxy-looking, and anæmic; lips and alæ nasi thickened, nose broadened, hair thin; hands and feet, arms and legs were enlarged and clumsy. No trace of the thyroid gland could be made out. Examination of the blood showed hæmoglobin to be seventy per cent. of the normal. Five weeks of massage brought some improvement, and then hypodermic injections of an extract of sheep thyroid gland were also used, and more rapid improvement followed. The patient was under this treatment for twelve weeks, continually improving. After treatment was discontinued she steadily progressed. "Now she is practically cured. The face looks natural, the skin of the face is no longer swollen, the lips and tongue are of natural size, the speech is rapid and easy, the hands are no longer clumsy, she can give a hearty and firm shake-hands, her rings are loose and easily removable, her movements are active, her hair, which had become thin, is now growing thickly; her memory has returned, menstruation, which was absent, is natural."

Massage of the Abdomen for Indigestion.—In dilatation of the stomach and chronic dyspepsia massage has proved of benefit, the distressing symptoms disappearing and the patients gaining flesh and strength. It should be applied as much as possible over the stomach, working from the left side upward and inward under the false ribs, so as to empty the stomach of its contents while stimulating the contractility of its muscular walls. The effect of gravity causes the food to lodge in the most dependent portion, in the greater curvature, and it needs to be pushed along toward the pylorus, at the same time that its peristaltic action is being increased. The whole abdomen should be *masséed* at the same sitting, as the bowels are also usually sluggish in these cases. Rubens Hirschberg, of Odessa, reports many cases of this kind which he relieved or cured by means of massage, and lays special stress on the fact that massage has an ultimate chemical influence in causing the disappearance of sour, burning eructations, foul breath, and bad taste in the mouth, as well as of sensations of weight and fulness, which would indicate an improved state of the gastric juice and better contractions of the stomach. I have witnessed the same result in several cases under my care. Hirschberg invariably found in these cases what I have seldom met with, that massage of the abdomen for thirty minutes had a decidedly diuretic effect, the daily quantity of urine in some being increased to three times the usual quantity, without any other inconvenience save that of frequent micturition. When massage was discontinued the urine fell to its former quantity. The increase of urine probably depends upon more active absorption of fluids from the digestive tract, increased blood-pressure, and stimulation of the splanchnic and pneumo-gastric nerves below the diaphragm, caused by massage. Contra-indications to the use of massage over the stomach or bowels would be symptoms of cancer or ulcer, acute or febrile states, and a suspicion of a tendency to hemorrhage. If cicatricial contraction of the pyloric orifice existed, massage might increase the dilatation, for the walls of the stomach would then in all probability yield more readily than the cicatrix.

Salol serves a useful purpose in showing us when the contents of the stomach pass into the small intestine. Insoluble in the gastric juice, it is decomposed into its

two constituents, salicylic acid and carbolic acid, in the small intestine, where it is subject to the action of the pancreatic juice, which renders it soluble and easy of absorption. Soon after absorption into the circulation it passes through the kidneys into the urine as salicyluric acid and sulpho-carbolic acid, its presence being shown by the production of a red-violet precipitate when the urine, after acidulation with hydrochloric acid and shaking with ether, is tested with a solution of perchloride of iron. Professor Ewald tied the pylorus of a number of dogs, then gave them large quantities of salol, without obtaining the reaction of this in the urine. Dr. Sahli found that acute catarrhal conditions, as well as chronic dilatation of the stomach, delayed the decomposition and absorption of salol. The experiments of Professor Ewald and Dr. Eccles agree in that they found, in most cases under natural conditions without massage, that salol could be detected in the urine in forty-five minutes after its administration; but after massage upon the abdomen for fifteen minutes the reaction of salol was obtained in thirty minutes.

In two obstinate cases the addition of general massage had a more favorable effect in hastening the absorption of salol than did massage of the abdomen alone.

After the administration of one gramme of salol to people suffering from chronic dyspepsia, Hirschberg, Brunner, and Huber found that it required from two hours to two hours and a half before the reaction of salol could be detected in the urine. But after a walk of fifteen minutes or gymnastic exercises for ten minutes, the reaction was obtained in one hour and five minutes. Similar results were obtained from faradization, but massage proved more efficacious than any other means. Hopadzë has made a series of observations showing that massage of the abdomen for ten minutes lessens the sojourn of the food in the stomach from fifteen to seventy-five minutes. He also made other observations upon healthy people, proving that the nitrogenous metamorphosis in four persons to whom he gave daily massage for twenty-five minutes invariably increased and lasted for seven days after a week of massage. The assimilation of the nitrogenous substances of the food increased in all the cases, and lasted during the week following the week of massage; but during the week of massage one gained in weight, two lost, and one was unchanged. The results obtained by Zabludowski were similar.

Relaxation of Ligaments is often erroneously diagnosticated after the improvement of a joint from the acute symptoms of disease or injury. It is much more frequently the case that the muscles moving it are atrophied and relaxed in consequence of the necessitated disuse, which thus allows too great traction upon its ligaments. Massage, carefully regulated movements, and faradization will restore the nutrition and tone of such muscles, and if the disturbance of the joint has disappeared, the limb can thus be got well. In three cases of this kind I had the pleasure of training the affected muscles as mentioned, so that from being totally unable to extend the affected leg at all, in a few weeks they could hold it fully and voluntarily extended for seven, nine, and ten minutes, respectively. The first of these was a stout elderly lady, who still had the remains of an old synovitis when she began this treatment, under which she fully recovered. The second was a gentleman of sixty-three years, who had developed a rheumatoid arthritis of his left knee in consequence of an injury, and though the peri-articular thickening disappeared, and the quadriceps extensor muscles improved so that he could hold the leg extended for nine minutes, yet grating of the articular surfaces remained, and locomotion was much impaired. The third was a long-levered, awkward woman, who had for many years suffered from relaxation of the quadriceps extensor to such an extent that it allowed the patella to slip externally without the power of voluntary or involuntary replacement, causing her many bad falls. When she had gained strength sufficient to hold the leg extended for ten minutes, she had correspondingly good use of the limb, but for security I still made her wear a few turns of roller bandage to keep the patella *in situ*. Let any of our readers take his watch and try to hold his leg and thigh fully extended without support for one or two minutes, and he will appreciate what was accomplished in these cases.

Massage in Sprains and Fractures.—It is an encouraging sign that physicians and surgeons are beginning to use massage themselves in sprains. The orthodox treatment of absolute immobility alone in these cases has little else to support it than the dogmatism of centuries, from which it has been almost impossible for a surgeon to free himself unless he has been the unfortunate victim of a sprain and had it treated with massage. Supposing that anyone wanted to make a well joint stiff, to what more effectual means could he resort than first to give it a wrench or sprain, and then do it up in a fixed dressing, so that the resulting inflammation would have an opportunity to produce adhesion of the tissues? Precisely the same course of treatment is employed for the purpose of closing up a hole, namely, that of exciting adhesive inflammation, and unfortunately it sometimes closes the cavity of a joint also. In my "Treatise on Massage" will be found the method of applying massage in sprains, and its results in seven hundred cases, showing that they got well in one-third of the time that they do without it, and with less tendency to subsequent pain, weakness, and stiffness than when massage had not been employed. The earlier after a sprain massage is employed, the more speedily does recovery take place. But sprains are sometimes complicated with fractures near and into joints, and of late years massage and movements have been used in these cases with advantage over the ordinary methods. In intra- and para-articular fractures the French surgeons, MM. Championnière, Tripier, and Rafin, have found that immobilization is accompanied with danger, whereas massage acts well from the first and can be used with other means. Their experience has been confirmed by Professor Lauderer, Dr. Kendal Franks, and others. The dangers of immobilization are stiffness of the joints and atrophy of the muscles; and the anæmia of the muscles (ischæmia) caused by fixed dressings may be mistaken for neuritis. It has been demonstrated by Kraske that the application of a rubber bandage to the leg of a rabbit for six hours has produced *vitreous* (hyaline) degeneration of the muscles, from which they cannot recover, The advantages of massage are that it promotes absorption of effused products, prevents stiffness of the joints and atrophy of the muscles, and favors repair. It should be done once or twice daily in these cases.

M. Championnière found that massage relieved pain, as most observers do who know how to apply it, but M. Rafin states that its application was painful. The manner of employing it would probably account for the difference. This is not stated. I have elsewhere given full directions how painful, swollen, and tender tissues can be gradually approached without hurting by working first on the adjacent healthy parts. Good recoveries were obtained by both MM. Championnière and Rafin, in from one-half to two-thirds of the usual time. Those cases in which there was no displacement did well under massage, and passive motion without immobilization. Those in which there was displacement of the fracture had massage at first to hasten absorption, then a retentive dressing for the shortest time possible to make sure that the displacement would not return, and after this massage and passive motion for the restoration of mobility. As soon as consolidation had taken place it was found that motion was free and easy.

In an article in *L'Union Médicale* of February, 1889, on fracture of the fibula treated by massage and mobilization, M. Marévery summarizes his experience by saying that almost all of his patients treated in this way recovered the use of their limbs in less than nineteen days after the injury. This treatment he finds can be used only for certain fractures, such as those of the inferior extremity of the radius, and of the lower end of the fibula. He also made use of cold applications and the rubber bandage as well as massage from the first, and passive motion was given to the joints early.

Professor Lauderer applies a fixed dressing for four or five days at first. After this he removes it for a short time daily in order to give massage, and at the end of ten or twelve days consolidation is sufficiently advanced to lay aside the splint altogether. This plan of treatment he finds preferable to all others for transverse fracture of the patella, as it is safe and simple and gives good results, the patients going about freely in four or five weeks. He has employed it in ninety cases of simple fractures of various bones, including fracture of the olecranon, of the anatomical neck of the humerus of the thigh, etc.[3] Dr. Kendal Franks considers that certain fractures are well suited for massage, such as fractures of one of the bones of the leg or forearm when the other bone acts as a natural splint and prevents displacement; and transverse fractures of the humerus and forearm or leg. The temporary removal of the splints in these cases for massage is not attended with any risk.[4]

In transverse fracture of the patella, even where good union has been obtained either by immobilization or by suturing of the fragments, or by fixation of them with Malgaigne's hooks, the resulting stiffness of the knee-joint, atrophy of the quadriceps extensor muscles, and impaired motion may cast a shadow of gloom over the most careful treatment or the most skilful operation. But the lesson taught by the cases in which the fragments have remained widely separated, and yet accompanied by good motion, has not passed unheeded. Professor Tilanus, of Amsterdam, treats cases of fracture of the patella without immobilization, using instead compression, massage, and early movements of the joint, leaving consolidation to take care of itself, for union is by no means certain under the best of care. In this manner the effusion is quickly dispelled, atrophy and stiffness prevented. His patients were encouraged to walk after the first week. Of six cases that Professor Tilanus treated in this way, the patients could walk very well in fourteen days (according to his own statement); —Rafin treated one case in this manner and the patient could walk perfectly in forty-two days, experiencing only slight difficulty in descending stairs. The seat of the fracture could then be felt with difficulty, being marked only by a slight depression of the skin, and the leg could be flexed within two fingers' breadth of the thigh.

Dr. Wagner, a regimental surgeon of the Austrian army, states that he has obtained astouishingly good results in five cases of fracture of the patella which he treated with massage, passive and active movements, but without even the application of a bandage. His method is somewhat as follows: The patient is put to bed and the affected limb stretched on a simple inclined plane, or on an adjustable wooden splint, so that the heel is elevated. In the first three or four days an ice-bag is placed upon the swollen and painful knee. As early as the fourth day massage may be begun, not only over the entire extent of the quadriceps extensor muscles, but also over a large portion of the knee-joint. This is done daily and soon followed by passive movements. As soon as possible the patient himself begins to move the joint, and after fourteen or twenty days may attempt to walk on crutches, and in six weeks is usually able to walk without support. Should the fragments be widely separated, Wagner advises subcutaneous suture, but even here massage and exercise "cannot be begun too early." In fine, by means of massage and movements, the indications in every case are largely met. These are, the removal of the effusion so as to allow the fragments to come closer together, the favoring of repair and the formation of callus, the prevention of atrophy of the quadriceps extensor and the shrivelling of the capsule, and the early restoration of motion. It is needless to state that these manipulations should only be undertaken by some one having sufficient anatomical and surgical knowledge.

It is worthy of notice that the principal muscles of the quadriceps extensor that effect extension of the leg, are the vastus internus and vastus externus. The insertion of these on the lateral aspects of the patella extends much lower than is generally supposed, and affords leverage to extend the leg when a fragment of the patella is detached above their insertion. Rupture of the rectus femoris alone has little or no influence in hindering walking (after the immediate effect of the injury is recovered from). Dr. Kummer, of Geneva, and Dr. Kaufmann, of Zürich, and Mr. Page, of Newcastle-on-Tyne, have each performed total extirpation of the patella for disease of that bone without impairing the patient's gait or interfering with the movement of the knee-joint, when the latter was healthy. Slightly weakened power of extension of the leg was the only noticeable feature on close examination.[5]

After union of any solution of continuity, whether of bone, muscle, or nerve, massage and movements are in order, and even when repair is going on the mobility of the joints may be still better secured by altering the position of them at each dressing.

Contusions of Joints or Muscles are speedily relieved of pain, swelling, and stiffness when massage is applied from the first, and atrophy, which is so apt to follow even slight injuries of this kind and of sprains, is prevented. M. Castex has recently made a very interesting series of observations, both clinically and experimentally, on this subject (*Archives Générales de Médecine*, 1891-2). For the sake of comparison he purposely bruised corresponding muscles and joints of the same legs of various dogs, and to one limb he gave massage, and to the other none. The limb that was *masséed* quickly recovered, while the other remained swollen, sore, and stiff, and later there was atrophy of the muscles. His experiments were carefully watched by others, who did not know which leg was being *masséed*. Massage gave like good results when applied *immediately after* the reduction of dislocations in dogs, and in man also the results were very favorable when massage was used after the joint had been held in place for a few days.

M. Castex reaches the following conclusions, which are based upon both clinical and experimental observations:

In *simple contusions* of muscles massage rapidly dispels the various troubles, but principally the pain.

In *articular contusions* massage dispels the reflex muscular contractures and the pareses, and above all it prevents the rebellious muscular atrophies which are the most serious complication thereof.

Applied to sprains, it is remarkable by the rapidity of its good effects.

In *luxations* we ought to have recourse to it as soon as the reduction is assured, for it very speedily reduces the swelling, the ecchymoses, and the pain. It awakens the muscular fibres from that local stupor into which they have been plunged by the injury. It prevents atrophy and stiffness.

Applied to *juxta-articular* fractures, massage rapidly terminates pain and swelling. By this means a simple fracture of the inferior extremity of the radius without deformity is cured in fifteen days, whereas it would take forty days, at least, with plaster immobilization. If it is applied after the removal of the fixed dressing it renders the parts supple and dispels the œdema.

Massage has proved of little use against acquired muscular atrophies. It prevents them when applied early.

Histological Results. — The muscle injured and not *masséed*, under the microscope presented a *diffuse sclerosis* with hypertrophy of the connective tissue in its various parts, interstitial hemorrhages, engorgement of the blood-vessels, and hypertrophy of their external coat.

The muscle injured but *masséed* presented a normal histological aspect.

The blood-vessels are normal in the muscle *masséed*. In the muscle not *masséed* they show a hyperplasia of their external coat.

The nerve-filaments in the *masséed* muscle are normal; in the non-*masséed* muscle they present evidences of perineuritic and interstitial neuritis with compression of the nerve-tubes. The perineurium is at least three times as thick in the *non-masséed* side as it is in the *masséed* side. The lesion of the nerves is more marked than that of the vessels.

In brief, massage acts by deterging a part from the various injurious materials which have been poured into it as a result of injury, in bringing this part back to its normal condition, and in preventing the process of diffuse sclerosis which would result. Such is the positive explanation of massage, and it can only increase its credit.

INCONTINENCE OF URINE IN FEMALES.—Some of our readers may wonder why attention has not been given in this article to massage of the uterus and its *suburbs*. For information on this subject we would beg leave to refer them to my "Treatise on Massage," which has a chapter on "*Massage of the Uterus and its Surroundings*," which the New York *Medical Record* said was "worse than ignoranee," while the *Dublin Journal of Medical Science*, August, 1891, said of the same: "Those who objected so strongly a short time ago to the employment of massage in these regions, would do well to read this chapter and to bear in mind the author's observation, that 'Massage of the pelvic organs should be entrusted to those alone who have clean hands and a pure heart.'"

It is both novel and interesting that massage can be applied to relieve and cure incontinence of urine in females. Dr. W. S. Bagot, of the Rotunda Hospital, Dublin, has used it with complete success in a number of cases of this kind. His method is that of Brandt stripped of all unnecessary details. He introduces the index-finger of the left hand into the vagina (the rectum in children), slightly flexed and passed obliquely, so as to partially encircle the neck of the bladder. The right hand grasps the wrist so as to regulate the pressure used, and then the finger in the vagina or rectum is made to vibrate against the neck of the bladder, compressing it with moderate force against the pubes. This is done three or four times, and then the opposite side of the bladder is treated in the same way with the index-finger of the right hand. In this manner one patient, who had suffered for a year and a half from incontinence of urine, with a patulous urethra and slight prolapses of the anterior wall of the vagina, and abnormal distensibility of the perineum, was cured in twenty-nine days, and nine months later had no relapse.[1] Another patient, twenty-four years of age, who had suffered from nocturnal enuresis from childhood, was treated in this way every other day for five weeks, and thus got well. Another patient, forty years old, whose water had passed from her involuntarily for three years while walking, got well in three weeks under this treatment. Brandt and Boldt have also reported numerous successful cases treated in this way when other means had failed. A lady who had been treated by some of the most eminent German specialists by dilatation of the urethra, electricity, etc., for incontinence of urine of six years' duration, was cured by Brandt in eight days. In two cases of children, aged nine years, Boldt reported success after treatment of three weeks.

Dr. Sänger's method is also a sort of massage, and has been successfully used for incontinence of urine in females.[2] It consists in dilating the vesical sphincter with the patient in the dorsal position. The urethra is disinfected and a metallic female catheter is passed into the bladder a distance of from five to seven ctm., so that its point is on a level with the orifices of the ureters. The tip of the right index-finger being kept in the mouth of the catheter prevents the urine from flowing off, while the index- and middle-finger of the same hand steady the instrument. The index- and middle-fingers of the left hand are placed upon the catheter close to the urethral orifice, and with these the operator makes a springy and forcible pressure, at first downward and then toward both sides, alternately, so that the urethra becomes widely open and urine flows out by the side of the catheter. Thus the sphincter of the bladder and the muscularis of the urethra are strongly stretched. Further massage can also be done by a finger in the vagina or rectum pressing against the catheter. The stretchings are not very painful, but in sensitive people the urethra can be previously brushed with a ten per cent. solution of cocaine. Ten or twelve *séances* usually suffice. They should be twice daily at first, and later every other day. The stretching causes an irritation of the sphincter which makes it contract more strongly, both in a direct and reflex manner, and thus a certain degree of hypertrophy from work is set up. This method is not applicable when there is an abnormal dilatation of the neck of the bladder and of the urethra with incontinence.[6] *Douglas Graham.*

[1] Practitioner, vol. xxxiv., No. 5.
[2] Archives Générales de Médecine, September, 1891.
[3] Sammlung klinischer Vorträge, No. 19.
[4] Dublin Journal of Medical Science, November, 1891.
[5] The Provincial Medical Journal, January, 1890.
[6] Dublin Journal of Medical Science, October, 1891.

MASTOID ANATOMY, FROM THE SURGICAL STANDPOINT. From its revival, in the middle of this century, the operation of opening the mastoid process to evacuate pus, which had undergone an eclipse after its introduction by Petit (1750) and Jasser (1776), has been growing greatly in frequency and success. To this nothing has contributed more than the anatomical studies which have thrown increasing light upon the structure of the parts involved and pointed the way to avoidanee of the dangers which surround it. Now, the well-posted aurist feels that the field is as safe as any in surgery, that the indications for operation are as well defined, and that the serious or fatal results of timidity or neglect are as likely to be the subject of lay criticism as unlueky temerity would have been at an earlier epoch. The advances of pathology have cleared up many of the mysteries as to the causation of brain-abscess, septic thrombosis, and neck-abscess, formerly not recognized as aural in origin; and the progress of otological teaching and practice has done much to disseminate information and lead each medical man to call in the aid of a specialist when he feels unwilling to proceed unaided.

The earlier operations were usually either guided by the presence of a fistula or softened bone, or were done with a blind boldness that could not be often repeated without disaster; and the procedures described and commended were sometimes such as could rarely be safe. Because Kölpin bored a hole up and back of Von Berger's ear, where he was certain to enter the cranial cavity or the lateral sinus, the operation was discarded for a century. In like manner the real dangers of imperfect procedures and the magnified risks of those better planned have greatly retarded the due acceptance of the measure. Yet the wide experience of many men has demonstrated the value of operation for the saving of life, of hearing, or of time; since the fatality among the cases not operated upon is many times greater; the damage to the organ of hearing, when they survive, generally much more serious; and the treatment, though at times many months long after operation, is apt to extend over years without it. Only in cases where the indications are very doubtful can the over-cautious any longer claim that it is less dangerous for the competent surgeon to temporize than to explore; and as the knowledge is spread of the best rules as to when and how to operate, a still more brilliant showing will be made.

The mastoid process is a conoidal protuberance of the lower posterior portion of the temporal bone, forming the major part of the insertion of the sterno-mastoid muscle. It is developed from the outer part of the petro-mastoid and the lower posterior part of the squamous, and enlarges from an inconspicuous tubercle at birth to form the large process usually found in the adult. It is a response in part to the needs of the muscle inserted upon it, and shows an external development usually corresponding to the general osseous and muscular development of the individual; being large, rugged, and massive in most strongly built males; smaller, smoother, and thinner-walled in females and those of slight physique. Its posterior border is only partly marked by the deep digastric fossa or groove, which intervenes between its apex and the skull-base; anteriorly its convex external surface slopes inward to become the back wall of the meatus. Above, it may be said to extend to the curving and often ill-defined temporal

ridge; but is better considered to end at the imaginary horizontal line on the level of the upper wall of the external meatus (Fig. 392). Almost exactly at the juncture of these anterior and superior limits there may almost always be found a depressed groove or pit, below which a ridge or spine projects toward the canal. This *spina suprx meatum*, to which Bezold especially directed attention, is present in the great majority of cases, and forms as fixed and clear a guiding-point as can be taken, not only for

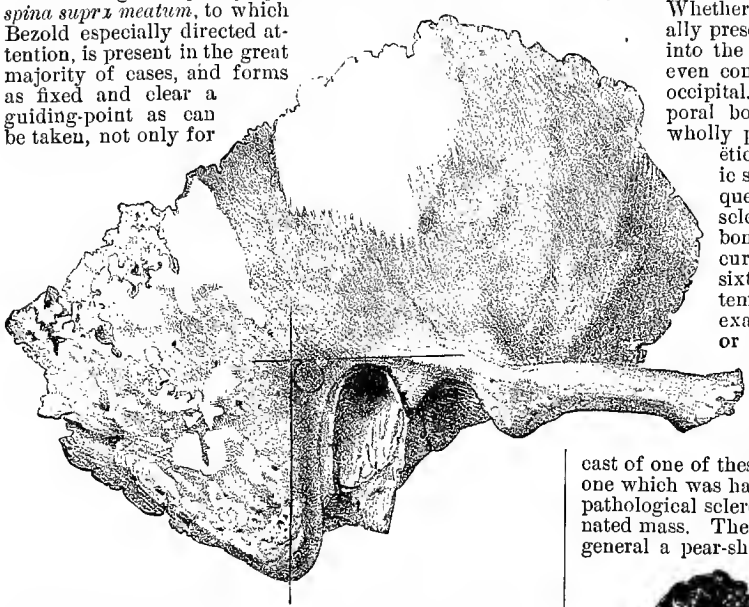

FIG. 392.—Right Temporal Bone, showing the vertical and horizontal lines and the position for opening the mastoid antrum. (After Nuhn.)

all measurements of the temporal bone, but for the entire cranium. It was absent or very ill-defined in but five temporal bones among one hundred and eighty in my collection, examined as to it—every time on the right; Kiesselbach found it in eighty-two per cent. of juvenile and eighty-seven per cent. of adult bones.

The median surface of the cranium, at the part which may be considered the inner surface of the mastoid, is grooved more or less deeply by the sigmoid sulcus to accommodate the lateral sinus, which is formed by separation of the layers of the tentorium in its posterior part, but is wholly in the posterior cranial fossa as it passes down to the jugular foramen. The middle cerebral fossa is partly formed by the squama and reaches downward toward the upper wall of the canal. The height of its floor is subject to great individual differences, and also at different points of the same bone, being lowest in front and rising backward. It is, however, practically never so low as the base line of the mastoid, although not rarely lower than the temporal ridge. It cannot be said, like the lateral sinus, strictly to belong to the anatomy of the mastoid; yet it has too great practical importance to be omitted in our consideration of the field of operation.

FIG. 393.—Metal Cast (freed by corroding away the structure of the bone itself) of the Spaces of an exceedingly Pneumatic Mastoid, showing the large cells so developed that only the thinnest septa remained to separate them. (Randall, Corrosion Anatomy.)

The interior of the mastoid is more or less filled by cavities, usually pneumatic, and lined by extensions of mucous membrane from the tympanum, with which they communicate. They may serve some unknown physiological purpose in connection with hearing, but probably they are only to be regarded as rarefactions of its structure. Hence they are hardly in existence when the mastoid forms but a tiny tubercle in infancy; but they increase in number and size with the growth of the process, and exhibit extreme growth by the thinning of walls and septa and the coalescence of adjacent cells in the rarefied bones of senile individuals. Whether pneumatic or diploëtic, they are generally present throughout the process and extend into the adjacent squama and petrous, and may even communicate with similar cavities in the occipital. Among two hundred and fifty temporal bones, Zuckerkandl found 36.8 per cent. wholly pneumatic, 20.4 per cent. wholly diploëtic, and varying combinations of pneumatic spaces and diploë in 42.8 per cent. The question as to how often an apparently sclerosed condition may be met in normal bones is still an open one, although its occurrence is well established. Among sixty-five pairs and fifty single macerated temporal bones, in the writer's collection, examined in this regard, only twenty-three, or thirteen per cent., showed absence of completely pneumatic structure throughout, although in sixty-two more, or thirty-five per cent., the cortex and the intra-cellular walls were thick and massive. Fig. 393 shows a metal cast of one of these fully pneumatic mastoids, Fig. 394 of one which was half diploëtic, and Fig. 395 one in which pathological sclerosis had rendered it a nearly solid, eburnated mass. The pneumatic cells are claimed to show in general a pear-shape (Figs. 396 and 397) and a radiating

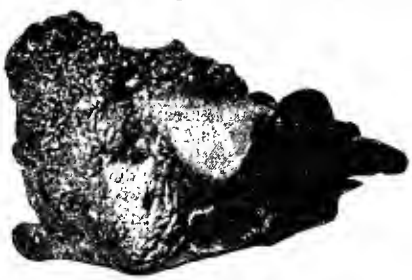

FIG. 394.—Metal Cast of the Spaces of a Temporal Bone, in which only the portion of the mastoid adjacent to the antrum was occupied by pneumatic cells, while the major part of the process was diploëtic. (Randall.)

direction, the smaller ends pointing toward the mastoid antrum, with which they communicate. This antrum, which has been generally described as the most constant in size and position of the mastoid cells, is really the upper posterior cavity of the tympanum, being full-formed at birth and of about the adult dimensions. Its later changes are principally in the fenestration of its walls for communication with the adjacent cells. The antrum is superficial in infancy, its outer wall and part of the

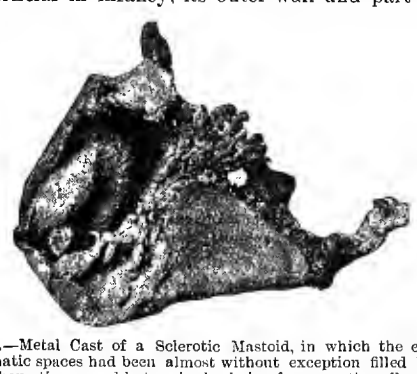

FIG. 395.—Metal Cast of a Sclerotic Mastoid, in which the extensive pneumatic spaces had been almost without exception filled by eburnated bone tissue, and but a single chain of pneumatic cells extended down from the antrum to the tip of the mastoid process. (Randall.)

upper being furnished by the thin vertical plate of the squama; but the thickness of the outer plate increases with maturity, reaching an average of 12 mm. as the squama grows outward to form the bony external meatus (Fig. 396). There is no dividing-line above between the antrum and the attic (*recessus epitympanicus*), the thin *tegmen* roofing in both cavities (Fig. 400, upper half); but the facial and external semicircular canals form a lower median prominence, which serves to narrow the communication and constitute the *aditus ad antrum* (Fig. 400, lower half). Measured from the middle of this threshold the antrum is 10 to 12 mm. in length, while about 6 mm. in breadth and height. Leidy describes backward and outward extensions of the antrum as occurring at times. Its long axis is about the same as that of the tympanum and tube, and at an angle of some fifty degrees to the axis of the external meatus (Fig. 401); but one case was found by Bezold where, on each side, the antrum lay above, and not at all behind the meatus. Its innermost end is, therefore, close above the upper posterior extremity of the auditory canal, but it diverges from it as it passes back and out, and the intervening wall of bone is wedge-shaped, as it increases to 4 or 5 mm. in thickness. This septum is rarely solid, but so occupied by small cells that the actual bony separation is quite readily broken down by antrum disease and a fistulous opening formed into the upper back part of the meatus.

The groove upon the inner posterior surface of the mastoid for the lateral sinus (*sulcus sigmoideus*) is one of the most varying features of the temporal bone. Generally distinct, but shallow, and presenting gentle curves, it may be almost too faint for recognition (Fig. 398); or again of double the usual size and with strongly pronounced curves and margins greatly overhanging (Fig. 399). Receiving the superior petrosal at about the point where it turns downward, and the inferior petrosal near its entrance into the jugular fossa, it experiences some change in size and form on this account. It gives off generally a good-sized emissary vein near the lower turn, which deeply grooves the bone at times in its passage to the mastoid foramen, where it unites with branches of the external jugular system. Rarely this emissary receives nearly or quite all of the blood of the lateral sinus, and may present quite a bulla where it enters the bone; the jugular foramen then giving exit merely to the inferior petrosal. Sac-like bullæ are also found upon the anterior part of the lateral sinus, and may thin the bony wall toward the meatus or the mastoid surface, even forming a considerable dehiscence. The bony surface of the sulcus is generally entire, though often as thin as paper between it and the adjacent cells; yet dehiscence here is only a little less rare than in the tegmen.

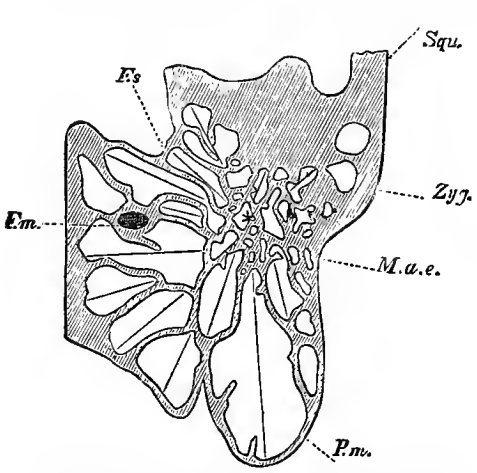

Fig. 396.—Vertical Section of Mastoid Process at Right Angles to the Axis of the Auditory Canal, showing highly developed pneumatic cells and their radiating relation to the antrum. (After Eysell.)

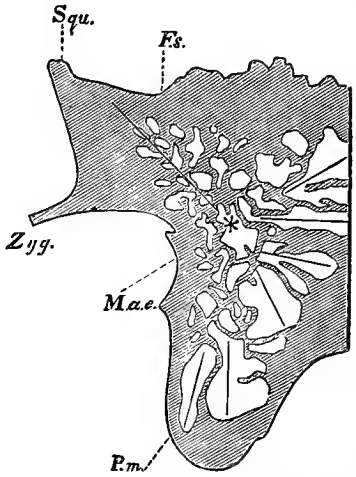

Fig. 397. — More Compact Temporal Bone, cut vertically at right-angles to the auditory canal and showing thicker septa of bone and medium-sized cells. (After Eysell.)

The relation of the sigmoid sulcus to the outer surface of the mastoid and to the back wall of the canal depends upon a series of varying factors. The sinus which it accommodates varies greatly in size, form, and position. The mastoid process presents very differing dimensions, wholly independent of the blood-vessel, and the interposed bone may be solid, diploëtic, or full of pneumatic cells, and thus present wholly dissimilar grades of protection against injury in the opening of the mastoid. Indeterminate as the mastoid process is in size, there is usually fair symmetry, so that the form of one mastoid when concealed by swelling may generally be determined from a study of the other. In a study of forty-eight pairs of bones Bezold found an average length of the process below the spina of 25.17 mm. on the right, 25 mm. on the left (19 to 31 on each side), with a max-

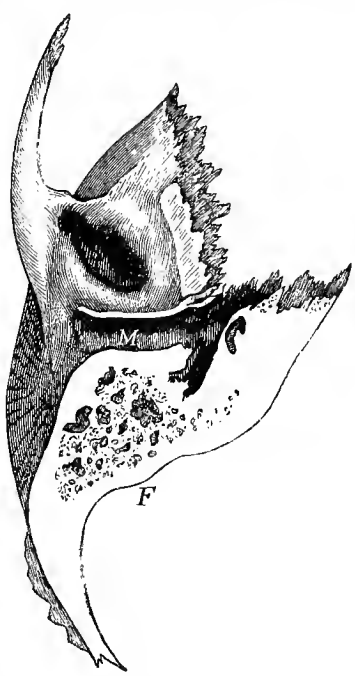

Fig. 398.

Fig. 399.

Figs. 398 and 399.—Horizontal Sections of Right and Left Temporal Bones at the Level of the Middle of the Auditory Meatus, showing the position of the sigmoid sulcus of the lateral sinus at F, in the left far anterior, and closely approaching the meatus and outer mastoid surface; further back, and separated, in the right, by abundant pneumatic cells from the meatus and surface. (After Hartmann.)

imum difference of 5 mm. where the right was larger, and of 3 mm. where the left was larger. Among fifty pairs of temporals in the writer's collection, studied in like manner, the average length was 28.3 mm. (35 to 21) right, 29 mm. (38 to 22) left, with a maximum difference

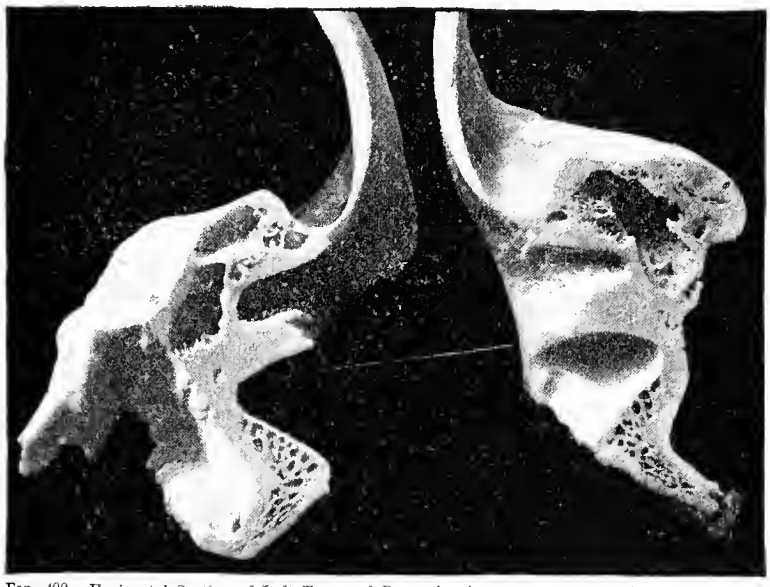

FIG. 400.—Horizontal Section of Left Temporal Bone, showing an extreme anterior and superficial position of the sigmoid sulcus, bringing the lateral sinus almost into contact with the meatus wall and the mastoid surface in the region of the spina, and rendering wholly impossible the ordinary operation for opening the antrum. (Randall, Photographic Illustrations.)

of 5 mm. with larger left, and 3 mm. with larger right. Hartmann measured from the linea temporalis and found an average length of 32.4 mm. (23 to 42) and breadth 26.7 mm. (18 to 35). The less determinate breadth averaged in the writer's series 22.9 mm. (17 to 27) right, 22.5 mm. (16 to 28) left, with a difference only once as much as 3 mm.

No such symmetry exists as to the sigmoid sulcus; on the contrary, one, more often the right, is almost always larger. This larger size of the right sinus, which Bezold, with Rüdinger, estimated at seventy per cent. (although only thirteen right and nine left among his forty-eight pairs), is given as forty per cent. by Schülzke (24 : 5 among 60), was fifty-six per cent. (28 + 5? : 12) among my fifty pairs, and among two hundred and forty skulls was forty-four per cent. (106 + 29? : 59 + 24?). With this larger size, which may be due to the fact that the superior longitudinal sinus generally goes to one side instead of dividing its blood stream at the torcular, and that the right jugular furnishes a shorter and readier path to the heart, there is often a more powerful flow of blood, which may be the reason for a more curved and deeply hollowed sigmoid sulcus. Hartmann and Bezold noted that the sinus extended in about equal proportion outward and forward (Figs. 405 and 406); and Koerner confirmed this so decidedly that he measured only its extension outward to approach the outer surface of the mastoid. Koerner also studied the relation of this curved superficial position to the general form of the cranium (Figs. 402 and 403), and confirmed Bezold's showing that it is more usual in brachycephalics (skulls short for their breadth). These views are combatted by Schülzke, who found little relation between the anterior and the external location of the sinus, and that the more dangerous position was commoner among the dolichocephalic (long and narrow) skulls. This controversy deserves careful statement and analysis, as it furnishes some of our most important data as to the anatomy of the mastoid. Koerner made

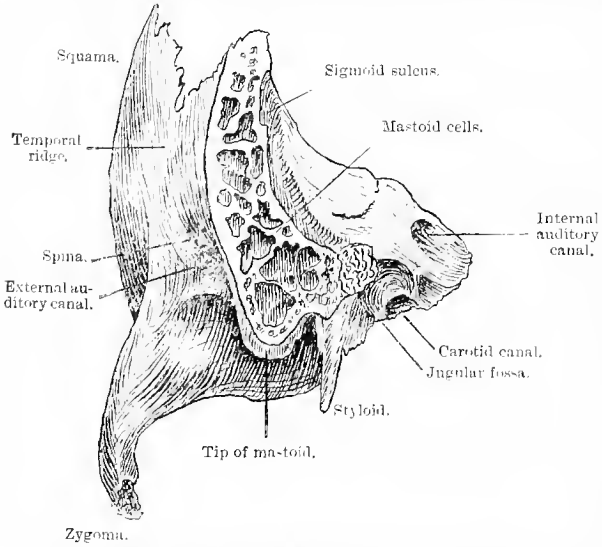

FIG. 401.—Posterior Inferior Aspect of Temporal, sectioned nearly frontally to show the mastoid cells between the lateral sinus and the exterior, generally thin-walled toward the sigmoid sulcus and the digastric fossa within the mastoid tip.

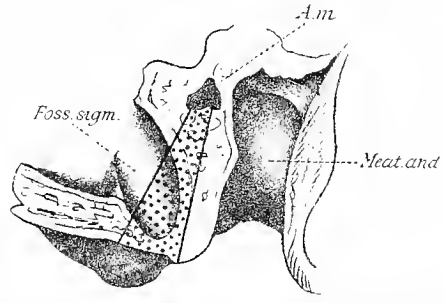

FIG. 402.—Horizontal Section of a Dangerous Temporal Bone, showing the anterior position of the lateral sinus, which closely approaches the auditory meatus and the mastoid surface, and lies in the operation path to the antrum, *A.m.* (After Koerner.)

the claim that the broad skull generally showed a lower cerebral fossa and a more forward and superficial position of the lateral sinus than the skull of lower index; and that this relation was more marked upon the right side. Hence the mere measurement of the length and breadth of a patient's head and consideration of which side is affected would serve to furnish most important prognostic data as to the safety or danger of operation. This relation he ascribed to the incurved line of the mastoid and the upward direction of the pyramid in the

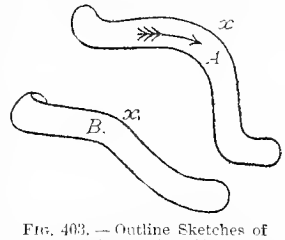

FIG. 403. — Outline Sketches of Casts of the Sigmoid Sulcus seen from the side. *A*, from brachycephalic; *B*, from dolichocephalic skull, showing at *x* the point of greatest curvature and most vulnerable position. (After Koerner.)

brachycephalic skull (as shown in Fig. 405). He measured in sixty skulls the thinnest point of the mastoid over the sinus, and in a later paper gives the data of twenty-seven more, while in a third paper he sets forth the results obtained from horizontal sections of twenty-seven of the same pairs. Yet Koerner's figures show the strange omission of any reference to the position of this most superficial portion of the sulcus, so that it remains wholly uncertain from his data whether the superficial sinus lay in or wholly beyond the field of operation. In Bezold's earlier work this point is well studied, and he gives the average distance of the sinus from the mastoid surface as 7.6 mm. (2 to 17), at an average distance of 15.6 mm. (6 to 24) horizontally back of the *spina supra meatum*. Koerner's results are rather specious, therefore, as to the vulnerability of the sinus. A much more important point was determined by Hartmann among the fifty pairs of bones he operated on and then sectioned. He measured the distance between the lateral sinus and the posterior wall of the auditory canal at about the level of the spina, finding it to vary from 5 to 19 mm. (Figs. 406 and 407), with an average of 11.5. In 41 of the 100 bones it was 10 mm. or less (in 1, 5; in 5, 6; in 6, 7 mm.). In like manner Schülzke found in sixty skulls the meatus-sulcus distance to vary from 3 to 20 mm. It averaged 11.9 mm. (3 to 16) on the right and 13.4 mm. (10 to 19) on the left in nineteen dolichocephalic skulls, and 12.5 mm. (5 to 20) right, 13.7 mm. (5 to 20) left in thirty-six brachycephalic skulls; the general average being 12.4 mm. right, 13.6 mm. left. The maximum difference in any skull was 7 mm. where the right, and 4 mm. where the left, was farther forward. Similar figures from twenty-seven skulls measured by Koerner gave averages of 12.50 mm. for dolichocephalic, 12.28 mm. for brachycephalic, 11.86 mm. right and 12.91 mm. left, with a maximum difference of 7.2 mm. in any one

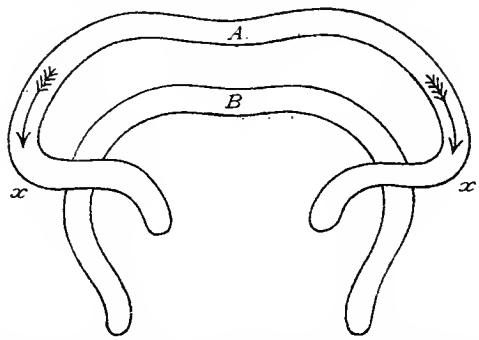

FIG. 404.—Outline Sketches of Casts of the Sigmoid Sulcus seen from above, showing the stronger curves and more outward extension in the brachycephalic, *A*, than in the dolichocephalic, *B*. (After Koerner.)

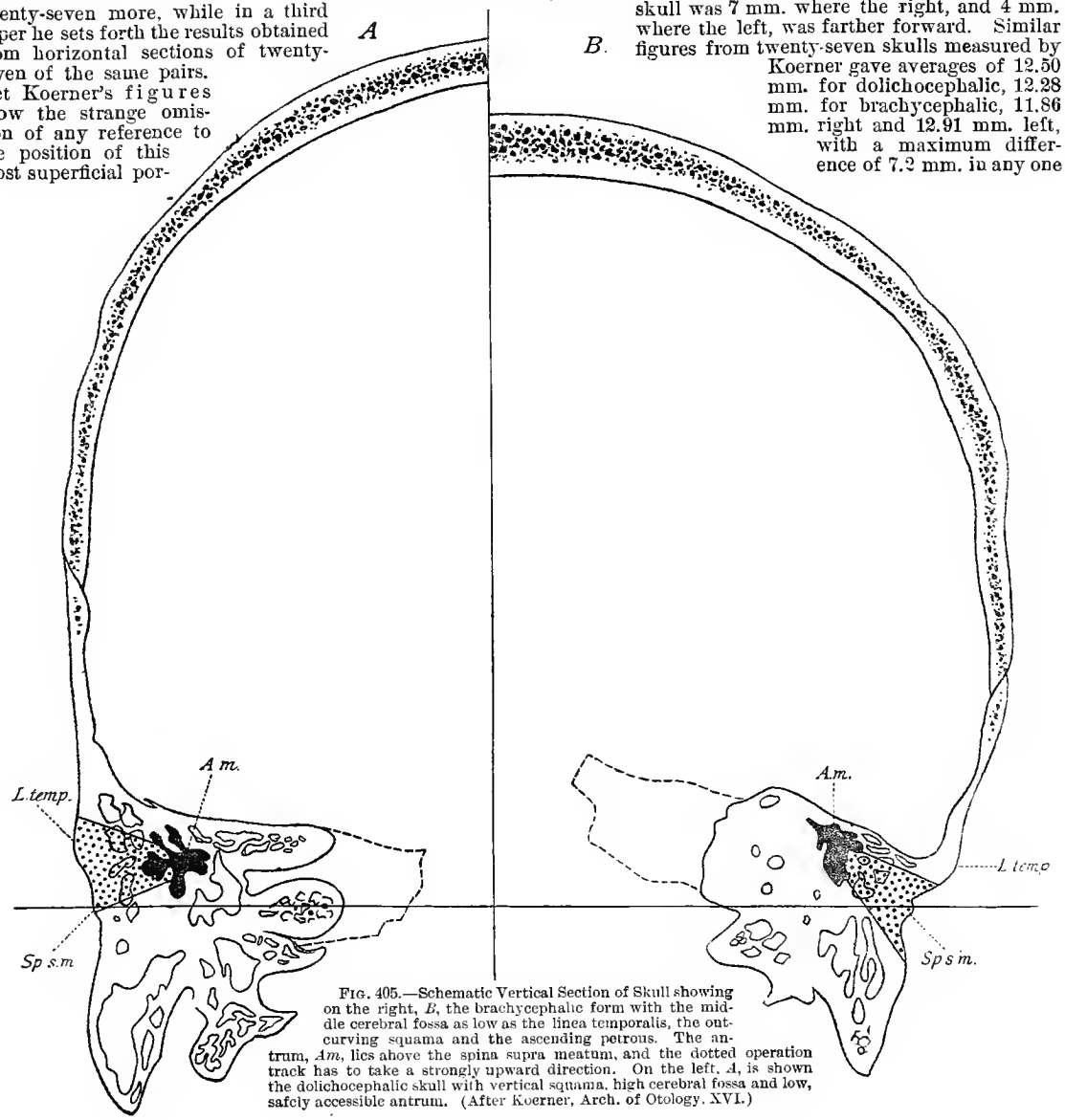

FIG. 405.—Schematic Vertical Section of Skull showing on the right, *B*, the brachycephalic form with the middle cerebral fossa as low as the linea temporalis, the outcurving squama and the ascending petrous. The antrum, *Am*, lies above the spina supra meatum, and the dotted operation track has to take a strongly upward direction. On the left, *A*, is shown the dolichocephalic skull with vertical squama, high cerebral fossa and low, safely accessible antrum. (After Koerner, Arch. of Otology, XVI.)

case. Study of two hundred and forty skulls has furnished the writer with an average of 11.9 mm. (1 to 20) right, 12.8 mm. (0.2 to 20) left, with the right sinus more anterior (13 mm. max.) in 101 and the left (7 mm. max.) in 78. The eighty-five long skulls gave

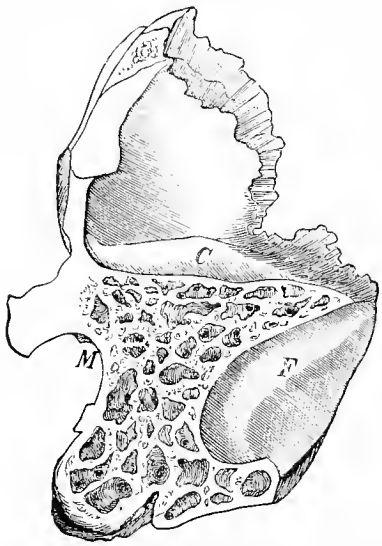

FIG. 406.—Vertical Section of Pneumatic Left temporal Bone at right angles to the Auditory Canal, showing abundant cellular interspace between the sigmoid sulcus and the meatus. (After Hartmann.) (Same lettering as in Fig. 407.)

exactly the same figures as the whole series, while the one hundred and twenty short skulls gave averages of 11.4 mm. (1 to 19 right), 12.5 mm. (1 to 20) left, with the more anterior sinus forty times on the right and forty-four times on the left.

Such figures wholly fail to support Koerner's view,

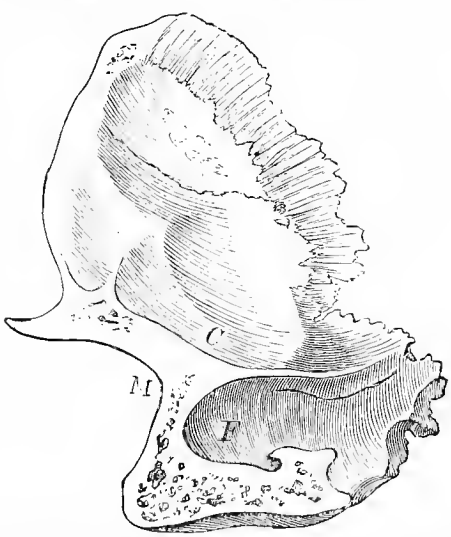

FIG. 407.—Vertical Section at Right Angles to the Canal, *M*, of a diploëtic right temporal bone, showing a forward and superficial position of the sigmoid fossa, *F*, and a low middle cerebral fossa, *C*. (After Hartmann.)

and the choice of the twenty extreme examples at each end of the scale gave averages of 11.5 mm. right (0 to 17) and 13.1 mm. left (9 to 16) for dolichocephalic, as compared to 12.8 mm. (7 to 17) right and 13 mm. (10 to 16) left for brachycephalic. His findings must, therefore, be regarded as accidental. The thinnest point over the sinus, as to which Koerner makes his showing, averaged 7 mm. (0 to 17) right, and 7.5 mm. (0.5 to 22) left, among the writer's two hundred and forty skulls, and its position back of the spina 16.5 mm. (1 to 25) right, 15.8 mm. (1 to 24) left—figures of small significance except in showing, as do the other parts of the study, that minimum results may be met on either side and in any form of skull.

Another series of measurements made by the writer have probably more importance than either of the former. The distance was determined between the most vulnerable point of the sinus and a point 5 mm. behind the spina —thus giving the "operation room" presented by each specimen. This averaged 10.9 mm. (2 to 19) right and 11.7 mm. (1 to 20) left, among 85 dolichocephalic skulls; the right sinus being in the more dangerous position in 43 and the left in 24. For the 120 brachycephalic skulls the averages were 11.6 mm. (3 to 18) right, 12 mm. (1 to 20) left, the more exposed sinus being fifty-two times the right and thirty-eight times the left. For the entire 240 skulls it averaged 11.4 mm. (2 to 19) right, 11.9 mm. (1 to 20) left, with the right the more dangerous in 112, the left in 72, and equality in 56.* In like manner, among the writer's fifty pairs of temporals, the right averaged 9.76 mm. (3 to 16), the left 9.66 mm. (0.5 to 16), the more dangerous side being twenty-one times the right and eighteen times the left. In eight instances the operation room was 5 mm. or less—4 on each side; the maximum difference was 8 mm. with the right, 5 with the left, the greater distance. It appears, therefore, from an analysis of all available data that the right sinus is usually larger, more anterior, and more vulnerable than the left, but in a degree too slight to be of practical moment; while the position of extreme danger may be met on either side and in any form of skull. Bezold's observation that an unsymmetrical skull has the more dangerous sinus on the larger side is as good a guiding indication as we can find.

FIG. 408.—Dehiscent Areas in the Roof of the Tympanic Attic and Antrum of a Right Temporal Bone, with a low middle cerebral fossa. The internal auditory meatus is seen to the left, part of the sigmoid sulcus to the right.

The other limitation of the operative field in opening the mastoid is the position of the floor of the middle cerebral fossa. This cavity extends in rare instances down to the field of the operation, and uncovering or wounding of the dura mater is readily possible in an ill-placed opening (Fig. 407). So long as the *linea temporalis* was accepted as an index of the height of the fossa, blunders were easy, since its variable position furnished no true criterion. The upper wall of the auditory meatus or its adjacent *spina* are now the usual guiding points, and by keeping below these safety is assured. In this matter of the height of the fossa Koerner has thought that a relation to the skull-form can be found, and that the brachycephalic skull and the right side (Fig. 409) are the more dangerous (Fig. 410), and that dehiscence of the tegmen tympani is therefore more common on the right (Fig. 407) and in brachycephalics, with consequent more frequent right-sided cranial involvements. His measurements of 87 skulls showed the height of the fossa above the upper meatus wall to average 11.5 mm. (7 to 17) among the very long, 8.7 mm. (4 to 14) among the less dolichocephalic

* Measurement of these dimensions with one branch of the calipers passed through the foramen magnum in the intact skull probably slightly exaggerates, since an error, fairly uniform throughout the series, and less than a millimetre in amount, was probably introduced from slight obliquity of the placing of the instrument.

skulls, as against 5.2 mm. (2 to 9) in the brachycephalic. Schülzke, on the other hand, found a low fossa (10 mm. or less) in fourteen long, ten medium, and fourteen short specimens, although 36 of his 60 skulls were brachycephalic; and 20 times it was on the left side, and 18 on the right. The average was 11.2 mm. (8 to 17) right,

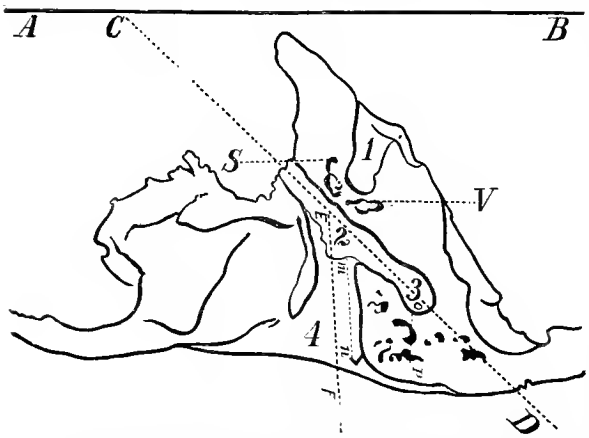

FIG. 409.—Diagram of Right Temporal Bone Sectioned Horizontally and Showing the Inclination of the Tubo-tympanic Axis, *C*, *D*, to the sagittal plane of *B*; the length, *m n*, of the upper back wall of the meatus, and the depth, *o*, *p*, of the antrum from the operation point. (After Allen.)

and 11.1 mm. (8 to 16) left, among the long; 12.5 mm. (8 to 19) right, and 12.2 mm. (8 to 18) left, among the short; with general averages 12.1 mm. right and 11.9 mm. left. The height was equal in 12, differed but 1 mm. in 41, and its maximum difference reached 4 mm. in only one case. In the writer's fifty pairs of temporals the right averaged 4.82 mm. (1 to 10), the left 5.41 mm. (2 to 11), with a maximum difference of 4 mm. among the 23 where the right fossa, and 12 where the left, was lower. In his study of this point in 240 skulls, the writer determined the vertical height of the fossa above the spina and the lateral displacement in the frontal plane within or beyond the spina. The averages were 6.5 mm. (1 to 14) right, and 6 mm. (0 to 14) left, with the left fossa lower in 138 and the right in 53. It was a shade lower in the brachycephalic—6 mm. (1 to 14) right and 5.8 mm. (0 to 14) left—than in the dolichocephalic—6.6 mm. (1 to 14) right and 6 mm. (1 to 12) left. The lowest point thus determined generally lay within the spina, sometimes 5 mm. internal, at times 5 mm. external, to it; while in some cases where it was but 1 mm. above, it was exactly over the spina. In no instance was it below the spina; although at times lower than the upper margin of the auditory meatus. In these measurements the extreme length and breadth of the skulls were taken to obtain the index, as was done was by Schülzke, in accord with most craniologists; although Koerner had used the breadth between the parietal protuberances. The distance was also measured from spina to spina, and from sulcus to sulcus within, at the widest point. It was thus shown that the sinus, like the middle cranial fossa, not rarely lay farther outward than the spina or the more prominent operation point, yet was far enough back to be well out of reach and covered by 5 to 7 mm. of bone. It was therefore evident that the form and convexity of the mastoid process itself play an important part; and that irrespective of the size and position of the sigmoid sulcus there may interpose a thick wall of compact or cellular bone to protect the sinus, even when its large size and sweeping curves make the danger of its position seem inevitable. This question, therefore, of the exterior configuration of the mastoid process, as revealed to palpation of one or both bones, may be really our very best indication as to the probable safety or danger of operation on the bone before us, as was pointed out by Bezold. A large mastoid, with not too deep a concavity below the temporal ridge and its convexity in the horizontal plane passing gently into the auditory canal, is probably safe; but there is no possibility of predicting the real condition, and nothing can relieve the surgeon of the duty of operating as though the case were known to be very dangerous.

The cells of the pneumatic mastoid are generally largest and thinnest-walled at its apex and especially upon its median aspect toward the digastric groove. Hence suppuration may rather readily break through in this region, especially when the outer mastoid cortex is thick. Dehiscence is not rare in this region, and may be met upon the outer aspect; but emphysema from such a condition almost never occurs.

The third structure to be avoided in opening the mastoid is the prominent inner wall of the antrum, where lie the facial and the horizontal semicircular canals. Generally these lie deeper than the part of the antrum reached by the operator; yet in a sclerotic mastoid there may be danger of striking them when the antrum is not found. These structures are never farther outward than the upper posterior tympanic margin, and this point may usually be found with the probe on the patient and its depth used as a guide. It is easily measured on the macerated bone, and its distance from the spina is given as 12 to 17 mm. by Allen. In my fifty pairs of temporals it averages 17 mm. (14 to 20) from the spina, and 19 mm. (16 to 21) from the operation point, 5 mm. back of the spina. A penetration of 15 mm., therefore, could hardly in any case wound these structures. Yet in many cases uncovering or necrosis of the bone may render uncertain the limits of the antrum, while calling for curretting of the surface. Cautious efforts should, therefore, be made to determine the location of these very important canals, since penetration of the semicircular canal may be the death-blow to the auditory apparatus, and through it or the facial, pus may readily penetrate to the cerebral base with fatal effect.

A point formerly more considered, and still practically

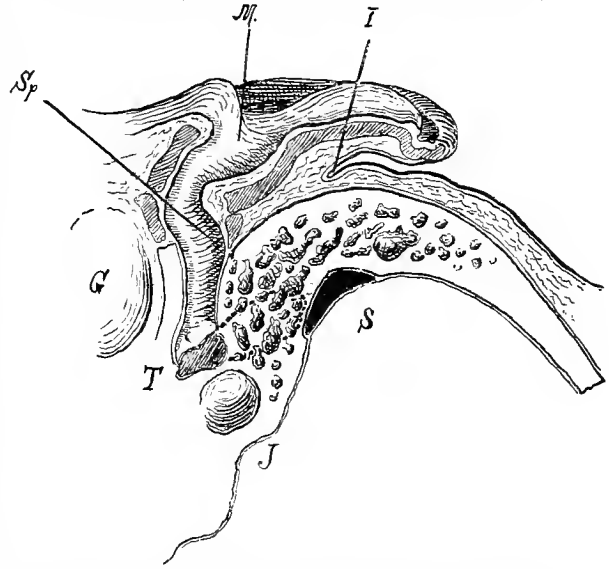

FIG. 410.—Horizontal Section (upper half) of the Left Ear, with the Soft Parts in Place, showing the location back of the meatus, *M*, and the spina, *Sp*, of the posterior insertion of the auricle, *I*. The glenoid cavity, *G*, the tympanum, *T*, and the jugular, *J*, are also shown; and the sigmoid sinus, *S*, which in this case is safely distant from the field of operation, is seen to be most superficial opposite the insertion of the auricle.

well worthy of mention, is the relation of the soft parts to the more important bony structures beneath. The incision preliminary to opening the mastoid has generally been made 5 to 10 mm. back of the insertion line of the auricle and not carried down very far toward the mastoid tip in order to avoid the branches of the posterior auric-

ular. Only to the aural specialist long unaccustomed to general surgery has the spirting of these little arteries any importance. Even in the swollen and infiltrated tissues they can generally be readily seized with hæmostats and afterward twisted, should they tend to bleed at all when released. It is more important, perhaps, to cut slightly behind the insertion of the auricle, in order that there may be the least projection of the pinna subsequently. The old rule that this insertion marked the point for entering the bone, has been wholly superseded; and it may be better said to mark the usual location of the most superficial part of the sinus (Fig. 411). According to Bezold it averages 15 mm. behind the spina, but Hartmann's finding of 10 to 12 mm. is probably more accurate. The older operators usually selected the area thus posterior to the auricle for entrance; modern operators usually work in the area covered by its insertion. A third location has been advocated as the best site for all cases—as it certainly is for some—the mastoid surface anterior to the spina, which constitutes the posterior wall of the auditory canal. For a case like that shown in Fig. 410, no other entrance would be possible at the usual level. Here we may be sure of thin bony plates to be opened, and a shorter, safer path to the antrum. Yet a little swelling of the soft tissues of the canal will serve to impede greatly free access to such an opening or the free exit of discharge; and whether made from the canal or from the incision back of the auricle, it is probably rarely so satisfactory as the more usual perforation.

The thin walls of the cells upon the median surface of the mastoid tip have been referred to. They are sometimes dehiscent, as Bezold found four times among 200 skulls, and often so thin as to be broken in the specimens; in 22 they could be readily pierced with a needle. Hence it is easy for pus to break through into the digastric fossa, thence to burrow beneath the fascia of the neck to form post-pharyngeal, deep cervical, or even mediastinal abscesses. Generally in the cases of this sort clinically met, there is a distinctly excessive thickness (whether natural or pathological, of the outer lamella of the mastoid, which probably as greatly influences the result as does the thinness in the digastric fossa. Such pus collections are apt to be concealed from ready detection by the interposition of the bony process and the tendon and muscle of the sterno-mastoid, which may, as a whole, be pressed outward. Surgical common-sense seems to demand that these cases should be attacked at the posterior margin of the digastric groove, where the neck abscess and the mastoid empyema are both within reach, the pus fully evacuated, and then such counter-openings made as the case may demand. A sinus can generally be found upon the digastric surface of the bone, and through it the interior can be emptied of pus and granulations, so that irrigation can pass freely in to the tympanum; yet a more typical opening of the outer surface of the bone at or below the usual point is also called for to give free access to the antrum. Bezold, indeed, now does this alone, neglecting the lower opening unless compelled to interfere here also; yet this seems to ill accord with the anatomical conditions presented.

The anatomy of the juvenile mastoid presents great variations according to the age, as has been previously suggested. A mere tubercle upon the surface of the infant temporal, some distance from the lowest part of the bone, the mastoid process changes in every respect as it grows. Small as are the general dimensions of the bone, some parts are full-sized even thus early. The tympanum undergoes little change in after-years, except in being separated from its fellow by the growth of the skull base between, and more deeply buried by the outward growth of the auditory canal. The size of the antrum, as of the other portions of the tympanum, increases little after birth; but while the bony wall separating it from the exterior grows from almost nothing to a thickness of 10 to 15 mm., the separation from the lateral sinus steadily decreases (Fig. 411). Hartmann found this wall never less than 3 mm., generally 4 mm., in 21 temporals of new-born infants; while in 12 bones of children from one to five years it averaged 2 mm., but was hardly 1 mm. in 5. This is due to the pressing forward of the lateral sinus as it grows, grooving more deeply the inner aspect of the petro-mastoid. It thus tends to approach the auditory meatus, for while in 40 infant bones measured by Hartmann the meatus-sulcus

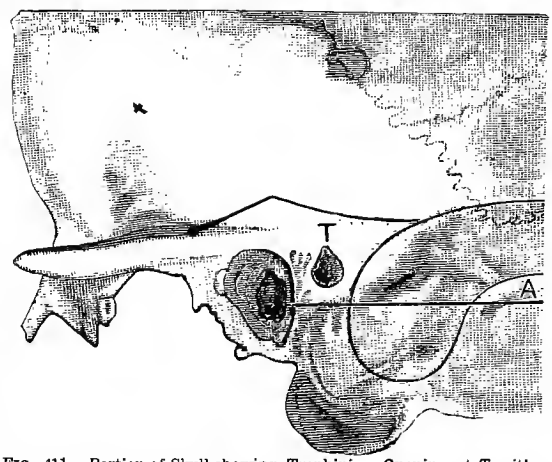

FIG. 411.—Portion of Skull showing Trephining Opening at *T*, with a dark line above to indicate the usual height of the middle cerebral fossa, the curved lines posteriorly to show the usual limits of the lateral sinus and the horizontal line at *A*, part of Reid's base line, passing through the lower edge of the orbit and the occipital protuberance. (After Birmingham.)

distance averaged 12 mm., and was never less than 10 mm. in the 12 bones of children from one to five years, it was sometimes but 8 mm., with an average of 10 mm. In 16 bones of individuals from five to twenty years it averaged still less. Similarly the writer found among 10 temporals of new-born infants in his collection a distance averaging 6 mm. (4 to 7 mm.) between the sulcus and the antrum, and 13 mm. (11 to 14 mm.) between the sig-

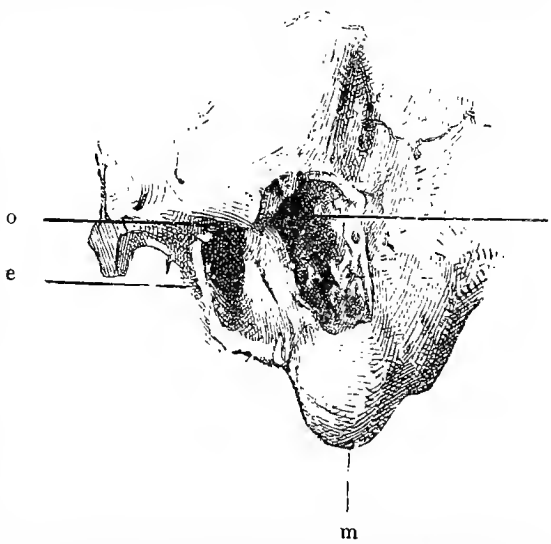

FIG. 412.—Left Temporal Bone Chiselled to Open the Mastoid Cells and Antrum. The opening, although not so extensive as sometimes figured and advocated, could be safely thus made in only a fraction of cases. (After Politzer.)

moid sulcus and the meatus. This latter dimension had an average of 11 mm. (8 to 14 mm.) among 15 temporals of children from one to five years of age, the smaller distance being in the more developed bones—figures a little greater than the average in the adult, and presenting no such minimal measurements as are there often found. The antrum is, therefore, readily reached at little depth

in the child, and the lateral sinus is generally well back of probable injury. The middle cerebral fossa is generally low (1 to 5 mm.), averaging 3 mm.; and in not a few instances a large venous sinus deeply grooves the most vulnerable outer portion of it. The spina is more often lacking and the outer margin of the meatus is less well-defined than in the adult; so special care should be taken to avoid penetration at too high a point.

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B. Alexander Randall.

MATLOCK. A favorably known spa and summer resort in Derbyshire, England.

LOCATION.—Matlock is situated on the banks of the river Derwent, between the sheltering tors of Matlock Dale. The place is noted for its agreeable summer climate just as much as for its indifferent thermal springs. Bradshaw describes the place as follows:

"Matlock Bath is built partly in a valley, through which flows the river Derwent, and partly upon terraces of tufa, deposited from its warm springs. It is sheltered from the north and east by the heights of Masson and the High Tor. To the south and across the Derwent are the grounds of Willersley Castle. There is a large pavilion in which a band plays and concerts are given during the summer, and a promenade by the side of the Derwent. The neighborhood is very beautiful and picturesque."

ACCESS.—Matlock Bath is reached by the Midland Railway in a four hours' trip from London.

ANALYSIS.—The temperature of the springs is 68° F. Their chief mineral ingredients are magnesium sulphate, carbonate of lime, and sodium chloride. But the solids amount to only about thirty grains per gallon of the water. Matlock water is palatable, owing to a fair proportion of free carbonic acid gas.

INDICATIONS.—Matlock is resorted to in cases of gout, rheumatism, bladder affections, skin diseases, and mild neuroses. Scrofula is also said to be treated with good results there.

ACCOMMODATION.—The bathing establishments, hotels, and lodging-houses are only moderately comfortable.

Edmund C. Wendt.

MENINGES (THE ENVELOPES OR MEMBRANES OF THE BRAIN AND SPINAL CORD). § 1. *Introductory Note.*—During the preparation of the present article points supposed to be clear have proved to need further elucidation, and problems altogether unexpected have arisen, demanding for their solution time, material, and apparatus at present unattainable.* Indeed, so impressed has the writer become with the vagueness, inadequacy, and inconsistency of current accounts, and with the necessity for a re-examination of the meninges in all their relations, that only a sense of obligation to the patient and considerate editor who has entrusted him with the subject stands in the way of retreat at the eleventh hour. Necessarily transmitted to the printers at a certain time, the article is neither so clear, consistent, correct, concise, nor complete as the writer would wish it to be. The least unsatisfactory position relates to the question of the existence of a natural communication between the true cavities of the brain and the spaces ectad of it.

Of the eleven figures four (418, 420, 421, 422) are original. One (423) is from Henle, and one (417) from Sappey. The diagram, Fig. 416, from Dr. Langdon's paper, 1891, is kindly loaned by the author. The remaining four (413, 414, 415, 419) are copies of the reductions of figures by Key and Retzius in Quain's "Anatomy."*

In quoting from these and other works the terms preferred by the present writer are commonly employed. See the article, "Anatomical Terminology," in Vol. VIII.

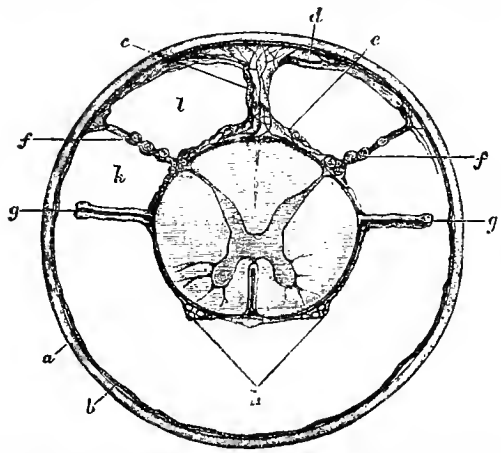

FIG. 413.—Transection of the Myel and its Meninges in the "Upper" Thoracic Region. Enlarged somewhat from Key and Retzios (Taf. i., Fig. 7), after Quain (iii., Fig. 132). *a*, Dura (not the spinal periosteum, but representing the ectal layer of cranial dura); *b*, arachnoid; *c*, septum posticum; *d*, *e*, *f*, trabeculæ in the subarachnoid space, those at *f* supporting the dorsal (posterior) nerve-roots; *g*, ligamentum denticulatum; *h*, ventral (anterior) nerve-roots, cut off; *k*, *l*, subarachnoid spaces. The pia is not designated, but may be recognized as the double outline of the myel dipping into the dorsal fissure as a narrow septum and into the ventral as a fold.

Note.—The foregoing is substantially the description in Quain. But some of the writer's observations lead him to suggest that the spinal, like the cranial, arachnoid comprises two layers, a dural and a pial, connected by the reflected layers of the septum posticum. This view, however, would homologize the space *k*, *l*, with the intrarachnoid space of the cranium, and hence their free communication with the postcisterna would be difficult to explain.

§ 2. Points illustrated by Fig. 413.† A. The subcylindrical form of the myel, and the relations of the areas of alba and cinerea at this level; for these and most of the other features shown in this figure see the account by Spitzka, Vol. VIII., pp. 476–477.

B. The existence of a dural sheath (theca) of the myel, independent of the periosteum, the two being united in the cranium.

C. The somewhat loose adhesion of the arachnoid to the dura, leaving slight and scattered subdural spaces.

D. The presence of the *septum posticum* at this level; it is said (Quain, iii., 188) to be most perfect in the cervical region, and more or less incomplete farther caudad.‡

E. The size of the subarachnoid space traversed by the

* The conditions of investigation of the meninges are peculiar. The pia and arachnoid are relatively delicate: they are easily torn and their attachments ruptured. But they are surrounded by an unusually tough membrane, the dura, and the whole is enclosed within a case of bone which must be sawn or otherwise forcibly opened by measures which are almost sure to rupture the pia and arachnoid. It is much to be desired that the whole subject be reviewed by some anatomist having the use of a mechanical bone-cutting apparatus, *e.g.*, the electro-osteotome of Dr. M. J. Roberts.

* Besides those here included, the new figure, 182, of the tenth edition, vol. ii., is worth consulting, although not altogether satisfactory.

† See note under the description of Fig. 413.

‡ *Septum posticum* is an undesirable term, but *septum dorsale* might be confounded with the prolongation of the pia into the dorsal fissure of the myel.

spinal nerve-roots, the trabeculæ, and the *ligamentum denticulatum*.

F. The location of the *ligamentum denticulatum* at either side of the myel. As shown in Vol. VIII., Fig. 5047, 9, 9, 9, and described on p. 477, this is a fibrous band connected with the pia, and reaching the dura by a triangular extension in the intervals between the nerve-

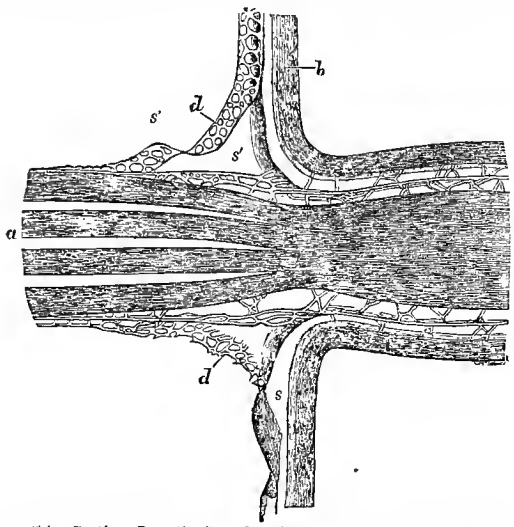

FIG. 414.—Section, Lengthwise, of a Ventral Nerve-root at its Place of Exit from the Spinal Canal. Enlarged. From Key and Retzius (Taf. i., Fig. 10) after Quain (iii., Fig. 128). *a*, Four funiculi uniting to constitute the root; *b*, dura reflected upon the root at its emergence through the intervertebral foramen (the periosteum is not shown); *c*, arachnoid; *d*, reticular lamella of the arachnoid reflected upon the root (compare Fig. 413, *f*); *s*, subdural space; *s'*, subarachnoid space.

roots; but opposite the roots (as in this figure) it is narrower, and does not reach the dura.

§ 3. *Definitions.—Meninges* is the plural of *meninx*, from the Greek μῆνιγξ, signifying any membrane or coating, as of the eyeball, and even the scum upon milk or wine; but, as stated by Hyrtl ("Onomatologia," p. 324), the word was restricted by Aristotle ("Hist. Anim.," lib. i., cap. 16) to the coverings of the brain (and myel ?), and the limitation has been since maintained. The synonyms of *meninx* are: Fr., *méninge;* It. and Sp., *meninge;* Ger., *Hirnhaut.*

§ 4. *The Three Meninges.*—Nearly all anatomists recognize three chief membranous envelopes between the substance of the neuraxis (brain and spinal cord) and the cranio-spinal canal, viz.: An ental, the *pia;* an ectal, the *dura;* an intermediate, the *arachnoid.* Their relative positions when the cranium is opened are indicated in Vol. VIII., Fig. 4687. Properly speaking the pia pertains to the neuraxis, and the dura to the cranio-spinal canal, while the arachnoid has more or less varied relations to both the other meninges. All three present differences according to their location within the cranium or the spine, and there are transition conditions in the cephalic portion of the latter which are not yet fully made out.

The term *pachymeninx* (tough envelope) is sometimes used for the dura, irrespective of the recognition of a parietal layer of arachnoid. In like manner *leptomeninx* (tender envelope) is sometimes used for the pia and the commonly admitted visceral layer of arachnoid. The pathological terms, *pachymeningitis* and *leptomeningitis*, are derived from these words.

§ 5. Points illustrated by Fig. 414. A. The formation of a nerve-root from the union of several funiculi or rootlets.

B. The extension of the myelic dura upon the root at its exit from the spinal canal, to be lost in the sheath of the nerve.

§ 6. *The Pia.*—This was formerly more often called *pia mater,** sometimes also *meninx vasculosa* (Ger., *dünne Hirnhaut, weiche Hirnhaut;* Fr., *pie-mère*). It is delicate, fibrous, highly vascular, and intimately connected with the neuraxis, into the substance of which it sends numerous nutrient small vessels. When stripped off, these vessels commonly break at a short distance from the pia, and their number and minuteness impart to the ental surface of the membrane a flocculent or woolly aspect, the *tomentum;* Vol. VIII., p. 111, § 11, F.

§ 7. *Myelic Pia.*†—This is thicker and firmer than the encephalic, less vascular, and more closely adherent to the nervous substance. It has sometimes been called the "neurilemma of the cord." Two layers are recognized: the ental, sometimes called *intima pia*, sends a fold into the ventral ("anterior") fissure, and into the dorsal a lamina not recognizable as a fold. Along the ventrimeson the pia presents a conspicuous fibrous band, the *linea splendens*, not represented in Fig. 413.

§ 8. *Points Illustrated by Fig.* 415.—A. The relative positions of the meninges; compare Fig. 416 and Vol. VIII., Fig. 4687.

B. The formation of the longitudinal sinus within the substance of the dura.

* The reduction of the polyonyms, *pia mater* and *dura mater*, to the mononyms, pia and dura, was urged by the writer in 1880 in a paper before the American Association for the Advancement of Science. Since that time the use of pia and dura, and of the natural adjectives, pial and dural, has become quite general. The simplification has been recommended by the Association of American Anatomists (December 27, 1889) and by the American Association for the Advancement of Science, 1890 and 1892.

† The paragraph in Quain (iii., p. 186), which is here substantially reproduced, is sandwiched, as it were, between two captions that might obscure it.

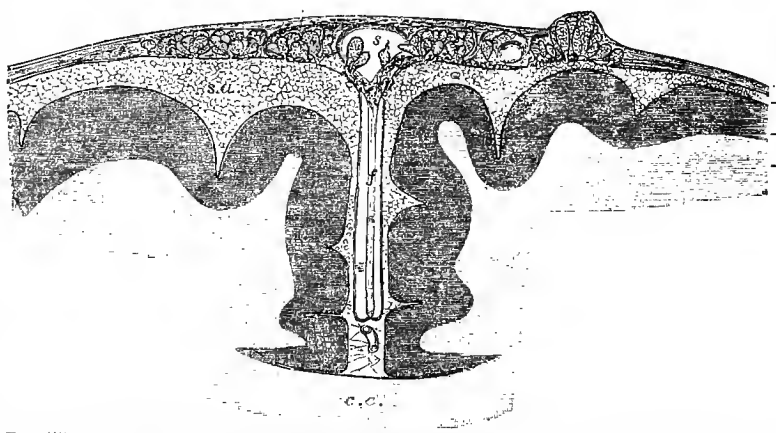

FIG. 415.—Transection of the Dorsal, Mesal Region of the Cerebrum, to show the Meninges and Arachnoidal Villi. Slightly enlarged. From Key and Retzius (Taf. xxix., Fig. 4) after Quain (iii., Fig. 134).

Preparation.—The spinal subarachnoid space (Fig. 413, *k*, *l*) was injected with a fine blue mass, which filled (and distended ?) the corresponding space upon the cerebrum and entered the arachnoid villi. The original figure is appropriately colored and on a larger scale. Judging from the relation between the width of the falx, and the interval between it and the callosum, the plane of section was not far cephalad of the splenium; see Fig. 418. *c.c.*, callosum; *f*, falx; *s*, falcial sinus; *s.a.* (at the left), subarachnoid space.

Defects.—The pia is not as distinct as the writer would make it. The relation of the arachnoid to the ventral margin of the falx is not quite clear. There is no extension of the cortical cinerea upon the dorsum of the callosum as an indusium; see p. 104, § 47. There is no indication of the existence of the two layers of the dura, *e.g.*, periosteal and encephalic, described by Spitzka (Vol. VIII., 47) and Langdon (Fig. 416). The falcial (inferior longitudinal) sinus may have been absent in this case, as it is said to be in many (Browning, Vol. VIII., 241). The *lacunæ laterales* are somewhat indistinct, probably in consequence of the reduction from the original figure, where they are much more clearly shown.

C. The projection of the arachnoid villi into the sinus and the parasinual spaces; see Browning, Vol. VIII., p. 242.

D. The accumulation of the villi at one point, on the right, to such an extent as to cause the protrusion of the dura, and presumably a depression of the ental surface of the cranium.

E. The separability of the arachnoid from the pia, leaving a distinct subarachnoid space increased along the fissure lines.

F. The conterminousness of the arachnoid and the falx, and their separation by a distinct interval.

§ 9. *The Encephalic Pia.*—According to Quain (iii., 186), only the ental of the two myelic layers of the pia is represented on the brain, but where and how the other layer disappears is not stated. The pia follows all the undulations of the encephalic surfaces, dipping into the fissures and rimulas as folds or rugas of corresponding depth; see Fig. 300 and Vol. VIII., Fig. 4687. At the bottom of the intercerebral fissure, the mesal cleft between the dorsal portions of the two hemicerebrums, the pia enters the callosal fissure at either side, is then reflected, and crosses the callosum.

Since the pia is practically the ectal surface of the brain, its cut edge is not commonly represented excepting when the figure is on a very large scale; but on diagrams its vascular character may be instructively indicated by a red line.† Sometimes, as in Fig. 59, § 43, 6, the pia forms the only boundary of an area.

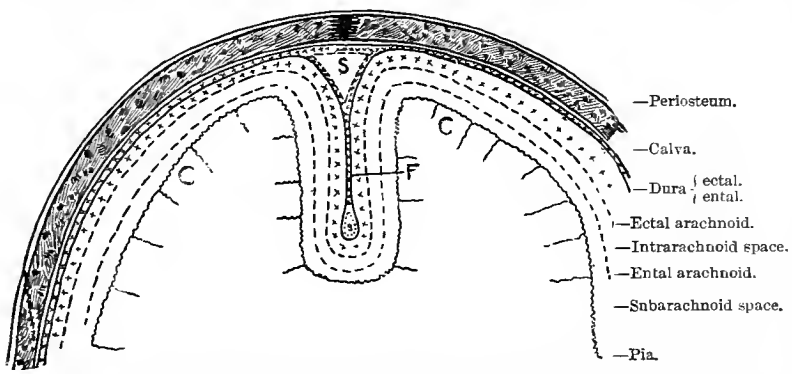

FIG. 416.—Schematic Transection of the Parietal Region of the Newborn, to show the Relations of the Meninges to the Cerebrum and Cranium. From F. W. Langdon, 1891. C. C. cerebrum; F, falx; S, longitudinal sinus; xxx, subserous connective tissue between the dura and the ectal arachnoid.

*Defects.**—The mesal dark area dorsad of S (the longitudinal sinus) represents the ligamentous connection of the two parietal bones; it should be continuous with the periosteum and ectal dura. The "subserous dura," between the dura and the arachnoid, represented by the series of crosses, is made too wide in proportion.

§ 10. *The Telas.*—As has been described in Vol. VIII., p. 118, § 44, Fig. 4707, the cœlian parietes, *i.e.*, walls of the true encephalic cavities, typically comprise three concentric layers, viz., an ental endyma, an ectal pia, and an intervening brain-substance. The endyma and the pia are nearly uniform in thickness and constitution: the nervous layer varies considerably in cellular structure and even more in thickness, from thin and apparently functionless areas, terma, valvula, etc., to the enormously thickened roof of the paracœle (lateral ventricle). In most animals at two places, and in man and apes at three, the proper nervous wall disappears (or in some cases, perhaps, is never formed), leaving the endyma and the pia in contact. The membranous area so constituted is a *tela*. The roof of the metacœle is the *metatela (tela choroidea inferior)*; Fig. 59 and Vol. VIII., Figs. 4684, 4710, and 4711; that of the diacœle is the *diatela* (Fig. 59 and Vol. VIII., Figs. 4711 and 4751. In man and apes a zone of the paracœlian floor is a membranous *paratela*. Fig. 61 and Vol. VIII., Figs. 4750 and 4751.

§ 11. *The Plexuses.*—At several localities in the brain the pia forms vascular quasi-intrusions (choroid plexuses) into the cavities, carrying before it, however, the endyma lining those cavities, so as to be, strictly speaking, excluded therefrom; see Figs. 60, 61, 62, and 418; also Vol. VIII., Figs. 4708, 4709, 4710, 4740, 4745, 4749, and 4751.*

§ 12. *Points Illustrated by Fig.* 416.—A. The existence of two layers of dura in the cranium, the one corresponding with the periosteum of the spinal canal, the other with the dural sheath of the myel, Fig. 413, *a*.

B. The existence of two layers of arachnoid—an ental or pial, and an ectal or dural.

C. The propriety of regarding the so-called subdural space as an intrarachnoid space, analogous with the serous sacs in other parts of the body; see § 24.

§ 13. *The Dura.*—This mononym is rapidly replacing *dura mater* and the German *harte Hirnhaut;* see § 6, note. As shown in Figs. 414 and 415, and in Vol. VIII., Fig. 4687, the cranial dura is apparently a single sheet, dense, strong, fibrous, and unyielding, lining the bones and constituting their ental periosteum. But a closer examination detects two layers, an ectal and an ental, which gradually separate in the cephalic part of the cervical region, and in the spine maintain diverse relations, the one with the canal, the other with the myel.

§ 14. *The Theca.*—The ental or myelic portion of the spinal dura constitutes a fibrous tube, the theca. It is considerably longer and larger than the myel itself, and separated from the periosteum, constituting the wall of the canal by venous plexuses and much areolar tissue. The cavity between the pia and the dura is occupied by cerebrospinal fluid (cœlio-lymph), and is divided by the curtain-like arachnoid into the spaces subdural and subarachnoid. Within the latter the myel, closely covered by pia, is suspended, being kept in position by a ligament on each side, *ligamentum denticulatum* (Fig. 413), which fixes it at frequent intervals to its sheath, and by the roots of the spinal nerves (Fig. 413, *f*), which cross the space from the surface of the myel to the intervertebral foramina.

§ 15. *The Epidural Space.*—In the spine, since there are two layers of dura, an ectal (periosteal) and an ental (myelic), the interval between them constitutes an epidural space. In the figures this is nowhere clearly shown, but it may be represented in Fig. 413 by drawing around the present ectal outline, the myelic dura, a second at a little distance therefrom; the interval would be the epidural space.

§ 16. Two questions naturally arise in connection with the epidural space.

1. Does it communicate with the subdural space? If so, where?

2. If not, what is the source of the liquid occupying the space, and what is its nature?

§ 17. *Points Illustrated by Fig.* 417.—A. The relation of the dura to the cranium as a complete lining of considerable thickness.

B. The relation of the falx and falcula, as mesal extensions of the dura, to the tentorium as a transverse extension.

C. The tent-like form of the tentorium, the lateral margins coinciding approximately with the long axis of

* Dr. Langdon informs the writer that the cut does not represent the original drawing quite fairly in some respects.

† On such diagrams the endyma ("ependyma" or lining of the cavities) may be represented by yellow or green.

* On the mode of formation of the rima (sometimes called choroid fissure) independently of the blood-vessels, see His, "Die Formentwickelung des menschlichen Vorderhirns," etc., Leipzig, 1889, pp. 694 and 712, as quoted by Cunningham, "Surface Anatomy of the Primate Cerebrum," 1892, p. 3.

the cranium, the intermediate portion rising toward the meson at an angle rapidly increasing from the occiput cephalad.

D. The inversion of the falcula as compared with the falx.

E. The general arrangement of the more prominent fibres of the falx; there is a marked divergence or radiation from about the place of intersection of the free margins of the falx and the tentorium.

F. The locations of the principal sinuses along the lines of attachment of the dural folds to one another or to the cranium.

G. The direction of the current in the principal sinuses:

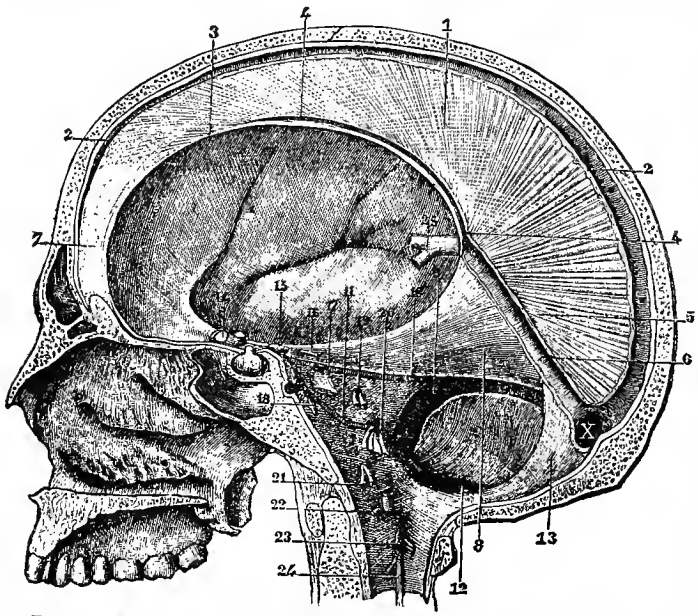

FIG. 417.—Mesal Aspect of Right Half of Medisected Skull retaining the Dura. ×.5. From Sappey (iii., Fig. 462); after Quain (iii., Fig. 129). Compare Fig. 759 in Vol. II. of this work.

Defects.—As usual, there is no indication of the change that occurs at or near the foramen magnum, by which the apparently single dura of the cranium divides into a true dura related to the myel (Fig. 413) and a spinal periosteum; see, however, Quain, iii., Fig. 182. The region of the postoccipital sinus (12) is so heavily shaded as to give the impression of its considerable width; as shown in the original of Sappey, this sinus is no larger than the subpetrosal; according to Browning (HANDBOOK, VIII., p. 242), this is merely a constituent of the irregular basilar plexus of venous channels. The vein of Galen (25) here joins the tentorial sinus at an angle of about 45°; really, as shown in Fig. 418, it curves about the rounded splenium and joins at nearly a right angle.

1, falx; 2, longitudinal sinus; 3, concave ventral margin of falx; 4, falcial (inferior longitudinal) sinus; 5, base of the falx where it joins the tentorium; 6, tentorial (straight) sinus or *s. rectus*; 7, cephalic, narrow end of falx, a little dorsad of the *crista galli* to which it is attached; ventrad of the line is a frontal (air) sinus, seen also in Fig. 4684; 8, right side of tentorium, sloping latero-ventrad from the attachment to the falx to the side of the cranium along the lateral sinus (9); X, the torcular, the place of confluence of the two lateral sinuses, the longitudinal and the falcial; 10, the superpetrous (superior petrosal) sinus; 11, the subpetrous (inferior petrosal) sinus; 12, postoccipital (posterior occipital) sinus; the arrows indicate the direction of the blood in the larger sinuses; the lateral sinus is continuous with the ento-jugular vein: 13, falcula (falx cerebelli); 14, optic nerve; 15, oculo-motor nerve; 16, trochlearis nerve; 17, trigeminus (trifacial) nerve; 18, abducens nerve; 19, facial and auditory nerves; 20, glosso-pharyngeal, vagus, and accessory nerves; 21, hypoglossal nerve; 22, 23, first and second cervical nerves; 24, cephalic end of the *ligamentum denticulatum* (see Fig. 413); 25, union of the velar veins to constitute the vein of Galen opening into the tentorial sinus (see Fig. 418).

in the longitudinal (2) and tentorial (6) (with the falcial, (4)) toward the torcular; in the lateral (9), toward the exit in the base of the skull at the jugular vein (4), in the superpetrosal and subpetrosal (10, 11) to the lateral.

H. The entrance of the supercerebral veins into the longitudinal sinus at the points indicated by the black spots in the course of the latter and at others not indicated; see Vol. VIII., p. 237.

§ 18. *The Tentorium.*—The cerebral region of the cranium is partitioned off from the region containing the cerebellum by a fold of the ectal layer of the dura, which, from its arched shape, is called the *tentorium (cerebelli)*. Its topographical relations with several of the sinuses are described by Browning, Vol. VIII., pp. 241-242, and indicated in Figs. 417 and 418.

The tentorium exists in most, if not all, mammals, but not, so far as the writer is aware, in other vertebrates; in the Carnivora it is ossified.

§ 19. *The Falx.*—From the cerebral side of the tentorium extends cephalad a mesal duplicature of the dura, the falx, well named from its sickle-shape; Figs. 417 and 419. The narrower cephalic end is attached to the *crista galli*. The distance between the free margin of the falx and the callosum increases cephalad. The relations of the falx to the longitudinal and falcial sinuses are shown in Figs. 417 and 418.

§ 20. *The Falcula.*—This name (wrongly printed *falcicula*) was proposed by the writer as a mononym for *falx cerebelli*, designating the mesal fold of dura which extends ventrad from the tentorium to the *foramen magnum*, where it bifurcates. It is vaguely shown in Fig. 418, 5, more clearly in Fig. 417, 13.

§ 21. *The Fontanels* (*Fr. fontanelles*).—These are the intervals between the corners of the infantile parietal bones before these corners have formed sutural union with the adjacent bones. There are six fontanels, two mesal and two pairs of lateral. The lateral, at the cephalic and caudal angles of the ventral border of the parietal bone, are small, irregular, and of comparatively little interest. The two mesal fontanels are at the ends of the sagittal suture; their more common designations, *anterior* and *posterior*, may appropriately give place to *prefontanel* and *postfontanel*.

§ 22. *Analogy of the Fontanels with the Telas.*—The structure of a tela was described in § 10. But since, in mammals at least, the telas are always more or less closely adherent to adjacent parts, and their margins are easily detached, their relations are sometimes not clearly appreciated. But if an infant or fœtal cranium be divided across the prefontanel diagonally, so as to include either parietal bone and the opposite frontal, the cut edge will present three layers, viz., an ental, the dura, representing the endyma; an ectal, the pericranium, representing the pia; an intermediate, the bone, representing the nervous parietes. At the fontanel this third element is absent, and the conjoined dura and pericranium contribute a membranous area quite comparable with a tela and available for illustration thereof.

A defect in the analogy is this: The cranial bone is of nearly uniform thickness, and thins out at the margin of the fontanel. But in the brain, although the immediate margins of the telas may be thin, the general parietes are commonly very massive, and there is usually a parallel zone specially differentiated, *e.g.*, the habena.*

§ 23. Points illustrated by Fig. 418 as to Meninges and Vessels; other points are indicated in Vol. VIII., pp. 121-123.

A. The degree of retention of the dura in this specimen is greater than with any brain ever seen or heard of by the writer. The brain was most skilfully removed, according to the writer's directions, by Professor W. C. Krauss, a former student; see p. 117, § 33.

* It is proper to add that, although this analogy between the telas and the fontanels had already occurred to the writer, he was reimpressed with it on listening to an admirable lecture upon the anatomy of the brain by Professor D. K. Shute, at the Columbian Medical College, Washington, D. C., December 16, 1889.

B. The existence, in the caudal three-fifths of the cerebrum, of a distinct and considerable mesal depression, containing the longitudinal sinus, so that here the retreating surface of the dura is seen beyond its dorsal cut margin ; presumably this corresponded with a mesal thickening of the cranium.

C. The distinctly sickle-shape of the mesal extension of the dura between the two hemicerebrums, whence its name, *falx*.

D. The non-correspondence of the width of the falx with the area dorsad and cephalad of the larger part of the callosum.

E. The location, form, and extent of the medicisterna (*cisterna ambiens*), the irregular space between the cerebellum, the splenium, and the geminums, roofed by the arachnoid and tentorium.

F. The location, form, and extent of the ventricisterna (*cisterna intercruralis*), between the crura, the pons, and the tuber*(*tuber cinereum*), infundibulum and hypophysis. It forms a very deep indentation of the ventral outline of the brain, corresponding with the cranial or mesencephalic flexure ; Vol. VIII., p. 112, § 16. It is bridged by the arachnoid, following substantially the line of the dura, and thus includes the arteries of this region.

G. The location, extent, and form of the postcisterna (*cisterna magna cerebello-medullaris*), the interval between the dorsum of the oblongata, the cerebellum, and the adjacent portion of the cranium, or strictly the ectal layer of arachnoid in that region, represented by the black line marked 10 ; see Figs. 420, 421.

H. The location of the metapore (Foramen of Magendie), the orifice in the metatela (*tela choroidea inferior*), constituting the roof of the metacœle or metencephalic portion of the "fourth ventricle." The metapore is thus a direct orifice of communication between the metacœle, one of the encephalic cavities, and the postcisterna, a part of the subarachnoid space ; see Figs. 422, 423, and § 28, note. In this specimen its relations are complicated by the postcerebellar artery, a loop of which lies just dorsad of it ; see under Defects.

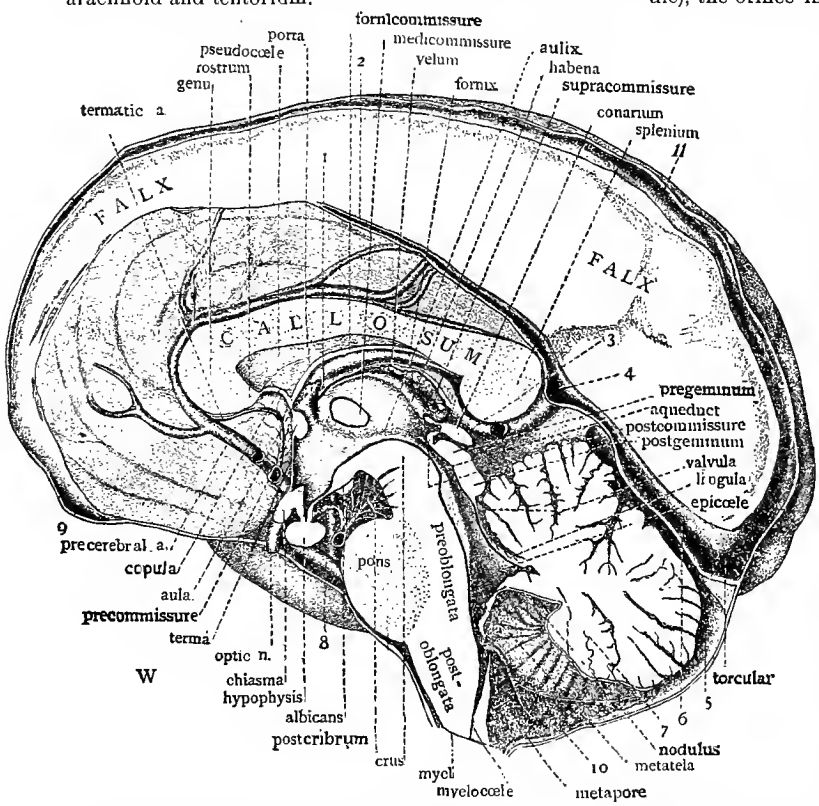

FIG. 418.—Mesal Aspect of the Right Hemiencephal of an Adult White Man. 376 × .65. 1, antiplexus; 2, falcial sinus ; 3, right velar vein ; 4, orifice of Galen's vein into the tentorial sinus ; 5, falcula or "cerebellar falx ;" 6, tentorial sinus ; 7, uvula, a mesal division of the cerebellum ; 8, tuber ("tuber cinereum") ; the line seems to stop at the artery, but should reach the thin floor of the diacœle just caudad of the hypophysis; 9, ventral end of the falx ; 10, cut edge of the ectal layer of the arachnoid ; the line is too heavy and should be white instead of black ; at a point between the lines from 6 and 7 it becomes attached to the cerebellar piarachnoid ; 11, longitudinal sinus.

Preparation.—This figure is reduced from the writer's Fig. 4711 in Vol. VIII. In addition to what is there recorded it should be said that the figure represents a combination of the more perfect portions of the two mesal aspects, and the left more than the right. The dura has since been removed, excepting its ventral margin. The left half has been transected through the mesencephal ; the dorsal portion of the right hemicerebrum has been sliced off to the level of the paracœle, but secured in place with long pins.

Defects.—Although one of the purposes of the preparation of the figure was to indicate the relations of the dura to the brain, the word is omitted altogether. *Falx* designates its mesal extension between the halves of the cerebrum, as shown in Figs. 415 and 417. Along the longitudinal sinus (11) should be indicated the points of entrance of the supercerebral veins (see Vol. VIII., Fig. 4684). The sinus, dorso-caudad of the cerebellum, between the torcular and the point marked 4, should be named *tentorial sinus*. On the precerebral artery, dorsocephalad of the chiasma, are two orifices. The more caudal, at the root of the termatic artery, is caused by the removal of the left precerebral (see § 23, P). The more cephalic, between the lines from *copula* and *aula*, should be omitted, together with the intervening depressed area ; they represent an accidental excavation of the artery. The arteries in the ventricisterna, the interval between the pons, the crura, and the tuber, are vaguely and inaccurately shown (see § 23, F). The postcerebellar artery (undesignated but lying between the lines from *metapore* and *metatela*) looks as if it begins in the metapore (see, however, § 23, H). The pia is nowhere distinctly represented. The black line marked 10 is the ectal layer of the arachnoid (see Fig. 421) ; the ental layer, in contact with the cerebellum, may be recognized ; they unite just dorsad of the line from 7. The curved white line about midway between the callosum and the fornicommissure is due to an error ; the surface of the hemiseptum forming the lateral wall of the pseudocœle should be uniformly shaded.

I. The location of the postcerebellar artery. This is not named on the figure and is imperfectly shown. The central portion, from its origin at the vertebral, is invisible here, but shows in Figs. 420 and 423. Just at the side of the metapore it turns sharply upon itself, forming a loop, somewhat as in Fig. 420, but in the present figure the peripheral portion of the artery alone is seen, and looks as if it began in the metapore. The two principal divisions are as here represented. There is apparently considerable variation in the course and subdivision of this vessel.

J. The length of the longitudinal sinus, equalling nearly the greater curvature of the cerebrum ; its cephalic end was probably not quite reached.

K. The presence of the falcial sinus (2) along the ventral, free margin of the falx. This is said to be often wanting ; see Vol. VIII., p. 129, § 59, and p. 241. The writer suggests that the alleged absence of this sinus in the fœtus may be due to its non-detection.

L. The straight course of the tentorial sinus in line with the falcial, along the ventral margin of the caudal fifth of the falx, where the latter is continuous with the tentorium (Fig. 417, 8). The tentorial sinus is not named or otherwise designated on this figure, but in Fig. 417 it is numbered 6 ; it is also called straight sinus or *sinus rectus*.

M. The junction of the mesal longitudinal and tentorial sinuses at the torcular (Herophili). The course of the lateral sinuses thence is indicated in Fig. 417.

N. The location of the right velar

* In previous articles in the HANDBOOK the tuber cinereum was called torus ; but the writer's attention has been called to the use of *torus*, either alone or in combination with *semicircularis*, to designate mesencephalic elevations in fishes ; hence it will be better to retain the substantive element of the original name.

vein (3) between the splenium of the callosum and the conarium, and its junction with its opposite at the point indicated by the circular spot at the edge of the spleninm, just in line with the dotted line from that word. The two velar veins form the short vein of Galen.

O. The brief course of the vein of Galen about the splenium, and its entrance at 4 into the tentorial sinus, at the place of continuity of the latter with the falcial when this is present.

P. The location of the right precerebral artery (anterior cerebral). Branches of this are seen dorsad and cephalad of the callosum. The main trunk extends dorso-cephalad from the chiasma. The dark spot between the dotted lines leading from the words *terma* and *precommissure* represents the junction of the two precerebral arteries at the meson; in some cases they are separated by a considerable interval and communicate by a slender precommunicant artery. Here, however, they unite by their full width and again diverge.

Q. The origin of the termatic artery from the place of junction of the two precerebrals; its course, parallel with the terma and copula, then around the genu at least to the dorsum; its short branches to the terma and adjoining parts of the hemicerebral meson.

R. The location of the postcerebral artery. The beginning of this, severed from the basilar, is represented by the circular spot between the hypophysis and the convexity of the pons. From it are seen small arteries entering the crura as described by Browning, Vol. VIII., p. 235. For the two large vessels represented in the ventricisterna, see under *Defects*.

S. The location of the aulix, the **S**-shaped furrow on the mesal surface of the thalamus ventrad of the medicommissure. This, originally called *sulcus Monroi* by Reichert ("Der Bau des menschlichen Gehirns," Taf. ix., i.) is held by Minot ("Human Embryology," pp. 611, 680) to represent the fundamental division between the "dorsal and ventral zones of His."

§ 24. *The Arachnoid.*—The word *arachnoid* is derived from the Greek ἀράχνη (signifying either a spider or a spider's web), and εἶδος (form or likeness).* Our knowledge of the arachnoid is even less complete and satisfactory than that of the dura and pia, and there are direct contradictions in the accounts by different anatomists which the writer has as yet been unable to reconcile.

As stated by Langdon (1891), Bichat described (1802, 1813) the arachnoid as a serous, shut sac, conforming in all essential particulars with the serosa of the other cavities. But most recent writers follow Kölliker (1860) in denying the existence of a parietal layer in contact with the dura, and Tuke regards (1882) even the visceral layer as merely an element of the pia.

§ 25. On February 17, 1888, the writer made and recorded the following observation upon a child, still-born, at term, No. 2258: In removing the parietal dura, a delicate membrane separated from it more or less easily in different localities on the two sides; it was observed also by the writer's colleague, Professor S. H. Gage. Although this distinctly indicated the existence of a parietal (ectal) layer of arachnoid, at that time the writer supposed the subject, Meninges, would be treated by another, and was, moreover, then fully occupied with the articles already undertaken; hence the observation was not made public.

§ 26. On December 29, 1890, Dr. Langdon's paper (1891) was presented before the Association of American Anatomists. He records observations made upon two children, at term, and one adult. His summary is as follows:

"The arachnoid is a true shut sac, similar in structure and function to the serosa of the other great cavities. Its parietal layer is easily separable from the dura at the vertex in the fœtus and young infant, but practically inseparable in this region in the adult. At the base of the skull it is demonstrable as a separate membrane, even in the adult. To assert that the parietal layer of arachnoid is absent because its subepithelial connective tissue has fused at the vertex with the dura (connective tissue), is as incorrect as to describe the great omentum as one layer of peritoneum, because its original four layers have become matted and adherent."

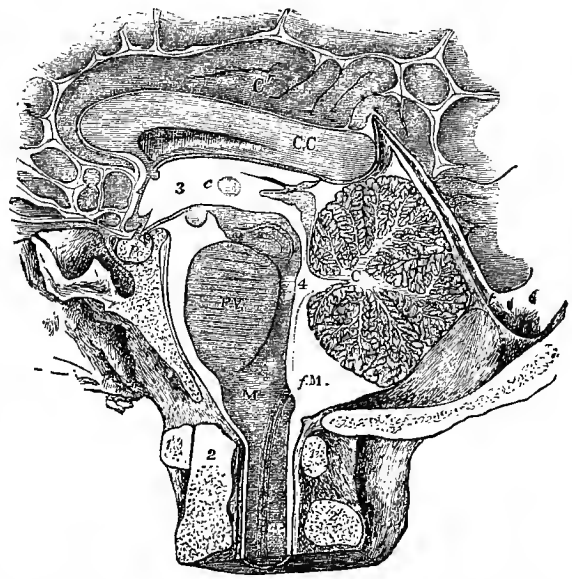

FIG. 419.—Medisection of the Cerebellum and Adjacent Parts. From Key and Retzius (Taf. viii., vii., Fig. 1); after Quain (iii., Fig. 131), reduced and somewhat modified. Compare Fig. 6, and Vol. VIII., Fig. 4684. 1, 1′, Atlas vertebra; 2, 2′, axis vertebra; 3, diacœle (third ventricle); 4, epicœle, the cephalic or cerebellar portion of the "fourth ventricle;" C, cerebellum; C.C., callosum; C′, callosal gyrus; M, postoblongata; P. V., pons; X, falcula (falx cerebelli) *c*, medicommissure; *c.c.*, just dorsad of (behind) the myelocœle (central canal of the cord); *f.* M., metapore; *p*, hypophysis; *t*, torcular.

Preparation.—A blue mass was injected into the spinal subarachnoid space; the head was then frozen and medisected. The original includes the mesal aspect of the entire head, less the integument and mandible. The true encephalic cavities and the subarachnoid spaces are colored, so only the actual mesal parts appear.

Defects.—In the original there is no indication of the arachnoid, although the circumscription of the subarachnoid space was the very feature supposed to be illustrated. Should it be claimed that the arachnoid is sufficiently indicated by the ental boundary line of the dura, the answer would be that, although in places the two meninges may be in contact, they are not in all; furthermore, as distinctly shown upon Taf. vi. of the same work, in Fig. 4711 of Vol. VIII., and in Figs. 420 and 421 of this volume, there is a point near the crest of the cerebellum (nearly opposite *t*) where the arachnoid (or its ectal layer) leaves the cerebellum and passes directly to the dura at the *foramen magnum*. There is no boundary between the metepicœle (fourth ventricle) and the subarachnoid space; even if, as in other cases, the membranous roof of the metacœle (metatela) adheres to the caudoventral surface of the cerebellum, the plexuses and the endyma constituting its ental surface must end somewhere; see p. 119, § 49.

The copy in Quain (9th and 10th eds.) omits the face and most of the cerebrum. Since the cavities are not colored, they appear as white areas without perspective, as if the preparation were a thin mesal slice. Most unfortunately, probably through some defect in execution, there is left a clear line between the conarium and the splenium, as if there were a passage from the diacœle (third ventricle) to the irregular subarachnoid space between the splenium, conarium, pregeminum and cerebellum. This is altogether misleading, for, as shown in Fig. 700 and on 4684, 4711, and 4718, and stated on p. 123 of Vol. VIII., the diacœle is completely circumscribed at that point by the endyma reflected from the velum upon the conarium. In the present copy this defect has been remedied so far as it could be by uniting the conarium and splenium so as at least to block the passage; but it should be remembered that it is closed not by nervous tissue but membranes. The editors of Quain have represented the missing metatela by the dotted line from near the number 4 to near the abbreviation *f.* M. A continuous line would have been more appropriate, and separated farther from the metacœlian floor; that could not be changed in the present copy, but the interval representing the metapore (foramen of Magendie) has been enlarged somewhat. Finally, the falcula (falx cerebelli), which was unmarked in Quain, is here designated by a cross (x).

§ 27. During the preparation of the present article the writer has verified the correctness of the previous obser-

* The open-meshed disks of the common garden-spiders, *Epeira*, *Argiope*, etc., are not comparable; rather the compact glazed sheet constructed by one of the house-spiders (*Tegenaria*) which will hold water, or the still more substantial nest of the water-spider (*Argyronetra*), which is like a stationary diving-bell and retains the air placed under it against considerable pressure.

vation as to the presence of an ectal or dural layer of arachnoid, and has noted its reflection upon the carotid and vertebral arteries to become continuous, presumably, with the ental, pial, or visceral layer. But no such reflection occurs at the nerve-roots unless at some depth within the foramens of exit, and this point the writer has as yet not had time to determine.

§ 28. Points Illustrated by Fig. 419.—A. The complete circumscription of the true encephalic cavities, excepting at the metapore.

A. The non-communication of these cavities with the pseudocœle (fifth ventricle).

C. The presence of considerable, irregular intervals, snbarachnoid spaces, or cisternas, between the pia and the arachnoid.

D. The continuation of the largest of these, *postcisterna*, between the cerebellum, postoblongata and occipital part of the craniun, with the spinal subarachnoid space.

E. The relation of the falcula (falx cerebelli) to the mesal portion, vermis, of the cerebellum; in Fig. 418

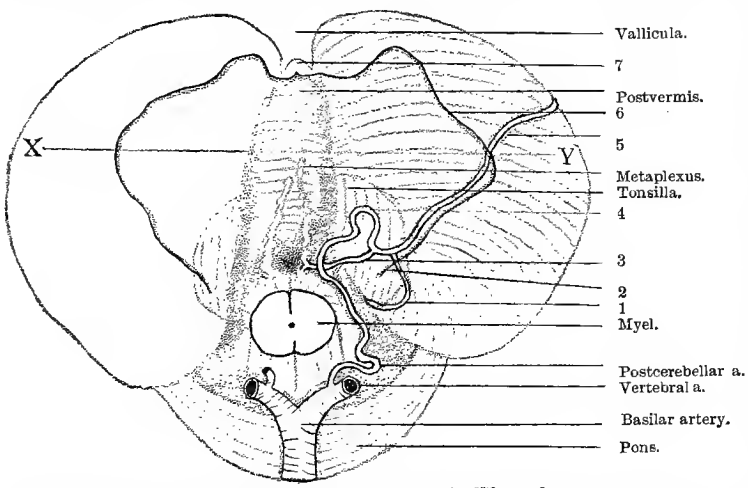

FIG. 420.—Caudal (lower) Aspect of the Cerebellum, etc., No. 376; × .9.

Preparation.—Through the kindness and skill of Dr. W. C. Krauss (a former student, now Professor of Pathology in the Medical Department of Niagara University in Buffalo, N. Y.), the brain was received fresh and in the dura. The cavities were injected with alcohol; the arteries first with alcohol and then with the starch mixture (p. 115, § 24). The alcohol passed through the metapore into the postcisterna and thoroughly preserved all the parietes; it had access also about the myel, where the arachnoid was cut in removing the brain. The ectal layer of the arachnoid was cut away along the line of its attachment.

Defects.—The perspective of the postoblongata is defective. The metapore is vaguely indicated and few of the vessels are shown. Of the lobes only the tonsillas are outlined. The flocculi and nerve-roots are omitted, also the rimulas (interfoliar crevices) on the left side. The most serious defect is the non-indication of the dorsal limit of the endyma which presumably accompanies the metaplexuses.

1, 3, Branches of the postcerebellar artery, the former passing between the cerebellum and the oblongata, the latter apparently supplying the corresponding metaplexus.

2, 6, Edge of the ectal layer of arachnoid bounding the area whence it had been cut away.

4, Loop of postcerebellar artery, an example of its tortuous course.

5, Main trunk of the artery near where it reaches the crest of the cerebellum; its branches are omitted.

7, Mesal ridge formed by the vein which divides into a right and left branch upon the caudal surface; the arachnoid here forms a somewhat sharp angle.

this is obscured by the fact that part of the left lateral lobe remains.

§ 29. *The Cisternas.*— At several regions the ental layer of arachnoid is separated from the pia by considerable spaces, called cisternas by Key and Retzius, 1875, p. 93.* They are enumerated and briefly described by Browning, Vol. VIII., p. 244.

§ 30. *Points Illustrated by Fig.* 420.—A. The general appearance of this aspect of the cerebellum together with the oblongata and pons; in Fig. 4177 these two parts were omitted.

B. The extent of the postcisterna (*cisterna magna* or *c. cerebello-medullaris*) upon about one-half the entire caudal aspect; there is, however, considerable variation in this respect.

C. The definite dorsal and lateral limitation of the postcisterna, although the boundary line is undulating and asymmetrical.

D. The lack of ventral boundary of the cisterna; the ectal layer of the arachnoid is attached to the dura so that this cisterna is continuous with the spinal subarachnoid space.

E. The union of the two vertebral arteries to form the basilar.

F. The origin of the postcerebellar arteries from the vertebrals near their junction.

G. The length and course of the postcerebellar artery, and the tortuous course of its central portion.

H. The passage of a branch of the postcerebellar artery mesad toward the metapore, apparently supplying the metaplexus.

I. The extension of the metaplexuses dorsad from the metapore upon the cerebellum.

§ 31. *The Postcisterna.* — Notwithstanding the presumption that all the cisternas form a continuous series, the writer's observations, up to the present time, compel him to regard the space in the angle between the cerebellum and the oblongata as presenting an important peculiarity, viz., as lying, not between the pia and the visceral arachnoid, but between two layers of the latter. The facts upon which this view is based cannot be detailed here. The view is indicated upon Fig. 421.

The writer is aware of the difficulties involved in its acceptance; without question, the postcisterna communicates on the one hand with the true encephalic cavities through the metapore, and on the other with the spinal subarachnoid space; its free communication with the other cisternas, although commonly accepted, seems to the writer not yet clearly demonstrated.

§ 32. *Points Illustrated by Fig.* 421.—A. The usual relation of the meninges in these respects, viz., the independence of the dura; the adhesion of the pia to the brain-substance; the dipping of the pia into the narrow depression at either side of the vermis as a vascular fold; the adhesion of the arachnoid to the pia over most of the cerebellum, so as to constitute a piarachnoid; Vol. VIII., Fig. 4687.

B. On the caudal aspect of the cerebellum, the formation of a considerable space, the postcisterna, by the separation of an ectal layer of the ental or visceral layer of the arachnoid.

§ 33. *The Metapore* (*Foramen of Magendie*).*—Historical. On December 18, 1826, before the Académie des Sciences, Magendie read the second part of his second memoir upon the liquid contained in the spinal canal and the cavities of the brain. It was published in the *Journal de Physiologie* for January, 1827, Tome vii., pp. 1–29.

On pp. 21 and 22 Magendie declares that the fourth ventricle of the brain communicates with the subarachnoid space of the spinal canal through an orifice in the roof of the ventricle. He adds that, in the human adult, this is a constant condition easy to verify, and briefly describes the method of exposing the brain for the purpose.

* Admitting that most of the cisternas do lie between the arachnoid and the pia, as commonly described, the writer's later observations lead him to regard the postcisterna as between two layers of the ental arachnoid itself; see Figs. 420 and 421.

* This portion of the article is based upon a paper by the writer, read before the Association of American Anatomists, at Princeton, December 29, 1892. See Amer. Neurol. Trans., 1893.

Magendie designated the orifice as *entrée des cavités du cerveau* or *entrée des ventricules cérébraux*. In 1855 Luschka published a description and figure of the orifice, which he re-named *foramen Magendii*. In the present article, as in Vol. VIII., p. 123, these and various other polyonyms are replaced by the mononym *metapore*, Latin, *metaporus*, signifying an orifice in the metatela, the membranous roof of the metacœle, the cavity of the metencephal.

§ 34. Most later anatomical writers have admitted the existence of the metapore, but the descriptions are commonly brief and the figures unsatisfactory. That by Key and Retzius is suspiciously symmetrical, though it is copied by Schwalbe; Henle's (Fig. 423) is more natural; the best figures and the fullest description are those of Carl Hess, 1885, but no figure has the appearance of having been based upon a photograph.

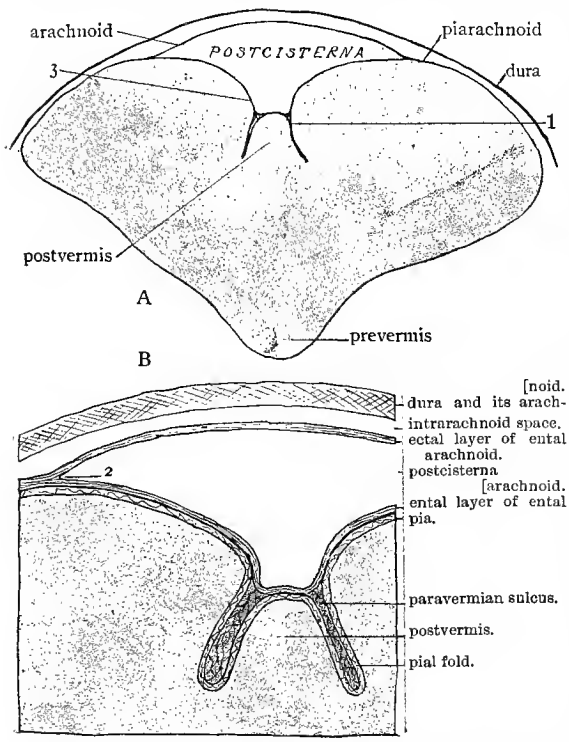

FIG. 421.—Sections of the Cerebellum and Postcisterna; semidiagrammatic.

A. Dorsal (cut) surface of the ventral portion of the cerebellum, together with the adjacent dura and the large "subarachnoid space," postcisterna, commonly called *cisterna magna* or *c. cerebello-medullaris*. At the meson appears the postvermis, separated by the paravermian sulci (1) from the large lateral lobes; 3 is the ental layer of the arachnoid. The meninges are here represented by lines only.

B. Enlargement of the meso-caudal region of A. The meninges are here represented by zones conventionally shaded; 2, the place of junction of the two layers of the ental arachnoid at the margin of the postcisterna.

Preparation.—An adult cerebellum (2891) was divided at a plane corresponding with the line X—Y in Fig. 8, so as to separate the dorsal two-fifths; on Fig. 4711 (Vol. VIII.) the plane of section would be indicated approximately by a line across the unshaded (cut) surface connecting the points where the dotted lines from the words *nodulus* and *epicœle* intersect the margin of that surface; as seen in Fig. 420 it passes dorsad of the plexuses. The ectal layer of arachnoid is represented as the continuous caudal boundary of the postcisterna, while in Fig. 420 it is supposed to have been trimmed closely along the line of its depression from the ental layer 3.

Defects.—For readier comparison with Fig. 421 the figures should have been inverted so as to have the postcisterna nearer the reader. In B the postcisterna is enlarged two diameters, but the several zones representing the meninges are disproportionately widened, and their shading is conventional for discrimination only, and not for the indication of histological structure. The ectal or dural layer of arachnoid was inadvertently omitted, and there is no indication of the two layers of the dura itself. The numerous rimulas and interventing foliums that were divided in the section are not indicated, and the usual relations of the pia and arachnoid to each other and to narrow encephalic depressions generally are illustrated only at the paravermian sulci.

§ 35. The metapore is regarded as an artificial orifice by Kölliker, 1884, p. 248, but apparently on *a priori* embryological grounds and without a personal examination of carefully prepared adult brains. An orifice in the metatela is shown by Reichert (1859) in a transection, Taf. ii., Fig. 14; the description, p. 113, merely states that the roof is incomplete, but in the *Résumé*, p. 185, he distinctly holds that any orifice in this region is artificial.

Gegenhaur (1888) admits the usual presence of the metapore (p. 819), but adds that it is sometimes absent, as in his Fig. 522.

§ 36. In 1884 (Cartwright Lectures on "Methods of Studying the Brain," *New York Medical Journal*, April 26, p. 458), the writer expressed doubts as to the existence of the metapore upon the following grounds:

1. Its absence in the cat and other animals examined.
2. Its morphological improbability, in view of the assumed conditions expressed in the phrases *endymal continuity* and *cœlian circumscription*.
3. The observed readiness with which membranous walls and adhesions are ruptured in the customary manipulations of the brain.

The paper of Hess (1885) and the possession of more perfect material, led to a re-examination of the subject. Several preparations were made and photographed (negatives 164 and 592). In a paper (1886), while reaffirming the unbroken continuity of the metatela in the cat, the writer stated that in man there is a mesal aperture approximately rhomboidal in outline, and about 5 by 8 mm. in diameter.

In 1889, in the article, "Gross Anatomy of the Brain," in the REFERENCE HANDBOOK, upon the supposition that a special article upon the meninges would be prepared by another, the writer restricted himself to indicating the location of the metapore upon a medisected brain, Fig. 4711 (this volume, Fig. 418), and to remarking, page 122, § 60, "that the metapore undoubtedly exists in man, though not, perhaps, in other vertebrates." The qualification was due to the conditions observed in a chimpanzee brain, but as this had been medisected no final conclusion could be derived from it.

§ 37. Notwithstanding the above declaration upon the part of one who at that time had been an anatomist for thirty years, in Minot's "Human Embryology" (1892), neither of the terms, foramen of Magendie or metapore, is used, and the whole subject is apparently disposed of in the following passages (p. 676):—"Several writers have thought that the membrane was broken through at certain points, but it probably is really continuous throughout life. The fourth ventricle is to be regarded, then, as an expansion of the central canal permanently bounded by the original medullary walls."

The writer infers that Minot follows Kölliker in regarding the almost unanimous testimony of anatomists as inadequate to outweigh the presumption against the formation of an orifice in a pre-existing membrane; yet he describes (p. 262, Fig. 170), under the name of *oral plate*, a septum between the mouth and the pharynx of the human embryo which must disappear before those two divisions of the enteron can become parts of a continuous canal.

§ 38. Aside, however, from the desirability of dispelling embryological scepticism, the question of the presence or absence of the metapore involves so many and so serious considerations, zoological, physiological, psychological, and even philosophical, that the writer has recently re-examined all the specimens in the Museum of Cornell University, and has prepared two with which the possibility of artificial disturbance of the natural relations had been avoided.

As the result, the following proposition is submitted:

In the normal adult human brain there is a considerable orifice in the roof of the metacœle whereby the liquid of the encephalic cavities may escape into the postcisterna. The only cases of apparent absence are in the brains of two insane persons, one of them hydrocephalous; but as both of these brains had been medisected, no final conclusion should be based thereon.

§ 39. *Points Illustrated upon Fig.* 422.—A. The existence of a natural orifice in the membranous roof of the "fourth ventricle."

B. The simplicity of the form and relations of the metapore in this specimen. It is mesal, symmetrical, and oval.

C. The appearance of the metaplexuses just within the cephalic margin of the metapore with no such extension upon the cerebellum as is shown in Fig. 420.

§ 40. There is perhaps no point in gross anatomy wherein the result is more dependent upon the method; hence the procedures in the two cases where the orifice was last observed shall be described in detail.

§ 41. *Alcoholic Specimen, No.* 2655.—In the spring of 1890 the head of an adult man, with most of the neck attached, was received in a fresh condition. The brain was hardened in place by the continuous injection of alcohol through the arteries; Vol. VIII., p. 200, and this volume, p. 114. The calva and contained portion of the cerebrum were sawn off, and the face with the frontal portion of the brain separated from the neck, cerebellum, and occipital region of the cerebrum. This latter mass was kept in strong alcohol until December 19, 1892. On this date, with a thin saw newly sharpened, the left side of the head and neck was removed so as just to clear the myel (spinal cord) and leave the region of the metapore wholly inclosed between the untouched right lobe of the cerebellum and the remnant of the left lobe. With a very sharp scalpel, frequently dipped in alcohol, the larger part of the cerebellum was cut away; more of the cranium was sawn off, and the vertebral arches removed with nippers. During all these operations the thorough hardening of the soft parts had prevented any movement of the cranium upon the atlas. The remnant of the cerebellum was now peeled cautiously up from its pia, and the left half of the oblongata cut out. Upon the region where the metapore was supposed to open was now dropped a little soapy water; the point of a blow-pipe was directed at—*not pushed into*—the metacœle from the ventral side; on blowing gently, bubbles formed on the dorsal side, showing the passage of air through the metapore. This was done in the presence of six witnesses, most of them trained observers.

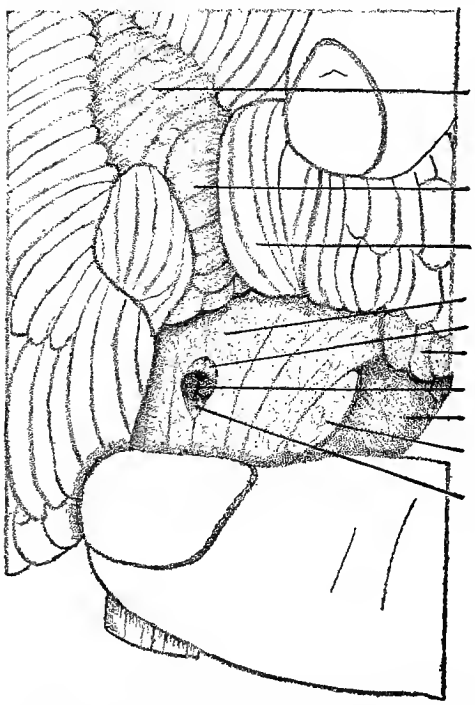

FIG. 422.—The Metapore (Foramen of Magendie) as Exposed by the Divarication of the Cerebellum and Oblongata. Specimen 318, Mus. Cornell University. × 1.

Preparation.—The brain of an adult Swedish* carpenter was removed with great care, according to the writer's method, *i.e.*, by dividing the calva sagittally at the left of the meson (Vol. VIII., p. 199), so as to avoid tearing membranous adhesions. The brain was supported on a bed of cotton; the arteries and the arachnoid extending from the cerebellum to the oblongata were cut away and the two parts held asunder with fingers so as to expose the region of the metapore. A photograph was then taken, upon which the drawing is based. After hardening, however, most of the cerebellum was cut away and another photograph taken of the reduced mass. The specimen and both photographs were shown at the meeting of the Association of American Anatomists, December 28, 1892.

Defects.—The right side of the cerebellum was displaced more than the left, giving rise to the marked obliquity. The metapore itself should be shown on a larger scale. The postcerebellar arteries are omitted; they do not appear distinctly in the first photograph, and no record was made of their locations. This is unfortunate, since in all the cases where they are preserved their relations to the metapore are close. Had more of the caudal aspect of the cerebellum been included, there might have been shown the line of attachment of the arachnoid at the boundaries of the postcisterna. The wavy lines on the dorsum of the oblongata hardly do justice to the vascularity of the pia covering that region.

*The left hemicerebrum is represented in Vol. VIII., Fig. 4778. Since that volume was published, and indeed after the pages of the present volume containing corrections of the article "Brain" therein, the writer has learned from a relative of the carpenter that he was not a Hungarian, as first stated, but a Swede.

The specimen was immersed in normal salt solution; the blow-pipe was so placed that the stream of air entered the metacœle. As soon as it was used the air collected in the postcisterna and gradually distended the arachnoid. At this first trial, in the presence of one witness, the arachnoid, notwithstanding its extreme delicacy, was absolutely unbroken, and when the cerebellum was permitted to tilt slightly cephalad, as in photograph 593, the distended sac presented a really beautiful appearance; during the subsequent manipulations a small rent was made at one margin where the arachnoid becomes attached to the cerebellum, so that the distention thereafter was less complete; it was observed, however, by several, that the air passed from the metacœle freely into the postcisterna, and the outline appears in the photograph, though vaguely.

It is essential in this connection to call attention to the fact that when the cerebellum was permitted to fall

Hitherto no instrument, even the comparatively safe syringotome (Vol. VIII., Fig. 4880), had approached the supposed location of the metapore. But when repeated trials had satisfied all interested that there was a natural communication, the syringotome was cautiously introduced, and the limits of the passage ascertained; then with fine scissors the left wall was removed. The cephalocaudal diameter of the metapore is more than 5 mm.; its transverse diameter would be about the same in the fresh state, but a knuckle of the right postcerebellar artery encroaches upon it.

In view of the ease with which natural membranous adhesions yield in poorly preserved brains, it is important to add that all the membranes in this preparation were firm and maintained their natural attachments so as to perceptibly resist separation. When it is added that the various operations upon the already hardened brain, which are briefly indicated above, consumed at least four hours, it may be believed that adequate precautions were taken against the production of any artificial conditions. Two stages of the dissection are represented in photographs 590 and 591.

§ 42. *Fresh Specimen,* 2971.—The head of an adult man was received fresh through the kindness of a former student, December 21, 1892. The neck and occipital region were sawn away from the rest of the head; the cephalic slope of the cerebellum remained attached to the cerebrum, but the larger part, containing the metapore, was undisturbed.

cephalad it was held by the arachnoid, even after removal from the liquid. Through the transparent membrane it could be seen that none of the parts included within it were upon the stretch.

Later the cerebellum and oblongata were removed from the remnant of cranium, the arachnoid was trimmed close to its attachment, and a second photograph (No. 594) taken. Then the specimen was hardened in alcohol and reduced to a more convenient size by cutting off most of the lateral lobes of the cerebellum.

There is no reason to suppose that any of the membranous attachments have been torn, but the presence of the metapore is unmistakable.

Even, therefore, if some doubt might be cast upon the reliability of the previously prepared specimens, the two whose preparation and examination have been here described, prove that Magendie and others have been correct in affirming the existence of a mesal orifice in the roof of the metacœle.

§ 43. The writer now feels justified, not only in reiterating the conviction which was expressed in 1886 and 1889, but in holding that upon the unbelievers now rests the burden of disproof. He is ready to demonstrate the metapore upon any fresh or well-preserved brain, and

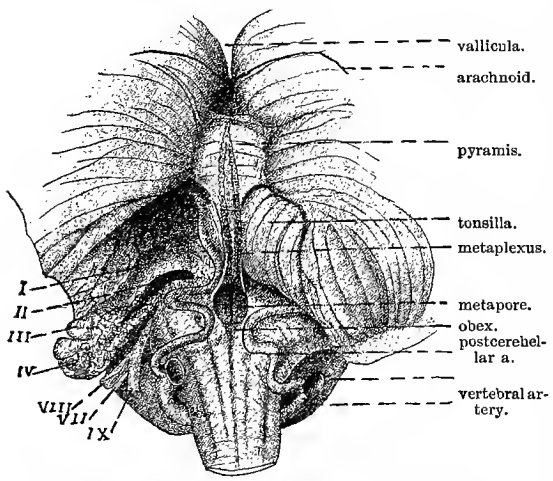

FIG. 423.—The Metapore (Foramen of Magendie) and Adjacent Parts nearly as represented by Henle. (Anatomie, iii., Fig. 232.)

Preparation.—In the absence of statement by the author, it may be said that the brain was probably removed in the usual way, and the cerebellum tilted cephalad so as to expose its caudal aspect and the dorsum of the oblongata. The left tonsilla was then cut out, exposing on that side the parts marked I, IX, and a continuation of the postcerebellar artery.

I, metatela (*velum medullare posterius*), its lateral portion; II, lateral recess of the metepicœle (fourth ventricle) opened by the removal of part of the metatela; III, flocculus; IV, epiplexus (*plexus choroideus lateralis*); see Vol. VIII., Fig. 4702; VII, VIII, IX, cranial nerve-roots.

Changes.—The boundary line of the tonsilla has been made more distinct than in the original. In the upper part has been introduced a line to represent approximately the line of attachment of the arachnoid, constituting the dorsal boundary of the postcisterna. (See Fig. 420.)

Defects.—The margins of the metapore are too sharply defined; this is, perhaps, unavoidable when the parts are upon so small a scale; it cannot be said to bear either way upon the question of the naturalness of the orifice, for the effect of tearing a tough membrane like the metatela would be to leave ragged edges. The relations of the plexuses and accompanying strip of metatela are inadequately indicated, and the writer regrets his present inability to elucidate them. The postcerebellar arteries are represented as if distributed only between the oblongata and cerebellum, and between the lobes of the latter. (Compare Fig. 420.)

will maintain its normal existence in the human adult until there are produced several otherwise normal brains presenting a continuous metacœlian roof.

§ 44. *Points Illustrated by Fig.* 423.—A. The admission of the normal existence of the metapore in the adult by so expert an anatomist as Henle.

B. The attachment of an extension of the metatela from the cephalic border of the metapore upon the uvula and pyramis of the cerebellum.

C. The extension of the metaplexuses upon the thus everted ental aspect of the metatela, whereas in the specimen represented in Fig. 420 they barely appeared at the margin.

D. The topographical relation to the metapore of the contorted postcerebellar arteries.

E. The relation of the flocculus to the lateral recess. See Vol. VIII., Fig. 4720.

§ 45. But while the main fact may be regarded as demonstrated, there are many subordinate points upon which our information is far from satisfactory.

§ 46. It is evident that there are two different arrangements. The simpler is apparently the less common. It exists in specimens 318, 376, 706, 2347, and 2870.

Here, as in Figs. 418 and 422, the metatela is readily separable from the overhanging cerebellum, excepting, of course, at the cephalic margin, where its two constituents, the pia and the endyma, are continuous with the same membranes on the ectal and ental surfaces, respectively.

In this kind the plexuses on the ental surface of the metatela appear, if at all, only just within the cephalic margin of the metapore.

In the second kind the metatela adheres closely to the cerebellum, the two apposed layers of pia not being separable; thus the cephalic wall of the metapore appears to be the cerebellum itself; but the extension dorsad of the metaplexuses shows that it is truly the metatela. As yet the writer has been unable to determine the precise limit of the metatela. See Figs. 420 and 423.

§ 47. Since the metatela consists of two different membranes, the ental endyma and the ectal pia, we should know their exact condition at the margins of the metapore. An analogous case is the orifice of the oviduct, where mucosa and serosa become continuous.

§ 48. At what period of development does the metapore appear? From the extreme softness of new-born and fœtal brains, it is evident that artificial rupture of the delicate metatela may easily be produced. Probably the best results may be anticipated from the examination of specimens prepared by transecting the brain at the mesencephal (gemina and crura), and injecting the preservative gently but continuously caudad through the mesocœle or aqueduct, so as to fill the cavities and fix the membranous attachments.

§ 49. How is the metapore produced? Is there an absorption of material over a given area? or is a rupture accomplished by spontaneous mechanical agencies, the margins of the rent becoming rounded off later?

§ 50. What is the significance of the close topographical relations of the postcerebellar arteries? The length and tortuousness of these vessels can hardly fail to impress anyone who carefully studies the region in question.

§ 51. Does the cœliolymph (cerebro-spinal liquid) pass in both directions with equal facility?

§ 52. Is the non-formation or obliteration of the metapore a cause or merely a concomitant of idiocy, insanity, or hydrocephalus? Horsley has recorded (*Brain*, July, 1885, p. 238) a case of encephalocele where the metatela was a "strong, fibrous sheet," and there have been already referred to two insane brains, one of them also hydrocephalic, where there is at least room for doubting the presence of the metapore.

§ 53. Does the metapore exist in any other animals, especially in the anthropoid apes? If not, then its presence would constitute one of the rather small number of absolute distinctions of humanity. Although the chimpanzee brain in the Museum of Cornell University probably is the most perfectly preserved in the world, its medisection prevents us from relying implicitly upon it. So far as may be inferred, there was a metapore, the plexuses extending upon the caudal surface of the cerebellum as in the second kind already mentioned. On January 11, 1893, through the kindness of Superintendent A. E. Brown, of the Philadelphia Zoological Gardens, the writer received the body of a baboon in excellent

coudition.* The cerebrum was removed without disturbing the cerebellum. Air was blown gently at the aqueduct; the stream was immediately felt escaping at the *foramen magnum*. A blue liquid allowed to run into the aqueduct from a small glass syringe, with a minimum of pressure, also escaped at the foramen. On removing the tentorium there was recognized a small but distinct postcisterna (*cisterna magna*), full of the liquid. On carefully lifting the cerebellum there was found to be a metapore of the first kind. This observation has been confirmed upon two other Old World monkeys. †

§ 54. *What is the Use of the Metapore?*—Those who admit its existence have generally supposed that, during the vascular congestion attendant upon cerebration, the undue compression of the brain within its unyielding case is prevented by the transfer of the cœliolymph, first into the postcisterna, and then into the spinal subarachnoid spaces.

But while the non-osseous portions of the spinal canal might yield to an ental pressure, is there any evidence of the distensibility of the myelic theca? And would not any pressure adequate either to distend it or to compress the liquid, injure the myel itself or the brain, or rupture the arachnoid bounding the postcisterna?

§ 55. *Are there other Natural Communications between the Encephalic Cavities and the Arachnoid Space?*—According to Quain (iii., 126, 188), Merkel and Mierzejewski have described an actual cleft in the pia along the medicornu. But the writer is not able to learn that these observations have been confirmed by others, or that any photographs or figures have been published. For the present, therefore, in view of the negative testimony of other anatomists, and the results of his own repeated dissections and experiments, he is compelled to regard such clefts, when found, as artifacts, comparable with the orifices near the porta in an alinjected brain (Vol. VIII., Fig. 4742).

§ 56. More generally admitted is the existence of natural orifices at the tips of the lateral recesses of the fourth ventricle. These recesses, parepicœles, are shown more or less imperfectly in Vol. VIII., Figs. 4702, 4703, 4704, 4714, 4720, 2, and in this volume Figs. 58 and 423. From Fig. 4702 it will be seen that, in the embryo, the extremities of these recesses are closed. The presumption is, therefore, that they remain closed in the adult. It is true that they are usually—perhaps always—found open in brains removed and examined in the ordinary ways; furthermore, Hess has given (1885) a representation (Taf. xxix., Fig. 10), apparently faithful, of what seems to be the natural condition of the parts. Nevertheless, so great is the probability of artificial rupture of the pia by reason of its adhesion to the nerve-roots (a probability far greater than with the comparatively protected metatela), that the writer feels compelled to withhold his recognition of the orifices until the publication of more detailed descriptions and of figures based upon photographs.

§ 57. *Is there Direct Communication of the Subarachnoid Spaces with the Intrarachnoid (or Subdural) Space?*—Whatever view they adopt regarding the constitution of the arachnoid as a whole, most writers agree that the arachnoid covering the brain and myel is continuous, excepting for the capillary spaces about the nerve-roots referred to in § 27. Hence, while the cœliolymph may pass to and fro between the true encephalic cavities and the postcisterna through the metapore, and may thus enter the other cisternas (§ 31) and the spinal subarachnoid space, it is nevertheless confined thereto.

But Dr. Langdon (1891) holds that "at the base of the cranium there are two points where the visceral [ental] arachnoid is deficient, one on either side, in the 'bridge' of arachnoid which stretches across from the cerebellar lobes to the under [ventral] surface of the oblongata. These foramina measure about half an inch (12 mm.) in longitudinal diameter by one-fourth inch (6 mm.) transversely, and are crossed by three or four fibrous bands, the attachment of which to the edges of the openings produces a multiple crescentic appearance of their margins, which suggests the name, '*lunulate foramina*.'"

It will be noted that the location of these alleged lunulate foramina in the arachnoid corresponds with that of the ventral ends of the lateral recesses. Hence, on the one hand, if both are natural, the transfer of the cœliolymph from the true encephalic cavities to the arachnoid space is provided for; on the other, the relation of the nerve-roots to both the pia and the arachnoid renders both liable to rupture during extraction or manipulation of the brain. Hess (op. cit., Fig. 10, *ar.*) implies that the arachnoid was cut and reflected at this point.

* This is No. 2977 of the University Museum; the chimpanzee above mentioned is No. 265; it also was sent by Superintendent Brown; the preparation of the brain by continuous arterial alinjection is briefly described in the *Proceedings of the Amer. Assoc. Adv. Science*, 1885, p. 527.

† Through the courtesy of Dr. W. A. Conklin, formerly Superintendent of the Central Park Menagerie, the writer has been enabled to examine the brain of an adult Orang, No. 3082 of the Museum of Cornell University. All precautions against artificial rupture were taken. Air passed readily from the mesocœle into a large and distinct postcisterna through several orifices in the metatela; these orifices and the postcisterna were photographed May 24, 1893; Nos. 657–660.

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Burt G. Wilder.

MENINGITIS. Etiology and Pathology.—The cause of cerebro-spinal meningitis is nearly absolutely established. Bonome, of Padua, declares that the *diplococcus of pneumonia* may now be regarded as the typical cause of epidemic cerebro-spinal meningitis, but as the cause of exceptional cases there are found (a) another diplococcus, (b) the streptococcus pyogenes, (c) a short, thick bacillus like the typhoid bacillus (Neumann and Schäfer),

and (d) an encapsulated bacterium like the pneumobacillus of Friedländer (Netter).

Bonome discovered a sixth micro-organism in an epidemic near Padua. The disease developed itself independently of any pneumonia and with quite peculiar symptoms: rapid, almost simultaneous attack of many and especially of robust individuals with chill, pains in the joints and along the spinal column, uncontrollable vomiting, fever up to 43° C., violent trismus, opisthotonus, fixation of the pupils, etc. Death, which was the result in seven of sixteen cases, often occurred within ten hours.

Section showed abundant exudation, and in one case pus in the vicinity of the cerebellum; cloudy fluid, with pus and flakes of fibrine in the lateral ventricles; numerous ecchymoses of the pia, and hæmorrhage into the ventricles twice; hæmorrhages under the peri- and endocardium. The lungs and pleura were always free from fibrinous inflammation; but there was hæmorrhagic exudation in the parenchyma of the lungs, and in a few cases in this exudation, as well as in that of the meninges, Bonome found constantly large round or oval immobile micrococci isolated or united in chains.

Huguenin makes the following divisions in explaining the origin of meningitis in general:

1. *Hæmatogenous Meningitis.*—The micro-organisms reach the pia through the arterial blood-supply. These are the cases of meningitis which occur after or in the course of ulcerative endocarditis, typhoid fever, cholera, pneumonia, typhus, recurrent fever, variola, scarlatina, measles; traumatic and puerperal sepsis; finally, cerebro-spinal meningitis. In most of these diseases it is a case of infection of the brain with streptococci. The streptococcus meningitis certainly occurs after ulcerative endocarditis, typhoid fever, variola, scarlatina (in both the last cases usually from the ear), measles, traumatic and puerperal sepsis. Of obscure origin are the cases which develop in the course of acute articular rheumatism. In this connection it must be remembered that hyperpyresis is often mistaken for meningitis. In the pneumonia meningitis the pneumococcus of Fraenkel has been unmistakably demonstrated. The bacteria of epidemic cerebro-spinal meningitis have not yet been isolated with certainty. Fraenkel's pneumococcus has often been found. Weichselbaum has described also a bacillus intra-cellularis meningitidis.

2. *Meningitis from the Lymph-Vessels.*—These cases are mostly infections by streptococci in connection with peripheric suppuration about the skull; caries of the temporal bone, of the ethmoid, bone tuberculosis, bone syphilis, traumatic osteitis of the skull.

Huguenin says the subdural space is a protection; but a direct bridge through this space is formed by the pia-sheaths of the nerves of exit, the pia-sheaths of the vessels passing downward, especially of the jugular and carotis and the Pacchionian bodies. The pia may be affected only directly. Suppurations which reach the brain in other ways are confined to the dura.

3. *Meningitis from the Veins.*—The cause is here mostly a sinus thrombosis from penetration of the pia by micro-organisms through the Pacchionian granulations, as from caries of bones and diseases of the external skin, and of the subcutaneous connective tissue, erysipelas, furunculosis, and the like. It is not yet definitely settled that syphilis and tuberculosis of the bone may excite a meningitis through the veins, but the virus of an erysipelatous meningitis certainly finds its way through the orbits and the sinus cavernosus.

4. *Meningitis from Brain Tumor.*—Rare cases may thus arise from a central necrotic tumor undergoing softening.

5. *Meningitis from the Spinal Column.*—Huguenin reports a case of streptococcus meningitis from a gangrenous bed-sore, which had broken inward in the course of transverse myelitis. Cases of gonorrhœal meningitis have been reported by Hayem and Parmentier. Gull reported two autopsies, one showing softening of the cord, the other meningitis.

Adénot distinguishes three varieties of parasitic meningitis as produced respectively by micrococci, bacilli, and mixed forms. The first may be divided into the forms produced by the micrococci of pneumonia, or the micrococci of Weichselbaum, and the streptococcus. By the term pneumococcus is understood the diplococcus of Fraenkel. What *rôle* the pneumococcus of Friedländer plays in meningitis is questionable. Concerning the bacillar meningitis, forms have been described by Neumann, Schäfer, Adénot, and others, resembling the typhoid bacillus of Eberth, but not identical with it. Concerning the mixed forms, Monti produced meningitis in one case by injecting the coccus of Fraenkel into the dura, and afterward the streptococcus into the blood. The cause of epidemic cerebro-spinal meningitis cannot be satisfactorily fixed as yet.

Boulay and Courtois-Suffit report the case of an habitual drinker, aged forty-four, who died after three days' illness, and upon post-mortem there were found suppurative meningitis and peritonitis, while the other organs showed no change. The authors found in the suppurative exudations capsule cocci, and besides these, in the exudation of the peritoneum, other bacteria. A mouse inoculated with the pus of the brain membranes died in twenty-four hours. The spleen was markedly swollen, and "characteristic pneumococci" were found in the blood. There was, therefore, in this case, a remarkable extra-pulmonary localization of the pneumococcus, produced perhaps by the chronic alcoholism. The exudation was green, thick, and plastic, characteristics which enabled the author to predict the presence of the diplococcus pneumoniæ.

In the ensuing discussion, Sevestre declared that he had encountered a case of peritonitis in a young girl recently where the exudation was accumulated in the left iliac fossa. In pus removed by puncture Netter demonstrated the pneumococcus. Netter also reported a case of meningitis and peritonitis in a small child where he found pneumococci in the blood, and supported the declaration of Debove that he was able to declare the existence of the diplococcus pneumoniæ in extra-pulmonary localizations from the macroscopic condition of the exudation, a declaration which had been advocated in former statements by Netter. But the diagnosis must not rest upon these conditions. It may be determined only by bacteriological examination.

Gabbi and Puritz declare that the occurrence of a meningitis or endocarditis, either or both, in the course of a croupous pneumonia, or during the period of convalescence, is, if not a frequent, at least an established sequence, and either may properly be regarded as a complication of this disease.

Weichselbaum, as early as 1884, declared that the micro-organisms of croupous pneumonia might be the cause of meningitis, and Foà and Bordoni-Uffreduzzi produced meningitis by the inoculation of animals with the pneumonic diplococcus. The same results were obtained by Fraenkel and later by Netter.

Lancereaux and Besançon were able to demonstrate Fraenkel's capsule microbe in many cases of endocarditis.

A review of the later works of Weichselbaum, Vinet, and others, shows with certainty that the above-mentioned micro-organisms may produce an acute inflammation of the meninges or of the endocardium.

Foà finds an organism that partakes partly of the character of the meningococcus and partly of that of the pneumococcus. If the latter is cultivated anaërobically it takes on the properties of the meningococcus in twenty-four hours. The meningococcus can be temporarily transformed into the pneumococcus, if it is inoculated at the same time with the staphylococcus pyogenes aureus.

Klippel reports a case of infection by micro-organisms in the course of mental disease. The patient, a fifty-year-old gardener, had suffered for ten years with dementia and slight paresis of the left side of the body. He was seized with sudden fever, extensive muscular rigidity and convulsions, and died comatose in three days. The most careful investigation failed to disclose any laceration or break of the surface, which could have furnished an avenue for outside infection. The post-mortem revealed an extensive purulent meningitis, extending from

a centre of softening, which had been regarded as the cause of the dementia. Microscopic examination of the pus showed the pneumococcus. Such secondary infections in the course of insanity occur frequently. Klippel claims that the pathogenic micro-organisms circulating in the blood find in the diseased centre a locus minoris resistentiæ.

The differential *diagnosis* between simple and tubercular meningitis may be established by the use of tuberculin, though the procedure is not wholly without danger in the tuberculous form.

In pseudo-meningitis (Boulay), aside from partial paralysis, all the symptoms of meningitis may be present, and the case may look very doubtful until unmistakable hysterical symptoms develop; or recovery occurs suddenly, sometimes after a convulsion.

Treatment.—Dauchez in the case of a child, aged four, was able to relieve excruciating headache at night only by narcotic doses of morphine and chloral, but succeeded during the day with antipyrin, in small doses—.02, .04, every hour for four doses. The distressing outcry ceased, though the child gave vent to sighs from time to time.

Essex-Wynter was able to give some relief in four cases of tubercular meningitis by puncture of the vertebral canal, and discharge of cerebro-spinal fluid. The breathing improved; sometimes coma was relieved. Irresponsive pupils regained the reflex, but all improvement was only temporary.

Opium remains the anchor in the treatment of meningitis. Dennison cured a chronic case with tuberculin.

Pachymeningitis, External and Internal.—As illustrative of the rarity of the disease, Northrup declares that he encountered internal hæmorrhagic pachymeningitis only four times in one thousand five hundred autopsies. In three cases, severe and prolonged convulsions finally terminated in death. In the fourth case there was no symptom except restlessness and slight rigidity. The patient died of acute enteritis. There was no paralysis in any case.

Bailey reported a case in a man, aged seventy-two, a subject of senile melancholia; death from convulsions. Autopsy disclosed encapsulated hæmatoma under the dura of the right parietal bone. The hæmatoma was composed of coagula of different ages, and there was a recent rupture in the arachnoid cavity.

Ruhemann found in percussing the skull in a great number of patients, that sensitive surfaces could be detected only in chronic pachymeningitis, and then with great regularity. In genuine epilepsy the remarkable observation was made that in twenty of twenty-nine cases a circumscribed portion of the temporal bone was sensitive.

Adamkiewicz emphasizes the fact that in spinal pachymeningitis it is the extension of the inflammation rather than the pressure of the connective tissue which damages the nerves and cord.

Hoffmann remarks that, notwithstanding the fact that the intra-cranial diseases as sequels of affections of the ear have long since received full consideration, purulent pachymeningitis externa, the most frequent form of intra-cranial inflammation in consequence of ear disease, still receives very little study. Most of the text-books do not even consider an isolated inflammation of the dura. Hoffmann collected from literature one hundred and two cases in which the autopsy, with certainty, confirmed participation of the dura. From his own and other studies, the author recognizes (1), a form in which pus occurs as a deposit on the outside of the dura, and (2), a form in which it shows itself as an extra-dural abscess.

The following are the conclusions: Purulent external pachymeningitis is the most frequent of the intra-cranial diseases after inflammations in the middle ear, but on account of its uncertain symptomatology it is recognized in life in only a few cases.

It is the most frequent cause of fatal intra-cranial diseases—meningitis, sinus phlebitis, and brain abscess. These consequences are favored by the long duration of pachymeningitis and retention of its pus.

So soon as the bones become diseased in consequence of affection of the middle ear, suspicion should be excited of a complication with pachymeningitis.

Treatment must be operative. It consists in trephining the mastoid process and exposure of the inflamed dura. *James T. Whittaker.*

MENTHOL. The decided antiseptic qualities, and the safety with which it may be administered, have led to the internal use of menthol in a number of diseases and conditions in which an antiseptic is indicated. In pulmonary and laryngeal phthisis it has been recommended to combine its internal use with inhalations and local application to the diseased parts when within reach. It is thought to give rise to a general amelioration of the symptoms, promoting expectoration and reducing the amount of the sputa, and lessening the night-sweats and fever. It does not irritate the stomach or kidneys, does not cause hæmoptysis, or produce any bad effects. For internal use from fifteen to twenty grains are given two or three times, and increased to five or six times, a day. It has also been used in the form of hypodermic injections, when mixed with vaseline in the proportion of ten parts to one hundred. For laryngeal phthisis it is advised to begin with a ten per cent. solution and gradually increase the strength until a fifty per cent. solution can be applied; if too strong a solution be used at first it produces irritation of the parts. Its use is followed by a relief from pain and a reduction of the local inflammation and infiltration; a healing of the superficial ulceration follows, but it does not seem able to heal the deeper ulcers. The intra-tracheal use of menthol has been adopted by Dr. Brookhouse (*British Medical Assoc.*, 1892)—one drachm of a twelve per cent. solution in pure olive oil is introduced into the trachea twice daily. This must be effected with the aid of the laryngoscope and syringe, the curved tube of the latter being introduced about half an inch below the rima glottidis. This method does not cause any pain or distress if carefully applied. The inhalation of the drug may be easily obtained by placing the menthol in a bottle with two glass tubes. As it volatilizes at 113° F., by placing the bottle in a dish of hot water, a copious supply of fumes is produced. The patient may take five or six inspirations several times a day, beginning slowly, as too great quantities might provoke irritation and choking. Menthol has also been employed in asthma and chronic bronchitis and laryngitis. In diphtheria it is advised as a local application in the form of a powder, one part being well mixed with ten or twenty of sugar. The powder is applied with a camel-hair brush, the membrane being removed as fully as possible. The application should be repeated twice or three times a day. It acts as a constant disinfectant, destroying the specific poison, and on the second or third day the membrane disappears, leaving a clean and easily healing ulcer.

Menthol has been found to have an anti-emetic action, and has proved of great service in all forms of vomiting, particularly when pregnancy is the cause of this distressing symptom. This effect is supposed to arise from a purely local stimulant action of the drug. For this purpose it is best administered at the commencement of nausea, before the vomiting occurs; a suitable way of giving it in this trouble is to prepare a solution in oil of twenty per cent. and place ten drops on sugar, and form it into a mass which is readily taken and swallowed by the aid of a mouthful of water. Another preparation is to mix menthol, one part; spirits of wine, twenty parts; simple syrup, thirty parts. One teaspoonful every hour until nausea is relieved.

The following combination also forms a permanent mixture: Menthol, two drachms; alcohol, one ounce; glyceriue, one ounce; syrup, one ounce. It may also be given in the form of pills: Menthol, one drachm; powdered acacia and sugar, of each half a drachm; to be made into forty pills.

Menthol continues to be of service as a local application in neuralgia, sciatica, pruritus, and other painful affections, and in various parasitic diseases. Its local use has been facilitated since it was discovered that when mixed

with certain other analgesics it assumes a fluid form. When triturated in the following proportions, colorless, transparent oily fluids are produced, which may be used for the purpose of inhaling or as local anæsthetics: Menthol in equal parts with thymol, absolute phenol or chloral; menthol three parts, camphor two parts; menthol two parts, butyl-chloral-hydrate one part; and menthol two parts, with one each of carbolic acid and butyl-chloral-hydrate. *Beaumont Small.*

MERCURY (Hydrargyrum, U. S. Ph.). INTRODUCTION.—In taking up the study of mercury after a lapse of six or seven years it must be borne in mind that material changes have taken place within that period, although it is doubtful if salts and preparations of the metal are any more highly prized by physicians and surgeons now than at any time during the past decade. That mercurials possess a wide range of application cannot be denied, but after a careful and comprehensive survey of the kaleidoscopic changes that have occurred in the minds of intelligent practitioners within a quarter of a century, there is no doubt but that their medicinal properties have been greatly overrated, and at the same time the deleterious action upon the economy largely underestimated. Judging by the character of reports appearing from time to time in current medical literature, it is evident that mercurials are now employed with a nicer discrimination, with more intelligence looking to the definite effects which are likely to follow, and more with a view to their conservative influences than ever before. However, this happy condition of affairs has not been reached through careful and deliberate investigation of the clinical properties of the drug, but, on the contrary, by a series of most reckless and flagrant abuses—a sad commentary when considered in connection with the coincident advancement in other sciences.

Through a strange concatenation of circumstances in teaching and practice—due largely to the fact that mercury was supposed to possess a so-called *alterative* effect upon the organism—physicians appeared to have lost sight of the oft-repeated caution that it was a substance foreign to the human economy, and an acrid, irritant poison. Its properties have been, in many instances, estimated from the clinical point of view, by considering the temporary or immediate benefits from its use rather than from the scientific standpoint, which would bring into prominence the ultimate disorders following its injudicious or long-continued employment. In studying these properties, therefore, in the light afforded by modern investigation, it will be necessary to take into account these facts, viz.: That mercury is a substance foreign to the organism, and an irritant poison producing both immediate and remote changes in structure, whether used internally, locally, or hypodermatically. And in view of the additional fact that the so-called "alterative" action has come to be regarded as without scientific meaning, and lacking in definiteness, the present seems an opportune moment for advancing certain evidences that promise to offer an explanation of its action, an explanation that shall be more in keeping with the demands of modern science, while at the same time strictly within the range of practical medicine. Scientific facts, supported by clinical facts, will go very far with intelligent practitioners in elucidating the mysteries which have so long surrounded and obscured the therapeutics of this important remedial agent.

In order to accomplish this laudable purpose it will be necessary to consider the nature of its cumulative action, and the causes at work which, apparently, prevent or modify this action in children. It will also be desirable in this connection to study immediate and remote effects, the primary and secondary actions of both soluble and insoluble salts and preparations, all of which can best be accomplished by a critical examination of its pharmacology, which naturally includes its toxicology, physiological actions in medicinal doses, and mode of elimination. This study should include, in short, a complete analysis of its general and specific influence upon metabolism, meaning by that its constitutional as well as specific action upon different organs and tissues, including in this category the entire nervous system. And, finally, having thoroughly digested and sifted all available information upon these various topics, the concluding section will be devoted to its therapeutic applications, the different diseases being grouped to facilitate study and reconcile the conflicting views hitherto held.

As a preliminary to the present paper, it will be profitable to consider briefly some of the more recent mercurial preparations, and to pass in review the antagonists and incompatibles. In the original article by Professor Curtis (REFERENCE HANDBOOK OF THE MEDICAL SCIENCES, Vol. IV., 1887, p. 737), the Pharmacopœial preparations were so fully studied that it does not appear necessary at this time to attempt a remodelling of that section, although their properties will be referred to incidentally in connection with toxicology. For more detailed information covering the toxicology the reader is referred to the contribution of Professor Hills (loc. cit., p. 744), which is exceptionally full and complete.

MERCURY COMPOUNDS.—The following list includes the principal mercurial compounds * aside from the Pharmacopœial products which have recently been brought to the attention of the profession. While some of them undoubtedly possess distinct therapeutic properties, the greater number are lacking sufficient clinical investigation to warrant their general use.

Mercuric Benzoate, $(C_6H_5COO)_2Hg,H_2O$, occurs in the form of small colorless crystals, tasteless and free from odor; readily soluble in alcohol and hot water, but sparingly soluble in cold water. This preparation has been used hypodermatically suspended in liquid paraffin (Stukowenko) for the treatment of syphilis, and also in combination with sodium chloride in watery solution (Cochery) for the same disease. *Dose*, one syringeful daily of a solution containing the following proportions of the different ingredients—3 to 1 to 400.

Mercuric Carbolate or Phenylate, $(C_6H_5O)_2Hg$, occurs in the form of colorless needles, soluble in hot alcohol (1 to 20), ether, or a mixture of alcohol and ether, and in glacial acetic acid; insoluble in cold water or cold alcohol. Mercuric carbolate has been employed to a limited extent (Schadeck) in the treatment of syphilis. *Dose*, for an adult, gr. $\frac{1}{8}$ to $\frac{1}{4}$, two or three times a day, and for children in proportion.

Mercuric Formidate occurs as a solution, produced by the action of formamide upon mercuric oxide. It has the advantage of not coagulating albumin, is rapidly absorbed, excretion taking place through the kidneys.

Mercuric Imido-succinate, $[C_2H_4(CO)_2N]_2Hg$, occurs in the form of a white, lustrous, crystalline powder; soluble in twenty-five parts of water or three hundred parts of alcohol. The substance was first described in 1852 (Dessaignes), and in 1888 was recommended as an antisyphilitic (von Mering, Vollert). *Dose*, subcutaneously, gr. $\frac{1}{6}$ in watery solution, with or without the addition of cocaine.

Mercury l'Alananate is a white, crystalline powder derived from lactic acid and propileglycole; soluble in three parts of cold water. It is prepared by dissolving the alananine in five times its weight of distilled water, and while boiling, small quantities of mercury hinoxide are added so long as it dissolves. *Dose*, subcutaneously (de Luca) gr. $\frac{1}{12}$ to gr. $\frac{1}{4}$ daily. It is said this treatment in syphilitic cases, continued for a period of forty-five days, has frequently proved sufficient.

Mercury Naphthalate occurs in the form of a lemon-yellow, odorless powder, containing 30.8 per cent. of mercury, insoluble in water. It was first employed in the treatment of syphilis (Jaddasohn, Zeissing), but proved unsuitable owing to the violent pain produced. *Dose*, internally, one grain.

Mercury Oleate, $Hg(C_{18}H_{33}O_2)_2$, a true chemical product containing 28.3 per cent. of mercuric oxide; it is in the form of a brownish-yellow or yellowish-gray unc-

* The author desires to acknowledge his indebtedness for much of the information on this topic to Helbing's Modern Materia Medica, 3d edition, 1892.

tuous substance, having the odor of oleic acid; soluble in benzene, but not in alcohol, and at ordinary temperatures is of the consistency of an ointment. It is best prepared by the double decomposition of sodium oleate (Castile soap) and mercuric nitrate, but the process is somewhat complicated.

Oleate of mercury as now prepared is a stable product, and has been favorably received as an acceptable *substitute for mercurial ointments*, being a more cleanly application, does not become rancid, and, besides, is more rapidly absorbed. It is generally employed as an external application in the strength of five to ten per cent. Constitutional effects may be produced to a limited extent by the use of mercury oleate, and it may therefore be substituted for internal medication when the condition of the stomach forbids the internal use of the mercurials, but its principal field has hitherto been confined to the treatment of diseases of the skin, specific and non-specific, including also parasitic affections. It appears to be especially adapted to diseases of the skin which are characterized by an indolent condition of the structures, eczema, tumors, pigmentation, and all forms of induration or thickening; it should not be applied to ulcerations where there is a solution of continuity.

Mercuric Oxycyanide, $Hg_2O(CN)_2$, has been employed to a limited extent (Boer) as an antiseptic, and is said to be superior to the sublimate in this respect, being less caustic, free from any coagulating action upon albumin, and less harmful to instruments. The following points are advanced in its favor: 1, Precipitates albumin only slightly; 2, less irritant than sublimate solutions; 3, not so readily absorbed; 4, antiseptic power in keeping soup six times stronger than sublimate; 5, more efficient as an antiseptic and safer in treating suppurating and mucous surfaces, owing to tolerance and feeble absorption.

Mercuric Peptone occurs in the form of a yellowish liquid, having a saline, feebly metallic taste, and slightly acid reaction. It was originally introduced for hypodermatic use, and is said to be mild and efficient, causing no pain or abscesses. *Dose*, one c.c., said to be the equivalent of gr. $\frac{1}{6}$ of the bichloride. (See Glutine-peptone Sublimate.)

Glutine-peptone Sublimate occurs in the form of a white, lustrous, hygroscopic powder (prepared and on sale in the form of a one per cent. solution) containing twenty-five per cent. of mercuric chloride. It is prepared by the action of hydrochloric acid on gelatin—a double compound of glutine-peptone hydrochloride—with sublimate. *Dose*, subcutaneously, one Pravaz syringeful (Hüfler), the equivalent of gr. $\frac{1}{6}$ mercuric chloride.

Mercuric Salicylate, $C_6H_4OCO_2Hg$, is in the form of a fine, white powder, tasteless and odorless, and acid in reaction. It was employed as early as 1887 (Silva-Aranjo), and again more recently (Schadeck), as an internal and external remedy in syphilis, and is said to be mild, yet energetic. It has also been employed by intramuscular injection suspended in mucilage, and locally in the treatment of gonorrhœa in weak solution as an injection. *Dose*, gr. $\frac{1}{10}$ to $\frac{1}{4}$, in pill form.

Mercury Sozoiodol, $[C_6H_2I_2(I_2)(OH)SO_3]_2Hg$, is in the form of a lemon-yellow powder; moderately soluble in sodium chloride solution, but scarcely soluble in water (1 to 500). In strong solution this product is an irritant to the tissues, but its insolubility recommends it for hypodermatic use in the treatment of syphilis. According to Schwimmer it is superior to all sozoiodol preparations in its curative value and certainty of effects. *Dose*, one grain, deposited in the gluteal region.

Mercury Stearate, recently brought to the attention of the profession, is in the form of a white, unctuous powder, and is said to contain twenty per cent. of mercuric oxide—about the same as blue ointment. It differs from the oleate in being entirely free from oleic acid, and may be used for insufflation, or as a "dry ointment" in place of the usual greasy applications when the local action of mercury is desired.

Mercury Tannate occurs in the form of brownish-green scales, tasteless and odorless; insoluble in water and alcohol, although when brought into contact with either tannin is given off. The theory of its action (Lustgarten) is based upon the assumption that metallic mercury is set free when exposed to the alkaline contents of the small intestine. *Dose*, one to two grains, an hour after eating.

Mercuric Thymolate, $(C_{10}H_{13}O)Hg\text{-}HgNO_3$, in the fresh state, is in the form of a colorless powder, tasteless and odorless; after exposure it gives off a faint odor of thymol, with change of color to a reddish hue.

Mercuric Thymolacetate, $(ClOHI_3O)Hg\text{-}HgC_2H_3O_2$, is a substance similar to the foregoing, although the latter is that principally employed in syphilis (Kobert). It has been especially advocated also in the treatment of pulmonary tuberculosis (Trangen), both in the early stage and in those cases far advanced in the disease, the medicament being suspended in liquid paraffin. For syphilis it is given internally or hypodermatically in the manner stated. *Dose*, internally or subcutaneously, gr. $\frac{1}{12}$ to $\frac{1}{6}$.

Mercury-zinc Cyanide, $[Zn_4Hg(CN)_{10}]$, occurs in the form of a white powder, which is said to consist of mercuric cyanide (not to exceed thirty-six per cent.) whose particles are "occluded" from the action of water by the insoluble zinc cyanide (Dunstan); insoluble in water. Mercury-zinc cyanide is obtained by adding a soluble zinc salt to a solution of the cyanide of mercury and of potash. The substance was originally introduced by Sir Joseph Lister as an antiseptic and non-irritant dressing, and is now employed by a limited number of surgeons with most gratifying success. The strength of the solutions used for the field of operation is 1 to 2,000, and that for compresses is 1 to 500.

Triturations of Mercury and its Salts have, within the past few years, come into very general use for internal administration, and their employment has been attended with such uniformly satisfactory results that it is but a question of time when this practice will be adopted in nearly all ordinary cases. The causes which have been instrumental in bringing about this change will be discussed under the head of Antagonists and Incompatibles, *q. v.*

Antagonists and Incompatibles.—When a lethal dose of corrosive sublimate has been taken into the stomach, albumin in some form—white of egg—should be administered and emesis secured as promptly as possible, before the resulting albuminate of mercury is redissolved by excess of albumen. Demulcent drinks are usually advocated, in the belief that they will protect the mucous membrane of the stomach from the irritant action of the poison; but mucilaginous substances do more than this, inasmuch as they cling to, and hold in suspension, such foreign substances as mercury albuminate, the form in which mercury enters the circulation. Mercurial salts being proverbially uncertain in some respects—especially the bichloride—they should be given preferably in the form of triturations, although this does not necessarily apply to the insoluble salts like the biniodide when suspended in mixtures. But even the use of this salt, as in the "mixed treatment," is far more satisfactory in the form of triturations, since incompatibles are avoided, smaller dosage required, and the untoward effects, immediate and remote, reduced to a minimum. The facility with which therapeutic effects may be secured by the exhibition of small doses of blue pill and calomel, prepared in this form, practically excludes the question of incompatibility. Both the soluble and insoluble preparations in this form, alone or combined with other suitable medicants synergistic in character, may be exhibited in suitable doses under proper dietetic regulations without regard to the possible dangers arising from their administration in bulk.

A note should be made to the effect that starchy foods delay or cause irregular absorption, while a nitrogenous diet with free ingestion of liquids heightens the activity of mercurials. Constipation, by interfering with elimination, may produce salivation, and under such conditions a dry diet, by lessening the urinary water, is not infrequently the exciting cause of occult renal disorders. Exposure to cold is also inimical to the therapeutic action of mercurials, while diaphoretics tend to promote con-

stitutional effects—favorable when the dose is small, but unfavorable when toxic symptoms are imminent. Looseness of the bowels following the exhibition of mercury may be counteracted by the temporary administration of opium or some of its preparations (codeine sulphate), although it is better to avoid distinct physiological manifestations by diminishing the dose, regulating the diet, and improving the hygienic environment.

So-called idiosyncrasy, when mercurials are used in appropriate dosage, is generally and principally a merely accidental or coincident effect, due to physical (personal) conditions, habits as to diet, exposure, hygiene, and the like, since there is reason to believe that the condition of the physical system exercises a more decided influence in favoring this manifestation than does the nervous system. Indeed, it appears as if the effects upon the latter were indirect or secondary, although there doubtless are reflex effects resulting from molecular changes which are not altogether independent of the nervous system. The effect of mercury upon the system may be compared to the effect of adding coal to a furnace when combustion is actively going on; the added fuel may cause a temporary lull in the heat dissipation, but this is followed by increased combustion and augmented heat. In the case of the furnace it is the coal which is destroyed, while in the case of the human organism it is the tissues that are consumed, each dose of mercury beyond that requisite being attended with increased tissue-metamorphosis.

Pharmacology.—In studying the *Toxicology* of mercurials as a whole or specifically it is not necessary or advisable to recapitulate from text-books, nor sift from current literature the details concerning their peculiar actions in causing death or contributing toward the production of pathological changes in the organism. It will be sufficient for our purpose to pass in review the various Pharmacopœial products, with the addition of some brief notes relative to their special properties and activities.

The preparations of mercury proper include mercury with chalk, blue mass, blue ointment, mercurial plaster, and mercurial plaster with ammoniacum. None of these preparations possesses any marked poisonous properties, and they may be used with benefit in properly selected cases, provided the dose be small and the drug not too long continued. *Moderate dosage*, for therapeutic effects, may be stated as follows: Mercury, with chalk and blue pill, grain $\frac{1}{10}$ at hourly intervals until six to twelve doses are taken, or two to four doses of one grain at longer intervals. *Synergists*, such as podophyllin resin, aloin, ipecac, ox-gall, salines, etc., will heighten the effect of small doses and lessen the dangers of toxic symptoms. Liberal draughts of hot water may also be of service in promoting diffusion and elimination, and there may be a demand for the exhibition of minimum doses of opium, pilocarpine, atropine, strychnine, etc., to meet special indications, and, as a rule, adjuvants are most serviceable when given separately, although administered at the same time.

Preparations of the chlorides include corrosive sublimate (bichloride), calomel (sub-chloride), ammoniated mercury (not used internally), and ointment of ammoniated mercury.

Of the two preparations belonging to this class which are used internally the bichloride is by far the most actively toxic, frequent reports having appeared showing unmistakably that it produces both immediate and remote pathological changes sufficiently characteristic of its poisonous action to be recognized both macroscopically and microscopically. Calomel, on the contrary, owing to its insolubility, is comparatively mild as a poison, so far as its immediate effects can be observed, although its remote action, when long continued or frequently repeated in substantial dosage, is antagonistic to a healthy state of nutrition, as will be shown presently.

The dose of these two preparations, as usually recommended, is entirely too large—if we desire to avoid the bad effects. Both are popular remedies in the treatment of diseases of children, who seem to be less susceptible than adults to the toxic action of the drug; and there are grounds for suspicion that the practice referred to is an important factor in prolonging convalescence, if not a fruitful source of factitious disease. In ordinary acute cases, where indicated, grain $\frac{1}{1000}$ of corrosive sublimate, or grain $\frac{1}{20}$ of calomel, given at hourly intervals, will fulfil every therapeutic indication, while the dangers incident to the use of large or toxic doses are avoided. The advice given in the preceding section concerning synergists and adjuvants applies with equal force to the administration of the chlorides. The antiseptic applications of corrosive sublimate will be considered under the head of Surgical Practice, *q. v.*

Preparations of the oxide include yellow oxide (*oxidum flavum*), used principally in the preparation of yellow ointment and mercury oleate, red oxide, and ointment of the same. The preparations belonging to this class are decidedly irritating, and are seldom used internally. The oleate (*q. v.*) is the only one which has attained any considerable degree of popularity.

Preparations of the iodide include the red iodide (biniodide), Donovan's solution (solution of iodide of arsenic and mercury), and the green iodide (protoiodide). Both the biniodide and green iodide have shown distinct therapeutic properties in the treatment of subacute and chronic diseases, specific and non-specific, their virtues being due largely to their practical insolubility and the fact that doses sufficient to produce physiological or toxic effects are extremely irritating to the gastro-intestinal tract. The incorporation of iodine with the mercury likewise exercises an important function, since the remedies, being but slowly diffused throughout the different structures, produce a more or less constant action upon the protoplasmic cells, by which metabolic changes are stimulated.

The usual dose of the biniodide, prepared by thorough trituration, for adults in the case of gastro-intestinal, hepatic, and syphilitic affections, need not exceed grain $\frac{1}{100}$ three or four times a day. The dose of the protoiodide should be about double this amount, grain $\frac{1}{50}$. In the treatment of *acute diseases of children*, peculiar to the summer season, with evidences of hepatic involvement, vomiting, diarrhœa, dysentery, pain, tenesmus, etc., the biniodide, in doses of grain $\frac{1}{1000}$ hourly, is a superior remedy. It is quite as prompt in its action as the bichloride, and the benefits appear to be of a more permanent character, probably because of its insolubility as previously stated. It is also of service in the treatment of *all throat affections*, owing to its local antiseptic properties and its antiseptic and stimulating action upon the stomach and liver respectively.

Of the acid combinations it is only necessary to say that they are actively poisonous. The nitrate is employed as a caustic and in the preparation of citrine ointment, the subsulphate (yellow) as an emetic. Mercuric sulphide is employed for fumigation, now rarely used, and the cyanide is actively poisonous. The latter in combination with zinc has recently come into use as an efficient antiseptic.

The foregoing summary is put in evidence to show that mercurials, in whatever form presented, are all either *immediate or remote poisons* to the organism, although this declaration must have slight effect since all practitioners readily admit the fact. It becomes necessary, however, to reconcile its therapeutic value, long established, with its well-known properties as *a protoplasmic poison*, inimical to all animal and vegetable life. And this brings us to the consideration of questions that have long vexed the minds of physiologists and clinicians alike, questions of weighty significance, pregnant with important but unsolved truths that have swayed the practice of the healing art generation after generation from the dawn of history down to the present time.

Turning to the text-books of the day we find mercury classed as a tonic, purgative, alterative, antiphlogistic, antiseptic, and sorbefacient, and, to a limited extent, cholagogue; but to the scientific mind this information conveys nothing definite, exact, or positive, as it has never been demonstrated either definitely, exactly, or positively how these manifestations were brought about. Of course we know that a peculiar fetor of the breath and

metallic taste in the mouth are early indications that "the drug is affecting the system," but evidently this is a loose way of calculating. It must be apparent that these early indications are, in fact, secondary or remote effects, and that the immediate or direct effects have been overlooked. For example, we know that corrosive sublimate taken in lethal dose causes vomiting, purging, and tenesmus, perhaps suppression of urine, and that its effects are especially marked upon the lower bowel, manifested at times by bloody stools, but apparently there is a long distance between this morbid complexus and salivation. Twenty, forty, or sixty grains of calomel will produce decided reflex nervous symptoms, but, on the other hand, medicinal doses, long continued, are almost certain to be followed by stomatitis. That stomatitis is a secondary effect is shown by the associated elevation of temperature.

Experimental workers speak of the *physiological action and effect*, and clinicians talk about *therapeutic action and effect*, just as though the two words, action and effect, were interchangeable or mutually convertible terms, when in fact there is a wide difference between them. What intelligent medical practitioners want to know is: *How do mercurials act* in order to produce the effects observed? The latter—the effects—the merest tyro in therapeutics can comprehend, but it remains to give a satisfactory working explanation of the *modus operandi* by which these effects are produced. In short, is there any other possible translation of the metamorphoses produced by mercurials than that they possess "*alterative*" properties?

In attempting to reply to these questions let us start by accepting as true the belief that the conservative processes of Nature tend toward the elimination of poisons and foreign substances. Now we know that certain channels are available for this purpose, viz., the liver, salivary glands, alimentary tract, skin, kidneys, and the pulmonary and bronchial mucous membrane. Mercury entering the blood-vascular system, either as an albuminate or oxy-albuminate, is not carried direct to the organs or structures named, but indirectly through the lymph-vascular system. It is therefore brought into contact with the protoplasmic cells, upon whose integrity the vitality of the various organs and tissues depends, elimination being finally effected from the intercellular fluid through the epithelial cells. If we proceed, now, to consider *the normal condition and functions of protoplasm*, recalling the well-known facts relative to its capacity for taking up and storing oxygen for its own proper work, its ability to produce ozone and thus stimulate katabolic processes, it will be apparent that when an organic substance foreign to the economy—a poison—is brought into contact with it, functional activity will be increased. Heightened functional activity usually means in such cases an increased discharge of carbonic acid and katabolic products, together with renewed activity in the up-building process. This is substantially what has long been recognized as cellular activity, and working principally in the direction of retrograde metamorphoses, studying degenerative effects, it formed the basis of Virchow's celebrated treatise, "Cellular Pathology." When we turn our attention in the direction of reconstructive metamorphosis with the object of learning the peculiar influences at work in connection with the exhibition of remedial agents, our line of investigation is practically in the opposite direction. In other words, our studies lie in the direction of *cellular therapy* rather than toward cellular pathology. But the two currents of thought are so intimately blended and mutually interdependent—like the warp and woof—that it is almost impossible to make satisfactory progress unless we take both into account in our reckoning. Simply to know or understand what is covered by the term "alterative," however, is not sufficient; we must have some definite, exact, and positive knowledge concerning the difficulties to be met and overcome in treating disease, and therefore, as a preliminary to the practical adaptation of cellular therapy, the student must be well-grounded in the principles underlying normal physiology and cellular pathology.

And there are good and sufficient reasons for insisting upon this course, since the ultimate object of medical study is to restore impaired or suspended function, which can only be successfully accomplished by the re-establishment of cellular activity. Thus the therapy best adapted to restore the functions of disordered cells is that which will prove most successful in removing disease and its symptoms; but care must be exercised in the exhibition of remedies in order to avoid what might be called "*cumulative*" effects, or the depression consequent upon over-stimulation. For instance, the early indications that mercurials are affecting the system are, in fact, evidences of toxic activity, evidence that there has been sufficient "action" upon the protoplasmic cells, their nutritive pabulum contained in the intercellular fluid, or their nerve-supply, to produce the effects observed, namely, fetor of the breath and metallic taste in the mouth. The proof is therefore conclusive that, while mercurials are protoplasmic poisons, it is to this property that they owe their therapeutic virtues as tonics, purgatives, alteratives, antiphlogistics, antiseptics, sorbefacients, and, as will be shown presently, their value as cholagogues, and the term cellular therapy, therefore, appears to be well chosen.

In the case of mercurials, for example, *the therapeutic effect is a resultant*, the two forces being the disease and the medicine, the conservative processes of cell-life being temporarily impaired or suspended. The depressing tendencies produced by disease, ptomaïnes, leucomaïnes, etc., are counteracted or overcome by the irritating, or, as it is usually called, stimulant action of the minute quantity of poison to which the protoplasmic cells are exposed. These *effete products are discharged or burnt up by the oxygen or ozone of the protoplasmic cells*, so that these latter are *changed or "altered"* in such manner that better prepares them for the performance of their normal functions, and to this circumstance may be due the word "alterative." Clothed in this new dress the term has a greater significance to the clinician, because it rests upon a foundation that is both scientific and practical.

The usual study of *physiological actions* includes also the *effect upon the blood.* According to the experimental studies of Harley, mercuric chloride added to blood lessens the evolution of carbonic acid, and, at the same time, increases the absorption of oxygen, evidence that it stimulates oxidation; but, on the other hand, albuminate of mercury added to blood in like manner gradually destroys the red blood-corpuscles, facts pointing to the necessity for exercising the greatest care in its administration. In comparing these results with the clinical evidence advanced by Keyes (*American Journal of the Medical Sciences*, January, 1876), showing that small doses of mercury (gr. ¼ of the protoiodide t.i.d.) increase the number of red corpuscles in the absence of disease, it is easy to understand the causes which combine to produce the apparently conflicting results. In truth, they do not conflict at all, but merely express scientific facts entirely independent of each other.

An observation should be made here to the effect that the therapeutic results following the exhibition of mercury are not all direct, since the increased oxidation which it causes in the system means more active metabolism, augmentation of the red blood-corpuscles, and improved primary assimilation. These are what might be termed *consequential benefits;* and in the light of these facts, and our knowledge that the inorganic substance is eliminated from the organism unchanged, it is not deemed necessary to combat the assumption that mercury must, in some occult manner, become an integral part either of the blood or tissues in order to effect reconstructive metamorphosis.

Upon *the muscular system* mercury produces a somewhat anomalous effect. For example, we might suppose that increased oxidation would be attended by augmented capacity for work; but such is not the case, although mercury has no material influence upon muscular irritability. And this explains in a measure why patients who have taken medicinal doses of the drug for a considerable time finally begin to show evidences of cardiac weakness and require tonics. The respiratory muscles

likewise show impairment of their capacity for work, so that in calculating the gains from stimulation of the internal respiratory function, we must not overlook the fact that increased dosage or continued administration may produce symptoms which are but transitory, evanescent, or misleading.

In addition to its action as a protoplasmic poison at the points of elimination by the *renal structures*, large doses have the effect of producing chronic interstitial nephritis by calcareous deposits in Henle's loops, which block up the tubules, and this in turn is followed by subacute inflammation of the glomeruli and tubules with atrophy and cirrhosis (Brunton), being similar to the effects produced by both lead and potassium chlorate.

That mercury profoundly affects the *nervous system* is confirmed by the remarkable manner in which persons in health are affected when exposed to its vapors. The irritability, melancholia, and in some instances furious mania, with other evidences of mercurialization that have been observed, afford abundant proof that either directly or indirectly it effects extraordinary changes in the centres of organic life that seriously interfere with the normal functions. In the case of leeches, for example, it acts chiefly upon the nervous system, and later upon the muscles. Although no evidence is forthcoming, there are strong probabilities that it affects in no small degree the molecular changes in serous membranes, and thus is added a new factor to its rapidly increasing list of physiological manifestations.

The well-known eliminative functions of the *glandular system* naturally point to it as one of the principal channels for the elimination of mercury, and this is confirmed by clinical observation; but it possesses no property aside from its influence upon cellular activity that would entitle it to be classed as a specific glandular stimulant. It is therefore somewhat *misleading to call mercury a specific sialagogue*, since we can trace the tissue-change to the effects of the remedy as a protoplasmic poison upon the cells concerned in elimination, and, fortunately for the scientific basis of therapeutics, the necessity for which this study is intended to develop, the foregoing admitted facts practically wreck the so-called "alterative" theory, viz., that "alteratives are remedies which improve the nutrition of the body without exerting any perceptible action on individual organs."

In compliance with the request of the writer a discriminating study, scientific and practical, covering the *physiological action of mercurials upon the liver and its functions*, has been placed at his disposal for the present article by Dr. William H. Porter, of New York, as follows:

"The action of mercurials upon the hepatic function is exercised in three successive characteristically distinctive stages, namely, as *stimulants*, as *cholagogues*, and as *depressants*.

"As the mild chloride or calomel possesses all these qualities to a marked degree, it is perhaps the best example by which to elucidate the complete action of mercury upon the hepatic and digestive functions. The blue mass and the gray powder act in the same manner, but, if anything, are a little less active. The bichloride has a similar action, but its more irritating properties make it less valuable, or even useless, as a cathartic principle. Still, it can be used as a powerful hepatic stimulant, and as an adjunct to the cholagogue action of calomel.

"The exact *modus operandi* by which mercury in any form produces the wonderful results upon the system that have been attributed to it for ages, has always been more or less in doubt, for the lack of a logical explanation; yet the most sceptical, after watching the effects of a few doses of this drug upon the human system, cannot deny the power and utility of mercury. Taking the stand that the inorganic compounds are not destroyed within the animal organism, no time need be wasted in speculation regarding the decomposition of any of the mercurials into other compounds. How, then, shall the action of mercury and its compounds be explained? Calomel, for instance, is almost insoluble; consequently it in itself is comparatively non-irritating to the intestinal tract. At the same time it is known to be one of the most active cathartic compounds of mercury—two almost contradictory propositions. The cholagogue action of calomel cannot be explained by any direct irritating action which it can produce upon the alimentary tract, through the increased peristalsis, by reflex irritation causing an increased flow of bile.

"The non-irritating character of calomel is just what gives it its chief power. Passing along down the alimentary tract without producing irritation, it is steadily absorbed into the entero-hepatic circulation and carried up to the liver. At this point of the animal economy the mercurial appears to act like a foreign body, and the hepatic cells, by their selective action, pick up the little particles of calomel from the blood, and eject them into the capillary bile-ducts. In accomplishing this task the hepatic cells are called upon to perform more work, and if the amount of calomel passed through the liver is small, its action is simply to stimulate the organ to a little greater activity. For a time the hepatic cells secrete a little larger quantity of bile, and such as has a little better quality. Up to this point the calomel has only been stimulating and physiological in its action. If now the calomel be administered in larger quantities—either by frequently repeated small doses or in one large dose—the eliminating action of the hepatic gland is greatly augmented. At the same time the protoplasmic elements which constitute the hepatic cells are stimulated, by the passage of this foreign body through their substance, to a more active production and elimination of the bile-acids.

"When sufficient calomel has reached the liver to produce this copious flow of bile-acids, the acids are discharged into the capillary bile-ducts more rapidly than they can react upon the alkaline phosphates or carbonates, and form the normal and neutral bile-salts. When this hypersecretion of the bile-acids is established, a cholagogue action is developed. This action, however, can only be temporary in character, because the protoplasmic vitality of the hepatic cells will, in a comparatively short time, be exhausted. After this excessive production of the bile-acids and their discharge together with the calomel, there is a period of protoplasmic exhaustion in which the bile-producing function of the liver is held in abeyance.

"Viewed in this light calomel and its class of mercurials may be stimulating, cholagogue, and depressing in their action upon the functions of the hepatic gland—one condition following in quick succession after the other. The rapid intestinal peristalsis and frequent discharges from the bowel, however, are not the direct result of the mercurial action, but *a secondary effect* which has been brought on by the irritating properties of the bile-acids, so copiously discharged into the intestinal canal—as just shown. This fact is established by the lack of cathartic action by calomel in cases of occlusion of the common bile-duct; and furthermore, by the counter-test that where bile-acids are administered medicinally, a brisk, cathartic, and cholagogue-like action is at once established.

"The hypersecretion of the bile-acids and its consequent effect upon the intestinal tract is not in any sense a physiological action, but is strictly a pathological process. But, by developing this abnormal condition in the functional activity of the hepatic gland, the liver-cells are stimulated to perform an abnormal amount of work, often vicarious in its nature, and by which the cells are empowered to expel many abnormal and by-products from the system—a task which, in their normal condition, they are absolutely unable to perform. In this manner Nature rids herself of many foreign and offending substances which, if allowed to remain and multiply within the system, would, in a short time, destroy the animal vitality, a result too often seen in cases imperfectly treated.

"The period of inaction which is imposed upon the hepatic cells as a sequel to this excessive action gives the protoplastic elements a chance to rest and to imbibe a more serviceable nutritive pabulum—thus augment-

ing their nutritive activity and enhancing their functional vitality. When the hepatic cells again resume their physiological work, they are in a condition of high nutritive tone, and consequently the secretory and excretory work of the liver is more perfectly effected. The intestinal and hepatic transmutation of the food-elements is more perfectly accomplished; and, as a natural sequence, all the nutritive processes of the body are intensified; secretion and excretion in general are more perfectly performed, and the animal vitality is raised to a higher standard. If the system has been poisoned by any form of microbic or ptomaïnic toxine, or is the seat of any inflammatory action, toxic or otherwise, the organism is, by the above-described processes, placed in the best possible condition to destroy the etiological factors and remove the resulting pathological processes, and thus restore everything to a normal condition.

"By a somewhat similar physiological action the well-known antiphlogistic power of the mercurials can be explained; and following this method of action for the mercurials generally, ptyalism, and all that class of toxic symptoms produced by mercury and its compounds, can be rationally explained. The same reasoning also shows clearly that the size of the single doses has little, if anything, to do in determining the liability to mercurial salivation. If, from any cause, the hepatic cells are inactive, and thus fail to respond to the presence of the mercurial salt, and to eliminate as speedily as it reaches the hepatic gland, then the mercurial will pass over into the general circulation, where, finally, the salivary glands will attempt to perform the work of elimination that should have been accomplished by the liver-cells. In like manner, when the calomel is given too freely, or when opium is given to check the cathartic action, and the hepatic cells either become exhausted from over-taxation, or they are retarded in their action by the opium, when the mercurial passes into the general circulation. Thus, again, the toxic symptoms with salivation will be produced. So long, however, as the hepatic cells retain their selective and excretory activity, it is absolutely impossible to develop the toxic symptoms of mercury. The use of enormous doses may become the cause of exhausting the hepatic cells, whereupon poisoning will, of course, ensue.

"From this study of calomel and its allied preparations, the belief is entertained that all mercurial preparations act in a similar manner, if of any value; that the specific effect of the mercurials in syphilis is simply due to the augmented hepatic function produced by the elimination of the metal. The more irritating preparations, in so far as they act at all, act in the same way as calomel, but if taken in too large doses, are so locally irritating that they become poisonous in themselves. Therefore mercury is indicated in all cases where it is necessary to increase the functional activity of the liver and aid this organ in eliminating not only more bile, but also poisons of all kinds, microbic, ptomaïnic, leucomaïnic, katabolic, and vegetable or animal in origin."

In contrast with the foregoing somewhat optimistic views concerning the therapeutic virtues of mercurials should be quoted the remarks of Budd ("Diseases of the Liver," 1846): "The frequent use of mercurials in functional hepatic complaints may lead to much mischief. When the liver has become accustomed to the stimulus of mercury, no other medicine will sufficiently excite its action. The person is then led to the habitual use of the medicine, and, after a time, the constitution is undermined by it. It increases the activity of the liver at first, but seems to leave it weaker than before, and, if frequently resorted to, the nutrition of the patient, impaired by the original disease, is still further impaired by the drug."

It will not be out of place to insert here the opinion of Thomas King Chambers, of London ("The Indigestions," third American revised edition, Philadelphia, 1870, p. 377), long and favorably esteemed as an authority on digestive disorders, as follows:

"The superstitious use of mercurials is very singular. They are supposed to make the alvine excretion normal, though the only visible result is its becoming more abnormal with each dose. They are supposed to do good by 'acting on the liver,' whether the liver is acting too little or too much. They are supposed to 'act on the liver,' though it has been shown by Dr. Scott's experiments ('Beale's Archives,' vol. i., p. 209), that the quantity of bile is not increased, nay, it is rather diminished when mercury is taken. All that the metal can be really seen to effect on the hepatic function is a poisoning of the bile, so as to prevent absorption by the ilia, and to cause the secretion to be rejected in excess and in a liquid form *per anum*, and that is a very doubtful advantage to most invalids.

"The only effect at all desirable following mercurial purgation, and which in fact seems to constitute for patients the attraction to its use, is the relief of certain cerebral symptoms, giddiness, muscæ volitantes, dark globes in the sight, singing in the ears, etc., which result from excess of venous over arterial blood in the brain. It acts in this case as a destructive upon the venous blood, and adjusts the balance by subtraction. Time after time, as the rough experiment is resorted to, the strength is lessened by it, and as the necessity for its use appears greater, more and more subtraction is required. The good and true way of restoring the circulation to its normal condition is by addition, by increasing the supply of new-made blood to the arteries."

In order to reconcile the differences existing between the views held now and those which obtained twenty-five or forty years ago, it should be noted that a generation ago practitioners had no true conception of the physiological effects of comparatively small doses, all dosage being determined by promptness in effect which, being followed by depressant manifestations, was very properly condemned.

While in the preceding remarks but little has been said of the *antiseptic properties of mercurials*—their value in this direction being inferred—it will be appropriate to consider this principle more fully than can be done in the section on Therapeutics. Undoubtedly mercuric chloride, owing to its actively poisonous character, stands at the head as a general antiseptic. Other drugs are of equal value as regards their power to destroy bacteria, but none of them seems to possess the same degree of antipathy toward the spores of bacteria: hence, when these spores are removed from contact with ordinary antiseptics and transferred to a suitable soil, they again multiply as rapidly as before. The favorable results attending the employment of less powerful antiseptics than the bichloride in surgical practice may be credited to the method of using the solutions freely, whereby the spores are carried off along with the *débris* and other foreign substances that would act as irritants and thus favor subsequent infection. And to this latter cause (irrigation) may be ascribed the beneficial effects of sterilized water. On the other hand, oily substances like creolin, lysol, and Peruvian balsam, owe their antiseptic virtues in part to the fact that they take up and cling to foreign substances, thus interfering with the reproduction of spores by preventing them from being lodged in a proper soil; the latter is an important factor in determining the vitality of spores as well as that of the bacteria themselves.

Again, it has been found that comparatively weak solutions will prevent the development of bacteria, while much stronger solutions are required to kill developed bacteria, all of which is graphically shown in the accompanying table, compiled by N. de la Croix, and for the most part confirmed by Koch (Brunton: "Pharm. Ther. and Mat. Med.," third edition, 1888, p. 91). (See p. 625.)

The hypodermatic employment of mercurials, popular with some, but strongly condemned by many, is advocated on the ground that curative effects in syphilitic lesions are produced more speedily than when the drug is given by the mouth or by inunction, and besides, that the digestive functions escape serious derangement. According to the investigations of Winternitz, when mercury is given by interstitial injection, elimination is effected principally through the kidneys; and he has also demonstrated that the percentage of the drug thus

TABLE SHOWING THE ACTION OF DRUGS ON BACTERIA.

	Prevent the development of bacteria taken from meat infusion.	Do not.	Prevent the reproduction of undeveloped bacteria.	Do not.	Kill developed bacteria.	Do not.	Prevent the reproduction of developed bacteria.	Do not.	Prevent the development of spores in boiled meat infusion.	Do not.	Prevent reproduction of spores.	Do not.	Prevent development of spores in unboiled meat infusion.	Do not.	Prevent reproduction.	Do not.
Corrosive sublimate	1 : 25,250	1 : 50,250	1 : 10,250	1 : 12,750	1 : 5,805	1 : 6,500	1 : 1,250	1 : 5,250	1 : 10,250	1 : 12,750	1 : 6,500	1 : 10,250	1 : 7,168	1 : 8,358	1 : 2,525	1 : 3,358
Chlorine	1 : 30,208	1 : 37,649	1 : 4,911	1 : 6,824	1 : 22,768	1 : 30,208	1 : 491	1 : 460	1 : 28,881	1 : 34,589	1 : 1,008	1 : 1,027	1 : 15,600	1 : 23,182	1 : 1,061	1 : 1,364
Chlorinated lime	1 : 11,135	1 : 13,092	1 : 488	1 : 578	1 : 3,739	1 : 4,460	1 : 170	1 : 258	1 : 8,148	1 : 4,716	1 : 109	1 : 134	1 : 286	1 : 519	1 : 163	1 : 226
Sulphurous acid	1 : 5,448	1 : 8,515	1 : 135	1 : 223	1 : 2,049	1 : 4,985	1 : 190	1 : 273	1 : 8,515	1 : 12,649	1 : 325	1 : 422	1 : 12,649	1 : 16,783	1 : 135	1 : 223
Bromine	1 : 6,208	1 : 7,844	1 : 769	1 : 1,912	1 : 2,550	1 : 4,050	1 : 336	1 : 550	1 : 13,931	1 : 20,875	1 : 493	1 : 603	1 : 5,597	1 : 8,575	1 : 875	1 : 1,153
Sulphuric acid	1 : 5,734	1 : 8,020	1 : 205	1 : 306	1 : 2,020	1 : 3,353	1 : 116	1 : 205	1 : 5,734	1 : 8,020	1 : 306	1 : 420	1 : 3,353	1 : 5,734	1 : 72	1 : 116
Iodine	1 : 6,687	1 : 5,435	1 : 59	1 : 80	1 : 1,548	1 : 2,010	1 : 410	1 : 510	1 : 10,020	1 : 20,020	1 : 510	1 : 724	1 : 2,010	1 : 2,867	1 : 843	1 : 919
Aluminium acetate	1 : 4,268	1 : 5,435	1 : 59	1 : 80	1 : 427	1 : 895	1 : 64	1 : 92	1 : 4,268	1 : 4,768	1 : 937	1 : 1,244	1 : 6,310	1 : 7,535	1 : 478	1 : 584
Oil of mustard	1 : 3,353	1 : 5,734	1 : 220	1 : 306	1 : 591	1 : 820	1 : 28	1 : 40	1 : 3,353	1 : 5,734	1 : 77 (?)	1 : 108 (?)	1 : 3,353	1 : 5,734	1 : 40 (?)	1 : 60 (?)
Benzoic acid	1 : 2,867	1 : 4,020	1 : 50	1 : 77	1 : 310	1 : 510	1 : 121	1 : 210	1 : 2,877	1 : 4,020	1 : 50	1 : 77	1 : 1,439	1 : 2,010	1 : 77	1 : 121
Boro-salicylate of sodium	1 : 2,860	1 : 3,777	1 : 303	1 : 394	1 : 72	1 : 110	1 : 30	1 : 50	1 : 1,393	1 : 1,694	1 : 35	1 : 50	1 : 2,860	1 : 3,777	1 : 35	1 : 50
Picric acid	1 : 2,005	1 : 3,041	1 : 706	1 : 841	1 : 1,001	1 : 1,463	1 : 150	1 : 200	1 : 2,005	1 : 3,041	1 : 200	1 : 300	1 : 2,005	1 : 3,041	1 : 100	1 : 117
Thymol	1 : 1,340	1 : 2,229	1 : 109	1 : 212	1 : 109	1 : 212	1 : 20	1 : 36	1 : 1,340	1 : 2,229	1 : 109	1 : 212	1 : 1,340	1 : 2,229	1 : 20	1 : 36
Salicylic acid	1 : 1,003	1 : 1,121	1 : 343	1 : 454	1 : 60	1 : 78	.....	1 : 35	1 : 3,003	1 : 6,004	1 : 603	1 : 1,003	1 : 1,121	1 : 1,677	1 : 343	1 : 450
Perman. of potassium	1 : 1,101	1 : 1,493	1 : 100	1 : 150	1 : 150	1 : 200	1 : 150	1 : 200	1 : 2,005	1 : 3,041	1 : 101	1 : 150	1 : 300	1 : 403	1 : 35	1 : 50
Carbolic acid	1 : 669	1 : 1,002	1 : 22	1 : 42	1 : 22	1 : 42	1 : 266	1 : 4	1 : 402	1 : 502	1 : 22	1 : 42	1 : 502	1 : 669	.....	1 : 10
Chloroform	1 : 90	1 : 112	.....	1 : 08	1 : 112	1 : 134	.....	1 : 08	.....	.....	.....	.....	1 : 103	1 : 134	.....	1 : 122
Borax	1 : 62	1 : 77	.....	1 : 14	1 : 48	1 : 69	.....	1 : 12	1 : 30	1 : 43	.....	1 : 14	1 : 107	1 : 151	.....	1 : 37
Alcohol	1 : 21	1 : 35	1 : 44	1 : 8	1 : 44	1 : 6	.....	1 : 118	1 : 11	1 : 21	1 : 177	1 : 203	1 : 21	1 : 30	.....	1 : 142
Eucalyptol	1 : 14	1 : 20	.....	1 : 205	1 : 116	1 : 205	.....	1 : 583	1 : 30	1 : 29	.....	1 : 14	1 : 205	1 : 308	.....	1 : 30
Chlorate of potassium	.....	1 : 30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1 : 13	.....	.....

excreted remains unaffected whether soluble or insoluble preparations are used, and that potassium iodide, even in substantial doses, exercises no influence upon elimination through the renal structures. The advocates of hypodermatic medication have, as yet, advanced no plausible explanation of the increased advantages therefrom, and its acceptance on the part of the profession will be referred to in the section on therapeutics. (See "Surgical Practice.")

The popularity of inunctions may be accounted for from the fact that mercury thus administered finds its way into the circulation in the form of extremely fine particles—without running the gauntlet of the liver—and its therapeutic effects are thereby enhanced in the same manner as when the drug is taken internally after thorough trituration. *Vaporization* also produces more distinct effects, probably for the same reason, but both methods are open to objection, since the amount actually introduced cannot be definitely measured or determined, and it requires the closest scrutiny to discover evidences of toxicity before serious harm results to the patient. It is doubtful if any considerable difference exists ultimately when mercury reaches the general circulation, whatever mode of administration is adopted.

SUMMARY.—Having now, in a general way, completed the study of mercurials, beginning with the gross lesions which attend acute poisoning, and following up with an investigation of their effects upon the brain, heart, liver, kidneys, etc.; and commented relative to their influence upon the blood, the tissues, the protoplasmic cells, oxidation, secretion, and elimination, when given internally, subcutaneously, by inunction, or vaporization, it seems as though nothing more could be said which would add to our present knowledge concerning the wonderful effects of this drug. And yet notwithstanding the abundant testimony brought forward to account for the effects witnessed, and the tentative suggestions advanced relative to its influence upon cellular activity, there is nothing, absolutely nothing offered which enables us to determine with any degree of scientific accuracy just how therapeutic results are obtained. There is still lacking an important link to complete this chain of evidence before the employment of mercury can be said to rest upon a strictly scientific foundation.

Perhaps an inquiry concerning its *action as a sorbefacient* will throw some additional light upon this mysterious and hitherto unexplained problem. To say that the effects of mercury are due to "*catalysis*," "*specific*," or "*selective*" action, or to assume that the "*hypothesis of interference*" is sufficient to account for them, is merely to substitute one unknown quantity for another. For example, with our present knowledge, we can understand and explain the causes which conspire to affect the pulse, temperature, and respiration; and we can also follow its action upon the functions of the liver, the kidneys, the skin, the alimentary tract, the salivary glands, and buccal mucous membrane, since these organs and structures are concerned in eliminating the poison; but how shall we demonstrate its sorbefacient properties in removing fibrinous exudations, syphilitic deposits, iritis, pericarditis, and inflammatory reactions of a benign character, without at the same time admitting that the drug may have some deleterious or untoward effect upon the organism as a whole? The only probable explanation of this paradox which suggests itself is based upon the assumption that in moderate dosage, the irritant (stimulant) action of mercury suffices to increase metabolism—*indirect or constitutional effects*—and that like all other poisons, it will be eliminated by those channels which are best adapted for the purpose—*direct or local effects*. The so-called "specific" action, "elective" action, or "catalytic" action on morbid products and diseased conditions, is nothing more than an incidental physiological effect, dependent upon the well-known properties of all poisons to manifest a disposition to associate themselves with retrograde changes—mercury not excepted.

The therapeutic study of mercury is therefore narrowed down to a consideration of *two principal factors*,

namely, the indirect or constitutional influences (*consequential benefits*), and the direct or local influences exerted upon functional or pathological disturbances (*physiological benefits*). This discovers the secret of the successful employment of all remedies, organic and inorganic, which are poisonous in themselves or foreign to the organism, and each has its value in certain directions, each has its limitations in all directions. When this value is overrated, or these limitations exceeded, harm invariably attends its administration. Our future triumphs in therapeutics, therefore, lie in the direction of studying, not alone the modifications affected by disease upon cell-life and cell-function, but the same strict rules must be applied to the reconstructive metamorphosis resulting from the employment of remedial agents, as has been done in the case of mercury, a remedy which, by its action upon cellular activity, removes and dissipates fibrinous exudations, syphilitic deposits, iritis, and pericarditis; which corrects the derangements of cell-function incident to inflammatory reactions, all phenomena bearing upon its therapeutic value being in perfect harmony with pathological study and physiological observation.

THERAPEUTICS.—In preparing the therapeutic section, the writer has aimed to give expression to the trend of modern practice in the use of mercurials, and to this end has incorporated under various sub-headings personal communications from recognized authorities in their respective departments. Such reports are, in many instances, more representative than a summary by a single writer, and in the following arrangement, which is intended merely to cover the principal disorders to which the drug is adapted, these contributions will be the means of guiding the student toward a true conception of its proper place in the physician's armamentarium.

Gastro-intestinal Affections. — Notwithstanding the harm which has attended the use of mercurials in this class of disorders, they undoubtedly possess distinct therapeutic virtues which entitle them to confidence; but in order to accomplish good, they must be exhibited with intelligence and discrimination, the conditions being clearly indicated in the following remarks by Professor Andrew H. Smith, of New York:

"Mercurials may be employed in gastro-intestinal affections with one of three objects, namely, to simply move the bowels, to excite hepatic and glandular secretion, and as anti-ferments.

"For the first purpose, calomel is the agent generally employed. It acts, probably, by increasing the flow of bile—which itself is a cathartic—and by stimulating the intestinal glands. This is a fair inference, from the fact that the purgative effect of calomel is not increased, but rather diminished, by giving large doses. A dose of several grains is sufficient to produce a large outflow of bile, and if more is taken the excess seems to act mechanically, like bismuth, to stay the cathartic action, rather than as a local irritant to the mucous surface. Short of producing a cathartic action, mercurials are much employed when there is evidence of deficient hepatic and glandular activity, such as is afforded by a furred tongue, a bad taste in the mouth, headache, anorexia, etc. Small doses are sufficient for this purpose, and they seem to influence cell-action in the epithelial as well as in the glandular structures. It is remarkable what an effect a single dose of a fraction of a grain of calomel will have in removing the 'patchy' condition of the tongue, so often observed in gastro-intestinal disorders.

"As intestinal antiseptics, mercurials are of great value, especially calomel and the bichloride. It is probable that the first becomes to some extent changed into the second. The efficiency of the bichloride as a germicide, in attenuated solution, is universally recognized. Indeed, it has been suggested that the whole mass of the blood might be rendered sterile by non-poisonous doses of this agent. Be this as it may, the intestinal disturbances attributable to ptomaines, generated in the digestive tube, are often relieved with remarkable promptness by remedies of this sort."

From the foregoing, therefore, it is evident that these remedies will be serviceable in the treatment of such disorders as gastric ulcer, gastro-intestinal catarrh, and to a certain extent in nearly all cases of diarrhœa and dysentery. As a purgative, calomel is mostly used when the immediate effect is desired, while in cases that do not require this effect, and when the object is to reach distant organs, one of the more irritant preparations (biniodide, protoiodide) may be given. Occasionally, during the progress of disease, sometimes in the early stages of febrile affections, a single substantial dose of calomel may be helpful. It requires a nice discrimination, however, to determine the conditions which demand a large dose of calomel for its purgative effects. To quote Thomas King Chambers: "Some call this clearing the decks for action; in a majority of instances, they may be said to throw overboard much of the best tackling on the ship and loosen her armor-plates."

In typhoid fever, calomel in small doses is unquestionably of benefit, but large doses, or its continuous administration as a routine practice should be condemned, since other remedies, safer to the patient, better for the disease, are now at our command. In all subacute and chronic cases, when the hepatic function is below par, the most striking results will attend the judicious employment of the biniodide in small doses (gr. $\frac{1}{100}$ two or three times a day).

Hepatic Disorders.—Mercury has long been recognized as a useful remedy in that morbid complexus known as "*biliousness*," and when administered in dosage that precludes the possibility of after-depression, it appears to be quite serviceable, although it is contra-indicated in acute congestion of the liver. In passive congestion, on the contrary, small doses of mercury—calomel or the biniodide in solution—will promptly produce beneficial effects. It is a mistaken notion that mercurials are of value in hepatic abscess, gall-stones, acute yellow atrophy, but they are of some temporary service as adjuvants in jaundice. It is doubtful if mercurials have any therapeutic value in hepatic cirrhosis, but they may be of service in ascites associated with this condition for their constitutional effects. Selwass (*Berlin. klin. Wochenschr.*, 1888, No. 38, p. 762) reports favorable results from the employment of calomel when treatment is begun in the early stages, although, even when combined with the use of digitalis, the disease is not cured. In a total of ten cases, only the recent ones (5) were benefited by the treatment.

Dujardin-Beaumetz advises a combination of calomel and corrosive sublimate as *an hepatic stimulant*—gr. jss. of the former and gr. $\frac{1}{3}$ of the latter—and this, with the addition of arsenic, is a favorite formula with Dr. William H. Porter (New York). On the whole, however, small doses of corrosive sublimate (gr. $\frac{1}{200}$ hourly) with suitable adjuvants, will generally accomplish all the good that can be gained from these large doses, and thus the depressant effects are avoided. In adults suffering from passive congestion of the liver, hæmorrhoids, and tenesmus, with or without bloody stools, these small doses produce magical results.

Diseases of the Kidneys.—The use of calomel as a diuretic was recommended some years ago, and has attracted considerable attention. The objection to its use, however, lies in the fact that it must be given in sufficient dosage to produce stomatitis, which requires active treatment in the way of gargles; and sometimes diarrhœa follows, making the use of opium necessary, and for this reason the beneficial effects have been questioned. It is especially advocated as a diuretic in œdematous conditions associated with cardiac disease, and it is said that, when continued for a sufficient length of time in the healthy subject, it produces in from two to ten days distinct diuresis, a condition similar to that which obtains from the subcutaneous employment of corrosive sublimate and the inunction of blue ointment. It is claimed that the subcutaneous injections act most powerfully as diuretics, the inunctions least, while the internal administration produces an effect about midway between the two. Small doses have no diuretic effect; only medium and

large doses increase the amount of urine. The somewhat doubtful claim has been put forward also, that calomel given under these conditions not only diminishes, but cures pathological changes in the kidneys. Biegarski (*British Medical Journal*, June 22, 1889) is of the opinion that cardiac dropsies are even more amenable to this treatment when corrosive sublimate is given subcutaneously, less to mercurial ointment by inunction, and that in dropsy due to kidney disease and obstruction of the portal circulation, the mercurials are of very little use; all of which confirms the view advocated by Nothnagel a year or so previously.

Various theories have been advanced to account for the diuretic action of mercurials in cardiac disease, when this does not obtain in renal disease proper, although in health the diuretic action is perceptible. Jendrássik suggests that calomel causes absorption of the dropsical fluid by the blood, while Fürbringer believes it is due to an irritation of the renal epithelium by the mercury; but neither of these theories appears to be satisfactory. There is reason to believe that increased oxidation (cellular activity) is an important factor—previously referred to—and that the determination of calcareous matter in the kidneys may likewise exercise an irritant (stimulant) action upon the epithelial cells of the convoluted tubuli, these cells being principally concerned in the elimination of solids (Heidenhain); and the elimination of mercury itself would fall within this latter category.

Phthisis.—In anæmia occurring as a result of phthisical dyscrasia, Dochmann (*Therap. Monats.*, September, 1888, p. 415) claims that calomel has a rapidly favorable action, even when iron has failed, since it improves the appetite, regulates the bowels, and corrects menstrual difficulties. The dose recommended is, gr. $\frac{2}{3}$, three or four times a day, the medicine being discontinued for several days at the expiration of five or six days. A recrudescence of the fever demands an increase of the daily dose for a time. Martell (*Prag. med. Wochenschr.*, 1888, No. 25) also reports good results from the same method. The latter authority advocates the employment of calomel topically as well as internally and by inhalation. Of course, in those cases where the tubercular process is of an indolent character, the increased oxidation resulting from the employment of mercury cannot be other than beneficial (consequential and local benefits); but it can have no direct influence upon the bacilli. Given in small doses and not too long continued, it stimulates cellular activity.

Syphilis.—As an indication of the conservative tendencies in the employment of mercurials in syphilis, it should be noted that Mr. Jonathan Hutchinson, the veteran syphilographer, now advocates the employment of gray powder (*hydrargyrum cum creta*), in one-grain doses, three to six times daily, one grain of Dover's powder to be given twice a day to control the bowels; but unfortunately the opium is extremely objectionable, since it involves ultimately the treatment of two diseases instead of one. There is no doubt of the curative action of mercury in syphilis, but in times gone by it has too often been accomplished at the expense of the patient's health, owing to the unnecessarily large doses administered, facts very fully brought out by the observations of Professor Edward L. Keyes, of New York ("Trans. International Medical Congress," September, 1876), whose positive conclusions are as follows:

"1. Mercury is an antidote to the syphilitic poison, and of service in controlling all its symptoms in all (even the latest) stages of the disease, its power over gummata being least marked and not to be relied upon.

"2. Mercury in minute doses is a tonic.

"3. Iodine cures certain symptoms of syphilis, but does not prevent relapse.

"4. The use of mercury, long-continued, uninterruptedly, as far as practical, in small doses, from the time of the earliest eruption, constitutes the best treatment of syphilis."

In connection with the above may be mentioned the views of Professor William Osler, of Baltimore (private communication) on this important topic, as follows: "Of course, we all know the striking influence of the mercurials in relieving the blood-condition of syphilitic cachexia, but here, I think, the action is undoubtedly similar to quinine in malarial cachexia, not so much a direct action upon the blood as a neutralization of the poison and natural restitution of the corpuscles."

Mercurials are also of value in non-specific as well as in the specific forms of *skin diseases*, the indications for their employment being deducible from our previous conclusions.

Ophthalmology.—The following concise report from Professor Samuel D. Risley, of Philadelphia, practically covers the employment of mercurials in ophthalmology:

"In ophthalmological practice I esteem mercury of great therapeutic value. There are large groups of diseases in which no other drug is so useful, and this is true not only of those forms of eye disease where syphilis is the important etiological factor, but also of affections of the uveal tract, and in certain forms of corneal inflammation not traceable to this disease. It is used without hesitation in all forms of plastic iritis, in exudative choroiditis, neuro-retinitis, etc., whether of known specific origin or not. My experience would seem to suggest that, as a matter of course, this drug should be administered in recognized syphilitic cases, whether occurring along with other secondary symptoms or associated with the later manifestations. It can be administered either in the form of the corrosive sublimate, in small, frequently repeated doses, by means of inunction, or the mercurial bandage.

"In acute forms of disease, as in plastic iritis, inunctions pushed to the point just short of ptyalism are to be preferred, the patient meanwhile being confined to his bed. In chronic forms of inflammation, *e.g.*, interstitial keratitis, corrosive sublimate is employed, or, instead, the bandage worn around the waist night and day, and kept well covered with mercurial ointment. Not infrequently, I employ the well-known formula of potassium iodide and corrosive sublimate, but this combination seems best adapted to cases of neuro-retinitis than to other forms of eye disease."

Diseases of the Throat and Nose.—As expressing the views of practitioners in this special department of medicine, the following report from Dr. George B. Hope, of New York, will prove interesting and suggestive:

"As a class, hypertrophic derangements of the mucous and submucous areolar tissues are so peculiarly resistant to the usual range of topical applications as to discourage all such measures, and lead to a resort to surgical or destructive agents in order to overcome the effects of structural changes. However applicable this may be under certain favorable conditions, there are yet cases where this course is neither rational nor practicable, and it is in these instances that a remedy addressed through constitutional channels offers the only prospect of relief. Iodide of potassium and mercury furnish the most striking types of active cellular-therapy agents, and from this standpoint—eliminating the former on account of its unfavorable action to the mucous membrane—the indications for mercurial treatment may be considered to be definitely established. As an illustration may be cited a case of simple, chronic, hypertrophic laryngitis, in which the ventricular bands were so far involved as to offer a serious obstruction to respiration, with the surrounding parts in accord with the prominent pathological condition. Under the administration of full doses of the protoiodide of mercury, a speedy and satisfactory resolution was obtained without the introduction of any auxiliary line of treatment.

"In a word, if the theory of mercurial action is correct in its clinical details—that it encourages the oxidation of loosely-formed cell-elements, and stimulates their elimination by the lymphatics—it would seem that the legitimate limits for its administration, aside from syphilitic affections, are particularly covered by conditions representing the imperfectly organized type of inflammatory exudation, as in (chronic) infiltration of the intercellular tissues, or the thickening of the epithelial layers, as in

moderate pachydermatous laryngitis—features of chronic catarrh."

Nervous Diseases.—From Dr. Wharton Sinkler, of Philadelphia, the writer has received the annexed report, which fairly comports with views already advanced, and in a large measure confirms them from the clinical standpoint.

"In regard to the employment of mercurials in nervous diseases, will say that in organic diseases of the brain and cord, when due to syphilis, of course, mercurials are of prime importance. It does not follow, however, that all scleroses of the spinal cord are benefited by the administration of mercurials, even in those cases where there is a clear and undoubted history of syphilitic infection together with secondaries. Locomotor ataxia is an illustration of the truth of this observation. A large proportion of the cases of tabes with which we meet have a more or less distinct history of syphilis, some writers asserting that as many as seventy or eighty per cent. of tabetics have had this disease. Notwithstanding this fact, few cases of locomotor ataxia are benefited, even by the most vigorous course of mercurials and iodide of potassium. On the other hand, some of the other forms of syphilitic infection of the nervous system yield promptly and completely to mercurials and iodide of potassium. Those cases which are spoken of as syphilis of the brain and cord seem particularly ready to yield to mercurial treatment; and in this class of cases mercury seems to be of more value than the 'mixed treatment,' or the iodide of potassium alone.

"For some reason, *mercury by inunction* gives better results in the treatment of syphilis of the nervous system than when the remedy is given by the mouth. I have had comparatively little experience in the use of mercury hypodermatically, but recall one patient suffering from spinal sclerosis with a specific history, who made very marked improvement under the use of the bichloride of mercury administered hypodermatically.

"In the treatment of nervous syphilis, I have not found it necessary to push mercurials to the point of salivation, and in one or two cases where I accidentally salivated patients, there was no apparent benefit to the nervous disorder for which the mercury had been given. As a rule, I find it preferable to give mercurials in conjunction with iodide of potassium, but frequently I administer it alone. In some of the forms of sclerosis of the cord, not due to syphilis, small, alterative doses of mercury are of great value. Usually, the remedy is to be persisted in for a number of months, and it is best to give it in small doses. I prefer in these cases to give the bichloride, as I think it is less likely to disturb the stomach and intestinal tract, and it is borne for a longer period of time than the other preparations of mercury. As a general nerve-tonic in some of the functional nervous disorders, mercury is of considerable value, more especially, I think, when it is combined with arsenic and iron.

"There are some forms of *headache*, especially those of specific origin, in which small doses of the bichloride of mercury are very useful. In the severe nocturnal headaches of syphilitics, one one-hundredth of a grain of this salt, repeated hourly, will sometimes afford relief. *Cerebral and spinal meningitis* are treated most effectively by the administration of mercury; and calomel or gray powder seems to answer better in meningeal inflammation than any of the other mercurial salts, as it is necessary to get a prompt and speedy impression."

Obstetrics.—In obstetric practice the use of mercurial solutions (bichloride, 1 to 5,000) has largely given place to carbolic acid, creolin, and lysol, and other less toxic substances for the vaginal *douche* and intra-uterine applications. Indeed, the employment of any antiseptic is strongly condemned as both useless and dangerous in uncomplicated labors. In 1889, Garrigues (*American Journal of the Medical Sciences*, August, page 109) published a synopsis of twenty-two cases in which death occurred from the use of corrosive sublimate solutions, and at that time he favored creolin solutions (two per cent.) as a substitute for mercuric chloride.

Corrosive sublimate injections in *ordinary midwifery cases* need not be practised, but the solutions may be used for the disinfection of the outer surfaces of the patient, for the hands of nurses and physicians, and for all materials brought into contact with the patient. When intra-uterine medication is demanded, the strength of the solution should not exceed 1 to 5.000 to 10,000, and the injections should not be given more frequently than twice in twenty-four hours, although the vaginal *douche* may be given as often as every three hours; and at the time care should be taken that no symptoms of absorption arise, and for which the physician must be constantly on the outlook. Upon the first appearance of toxic symptoms, the medicament must be immediately discontinued until all danger has passed. As the bichloride combines with impurities in the water as well as with albuminous principles and alkaloidal poisons, and is seriously affected by alkaline fluids, it has been suggested that it might be prepared in concentrated form with glycerine and hydrochloric acid dilute, from which solutions could readily be prepared.

By the use of antiseptics and the adoption of measures looking to asepsis, the *septic death-rate* in American maternities has been reduced to less than one per cent. Intoxication from the intra-uterine *douche* has been of such frequent occurrence that a suggestion is offered to the effect that hydrogen dioxide solutions be substituted, on account of the latter being harmless to patient, efficient as a destroyer of unhealthy tissues and discharges, cleanly and perfectly manageable, and, withal, prompt in action. Owing to the rapid oxidation which takes place when the dioxide is brought into contact with morbid products, in using it for the intra-uterine *douche* care must be taken that the outflow is not obstructed, since the gas generated might be sufficient to force morbid material into the tubes, and thus defeat the purpose for which it was used.

Concerning the employment of mercurials internally against syphilitic infection, the following brief report from Dr. Joseph Price, of Philadelphia, will be read with increasing interest, since it furnishes a demonstration of their almost universal value:

"I have for years used mercurials freely in *syphilitic child-bearing and pregnant women*, also in syphilis of the new-born. The iodides are of but little value, except in the management of symptoms, and in the tertiary stage in mothers. At present, I have a number of mothers under treatment continuing from periods of two to nine years; some of them have borne as many as three healthy children in that time, no symptoms reappearing in either mother or offspring."

Diseases of Children.—Mercurials find a wide range of application in the treatment of diseases peculiar to childhood and infancy, although indications point to the probability of their too liberal use in some cases. Albeit their value is not denied, there are many instances where other and more efficient medicaments may be substituted, so that in them alone does not lie our only hope. For example, in *croup* and *diphtheria* mercurialization really accomplishes no good purpose, and besides, we have other remedies that can be used as adjuvants, which are more effective and entirely free from the dangers arising from mercurialization. The routine method of treating diphtheria should be remodelled upon a scientific basis corresponding with our present knowledge concerning the life-history of the pathogenic microorganism associated with it. Clinical observation is opposed to emetics in both croup and diphtheria, the two being so closely connected that it is difficult to say positively where the one ends and the other begins.

By many, calomel is given as a preliminary in diphtheria to produce some effect upon the bowels, when corrosive sublimate is substituted, but this course must be followed with caution, because in the serious cases absorption may be interfered with to an extent that will prevent or delay the manifestations of mercurialization, when constitutional symptoms rapidly supervene. It is doubtful if, in such cases, the mercury be of any service; nay, indeed, clinical experience is against the production of a factitious disease.

The *medicinal treatment of diphtheria* should be conducted with two principal objects in view, viz. : (1) To arrest the rapid multiplication of germs, and (2) to counteract the pathological changes effected by their products. For the first, an *anti-biotic* is required, to render the soil unsuitable for their growth; and for the second, an *anti-toxine* is demanded, to fortify the system against the morbid products. Unfortunately, mercurials cannot be used in sufficient dosage, with safety to the patient, to accomplish either purpose. *Locally*, the mercurial preparation must not be too readily soluble, and should not too easily combine with albumin or other substances which destroy its antiseptic value. *Internally*, diffusibility is desirable, and with the recent introduction of new compounds it is hoped a better and more efficient therapeutics will be instituted. In this connection should be mentioned an interesting and valuable analytical report by Dillon Brown, covering 2,368 patients in whom intubation was practised, with 647 recoveries, or 27.3 per cent., and including from his own personal experience 115 cases, all seen in consultation. Of the latter number, 50 had not been subjected to the bichloride treatment, and the recoveries were 24 per cent. ; in the other 65 cases, with bichloride, 36.9 per cent. recovered. Stellden, a Swedish physician, reports 1,400 cases of diphtheria treated by mercury cyanide, with but 69 deaths (approximately, 5 per cent.), while the usual rate of mortality in his district has been 92 per cent. The method of using the cyanide consisted in adding to gr. $\frac{1}{8}$ mercury cyanide, half a drachm of tincture of aconite and two ounces of honey, and of this mixture the patient takes a teaspoonful at intervals of an hour or less. In addition to this, a gargle—1 to 10,000 mercuric cyanide and peppermint-water—is employed every fifteen minutes.

The following comprehensive *résumé* by Professor Mary Putnam-Jacobi, of New York, very fully embodies the practical adaptation of mercurials in this class of cases :

"The position of mercurial preparations in the nursery has varied greatly within the present century. At one time vaunted under many forms, as specific for many ailments or serious diseases; at another, almost completely condemned ; they have recently been reinstated to a considerable extent in the *armamentarium* of the family practitioner. The list of cases in which mercurials are to-day employed is not, indeed, long ; but each disease on the list is important and of frequent recurrence.

"The revival of mercurial medication, perhaps, principally depends upon the modern demonstrations of the great antiseptic power of mercury, and especially of its most poisonous salts, as the bichloride and the biniodide. Coincidently has been demonstrated the microbic etiology of such diseases as diphtheria, and the occurrence of fermentations due to microbes in gastro-intestinal disorders. The utility of mercury in syphilis was well established by clinical experience before syphilis, as an infectious disease, had been referred, like other infections, to microbic inoculation. Although the precise infecting agent of syphilis has even yet not been isolated, its existence is unhesitatingly assumed ; and with as little hesitation are the curative powers of mercury attributed to the antiseptic virtues of the drug.

"In the great *epidemics of diphtheria* which raged in France in the first half of this century, Bretonneau used calomel extensively and pushed it to the point of salivation. The result was disastrous, as was, indeed, every other form of treatment used in these terrible times. From about 1850–53, calomel was altogether abandoned, and tincture of iron and powerful stimulation adopted in its place. Quite recently, however, has been introduced, in addition to such stimulation, the internal administration of minute doses of bichloride of mercury, especially when croup is threatened ; the use of sprays of solutions of bichloride, 1 to 4,000 to 6,000 of water ; finally, fumigations of calomel in croup, both before and after tracheotomy or intubation. One milligramme (gr. $\frac{1}{65}$), per hour, may be administered for one or two days to even very young children, and in association with tincture of iron given throughout the hour. It does not, as has been occasionally asserted, cause depression ; and it certainly does not cause salivation. Of course, like all other remedies in this dreadful disease, it often fails to cure. The spray can also be used once an hour. The fumigations are made by burning ten grains of calomel on a tin plate in the bed where the child is lying, while this is surrounded by a blanket to retain the fumes. In ordinary *non-specific laryngitis*, the same small doses of corrosive sublimate, or else hourly powders of calomel, gr. $\frac{1}{12}$ each, will often arrest an attack in a day or two.

"What is the precise mode of action of the gray powder (hydrarg. cum creta) in *acute gastric catarrh*, is by no means well known ; but empirically, its efficiency cannot be doubted. In *fermentative diarrhœa*, the bichloride, combined with bismuth and the carminative oils, is more useful. Even in adults, hourly doses of gr. $\frac{1}{60}$ of bichloride are extremely efficacious for this disorder, the poisonous drug seeming to neutralize the poisons which are forming in the intestinal tract. The same dose may also be given to children.

"The time-honored method of giving a dose of calomel for the so-called *bilious attacks* of children, as of adults, is also again revived. In children these attacks generally mean gastro-duodenal catarrh with extension to the mucosæ of the bile-ducts. Calomel certainly increases the flow of bile, even in healthy animals—more probably its secretion ; under increased pressure this is able to force its way through the ductus choledochus—occluded by swelling—and the free passage of the secretion initiates the reduction of the swelling.

"*The points to remember* in all these gastro-intestinal diseases is, that the mercurial is to be administered for a comparatively brief period—two or three days at the outset—and not to be relied upon for prolonged use, nor to be frequently resorted to in states of chronic indigestion ; that is, if the conditions recur, and tend to become chronic. The old method of an occasional blue-mass pill is insufficient for the purpose ; other treatment is coincidentally required to stimulate the sluggish portal circulation.

"In *dysentery*, fractional doses of calomel, combined with ipecac and opium, although an old, is a still justly accredited mode of treatment. Its value is increased when associated with the newer method of systematic irrigation of the bowels. The *so-called method of Law*, originally applied to peritonitis, by which calomel, $\frac{1}{2}$ grain, was administered hourly, is still valuable, for in this way much more of the drug can be introduced into the system than when it is given in massive doses—or, possibly, a larger amount is converted into bichloride, and thus becomes a potent disinfectant to the putrid contents of the intestine.

"No opposition has ever been raised to the administration of mercury in *infantile syphilis*, except by the fanatics that profess to cure adult syphilis without mercury. The bichloride, Van Swieten's liquor, is a convenient form, and can frequently be tolerated for a long time without causing gastric irritation. If this occur, the medication must, of course, be interrupted, or replaced by mercurial inunctions. These, as well as bichloride baths—grains vij. to a bath—are well suited for the cutaneous and articular lesions of syphilis. Citrine ointment, diluted four times, is best adapted for syphilitic vegetations around the anus and genitals. The mercurial treatment should be continued, with interruptions at intervals of six or eight weeks, for a period of two years."

Surgical Practice.—A full discussion of the antiseptic properties of mercurials in surgery does not properly come within the scope of this article, and it will be sufficient to refer briefly to the methods now in vogue, and which are set forth in the annexed communications. It should be stated that the value of corrosive sublimate as an antiseptic may be modified by various conditions, namely, *temperature, albumin, bacteria, and light in the presence of organic matter*, so that although immediately available, its power for good may not long remain, and thus a false sense of security is given the surgeon. Professor N.

Senn, of Chicago, expressed his continued confidence in it as follows:

"I have tried many substitutes, but always fall back upon corrosive sublimate. I use for disinfection of hands and field of operation, a 1 to 1,000 solution; for disinfection of infected wounds, 1 to 1,000 to 10,000."

Professor Roswell Park, of Buffalo, who seems to have followed closely the teachings of Sir Joseph Lister, is favorably impressed with the mercury-zinc cyanide. He writes as follows:

"Mercuric chloride and mercury-zinc cyanide I ordinarily apply or employ in my surgical work. The latter comes very near being an ideal antiseptic, in my estimation. When either of these is used with judgment, it is capable, I think, of giving the greatest satisfaction. Still, I think we have now so many antiseptic drugs to choose from, that one may succeed in any branch of surgical work *without* using mercurial preparations. This is especially true since *aseptic* methods have been introduced. Indeed, every operator learns to place reliance on one or two drugs for this purpose in accordance with his training, his surroundings, or his personal idiosyncrasies. I do think, however, that we could dispense with mercurials as antiseptics, were we compelled to, without perceptible loss.

"For occasional internal use, as intestinal antiseptic agents and general alteratives, it does not seem to me that we could make substitutions without serious loss.

"The mercury-zinc cyanide solutions which I employ are usually 1 to 2,000. Compresses are used wrung out of a solution, 1 to 500. For disinfecting hands I ordinarily use hydrogen dioxide in full strength. Instruments I boil, usually in a two per cent. soda solution. For the hands I use green soap with five per cent. lysol, and after that, frequently, the permanganate bath with bleaching in oxalic-sodium hypophosphite solution."

Hypodermatic Medication.—Calomel by intra-muscular injection was first used by Scarenzio as early as 1864, but owing, perhaps, to the faulty methods and lack of antiseptic precautions, it was not brought prominently to the attention of the profession until advocated by Neisser, of Germany (1885), who in 1888 modified Lang's formula for "gray oil." By the observance of strict antisepsis, it is said, abscesses are of rare occurrence. Wilson (*Medical News*, vol. lii., 1888, p. 593) reports twelve cases treated (sixty-nine injections) with very satisfactory results. A grain of calomel, rubbed up with glycerine (℥ xv.), to which is added at the time the operation is performed a few minims of recently boiled water, and thoroughly shaken, constitutes the medicament. These injections are given at intervals of a week or ten days. In a private communication to the writer, dated March 10, 1893, Dr. Wilson says he has continued to use the treatment in proper cases since that time without modification of importance.

Lang's original formula (*Brit. Med. Jour.*, June 16, 1888) for *gray oil* (oleum cinereum) is as follows:

Mercury,	
Lanolin	each 3 parts.
Olive oil.....	4 parts.

M. Sig.: For hypodermatic use; contains thirty per cent. of mercury.

The dose of gray oil is 0.10 to 0.15 c.c., introduced deep into the back or nates every five to eight days. Neisser's modification (*oleum cinereum benzoinatum*) is given herewith:

Mercury.....	20 parts.
Liquid paraffin.....	40 parts.
Benzine-ether	5 parts.

M.

One cubic centimetre contains about six grains of mercury. The dose is 0.25 c.c. at the same periods as the gray oil, and treatment is interrupted from time to time. When resumed, smaller doses are used, and the injections practised more frequently, as it has been found that the small dose at short intervals is better than the large dose at longer intervals. The gray oil can also be used as a topical application at points affected by the specific poison —bone disease, specific disease of the larynx and nares. It is claimed that the gray oil subcutaneously has shown special benefits in cases where the disease affects the ear, the Eustachian tubes, or the forehead.

Lang has published the following conclusions: "(1) Gray oil is efficient with the least dosage of mercury; (2) it is convenient for both patient and physician; (3) dangers of reaction are but slight; (4) no abscess has attended several thousand injections; (5) can be employed in all cases where a mercurial is indicated; (6) can be used in the immediate neighborhood of syphilitic lesions."

Watraszewski (*Archiv für Dermatologie und Syphilis*, 1889), in comparing the therapeutic adaptation of calomel, yellow oxide of mercury, and gray oil, gives a decided preference to the yellow oxide in the dose of two-thirds to one grain. Mucilage is preferred as a vehicle for the following reasons: (1) It can be made of proper consistence to hold the powder in suspension; (2) it has no local irritating effect; (3) it does not decompose the mercurial salt; and (4) it excites no general disturbance.

Notwithstanding the favorable evidence in favor of these preparations, the probabilities are that corrosive sublimate is more extensively used in this country than any other mercurial for hypodermatic medication.

Dr. Yvert, of Paris, some years ago submitted to the Academy a note on the value of the *bichloride as an anti-cholera vaccine*, giving in evidence an account of forty-five patients so treated in Tonkin, with nine deaths (twenty per cent.), while the mortality in that section of Asia averaged sixty-six per cent. The dose administered ranged from one-third to two-thirds of a grain, when the patients were seen within twenty-four hours after the first manifestations of the disease. As a prophylactic it proved efficient.

Topical Applications.—For boils and felons the citrine ointment is usually recommended, but it is less efficient than the biniodide, 1 part to 10 of benzoinated lard. The affected area should be covered with a thin layer of the ointment, and allowed to remain for two, three, or four hours, according to the tenderness of the skin, when it is thoroughly removed, internal medication being depended upon to complete the absorption. Mercurials are used as caustics in specific ulcerations and chancroids, but in ordinary cases they have been supplanted by other more acceptable products. As previously noticed, the oleate is very generally employed, and by means of ingeniously constructed instruments a powder can be deposited in the urethra in the treatment of urethritis.

Mercurial inunctions have lately been more favorably received than hypodermatic injections in the treatment of syphilis, and at the recent Paris Congress there appeared to be a strong sentiment against the latter method, some going so far as to assert that it was dangerous. It is said the method has been abandoned by Schuster, Kaposi, Julien, Fournier, and others, who have all returned to the earlier methods. *John Aulde.*

METHACETIN (Para-oxymethy-acetanilide). This compound is a derivative of acetanilide, introduced in 1888 by F. Manhert as a substitute for phenacetine, to which it is closely allied. Its formula is $C_6H_4OCH_3$-$NHCH_3CO$, which differs from acetanilide, C_6H_5NH-CH_3CO, by substituting for one atom of H one atom of the oxymethyl group OCH_3. In phenacetine, $C_6H_4OC_2$-H_5NHCH_3CO, the ethyl group replaces the methyl group of methacetin.

It forms in white, glistening, scaly crystals, without color or faintly reddish; odorless; melting at 127° C.; it has a slightly bitter saline taste; is soluble in water at 60° F., 1 part in 530; in boiling water it dissolves in 12 parts; is freely soluble in alcohol, chloroform, glycerine, and fatty oils. Methacetin possesses antipyretic, antiseptic, and analgesic properties similar to those possessed by phenacetine, which it resembles therapeutically, as well as chemically. The advantage claimed for it over

all other antipyretics is its freedom from toxic effects or any injurious action on the blood-corpuscles. It is said not to cause any depression, malaise, tinnitus, or any of the lesser annoying symptoms. It is recommended particularly for children and enfeebled persons. The only unpleasant effect is the production at times of free perspiration. Further experience has shown that it is not so devoid of these unpleasant symptoms as is claimed, as in addition to the profuse sweating, it occasionally causes very decided symptoms of collapse. It is, however, the most harmless of similar antipyretics.

It has proved very serviceable in typhoid fever, typhus, pneumonia, phthisis, and all febrile diseases. It produces a rapid fall of temperature, sometimes in fifteen or twenty minutes. The fall usually reaches its minimum in about three hours, remains stationary for about an hour, and then rises rapidly. With small and more frequently repeated doses the temperature may be kept low, but not at an apyretic point. The action of the drug also varies according as it is given with the daily rise or fall of the fever, and its most marked action occurs when it is given to act with the normal decline. In typhoid fever its effect is also more decided in the latter periods of the fever with the remissions than during the continuous stage. Its power of lowering temperature is also evident during health. The dose is from two to three grains, to be repeated in three or four hours if required. Larger doses of five and seven grains are frequently given when a rapid and decided effect is required.

In acute rheumatic fever and painful febrile troubles, as pleurisy, etc., five-grain doses prove very satisfactory in reducing the swelling, pain, and fever. As an analgesic in neuralgia and migraine it has not proved as useful as phenacetine and acetanilide. Although its employment is accompanined by fewer unfavorable symptoms, it has not replaced phenacetine, which it most resembles in action, its antipyretic properties being less marked, and as an analgesic it has proved very much inferior.

Physiological experiments have proved that forty-six grains will cause death in a rabbit, producing spasms in the posterior, and later in the anterior, half of the body. After death there is found hyperæmia of all the organs, and the heart flaccid and filled with blood-clots. No hæmoglobin is found in the urine. *Beaumont Small.*

METHYL CHLORIDE (Monochlormethane). A colorless gas with a sweetish taste and an ethereal odor. It is soluble in one-fourth its volume of water, much more so in ethyl and methyl alcohol, and freely in ether and chloroform. The gas is not very inflammable; when ignited it burns with a greenish flame. At a temperature of −13° F., or under a pressure of five atmospheres, it is converted into a liquid, with a specific gravity of. 9915, neutral to test-paper. This liquid boils and becomes a gas at a temperature of −5.8° F., the change of condition being accompanied by the absorption of a great amount of heat. On account of the rapidity of this change an intense degree of cold is produced, amounting to a fall of 40° or 50° F. or more.

The use of this refrigerant action was applied by Débove, in 1884, as a local anæsthetic for neuralgia and other painful affections. It has been used in sciatica, pruritus, spinal pains after railway accidents, and in the painful joints of rheumatism, and in pleurisy. The duration of relief from pain is never prolonged or permanent; from one hour to three or four hours is the average. In the latter conditions the relief has not been satisfactory, and any such use is beyond the scope of the remedy. The most important application of this compound has been as a freezing mixture for the performance of minor surgical operations. It has been used with decided success in circumcision for phymosis, evulsion of toe-nails, excision of cancer of the lip, opening of mammary abscess, incision for empyema, and many similar painful procedures.

Methyl chloride is very extensively used for this purpose in the Paris hospitals, where it is prepared and stored in specially formed flasks, resembling those in which nitrous oxide is supplied. These are so arranged that the spray may be made to issue as required, without any trouble or waste.

A stream of the spray may be applied directly to the part, in an oblique direction, for one or two seconds, or it may be directed upon a tampon of wool which is surrounded by floss silk and covered by thin silk. The tampon becomes saturated with the liquefied gas, which rapidly evaporates and absorbs heat from the adjacent parts. This latter method is more suitable for the relief of pain; for operative purposes the spray is to be desired.

The first effect on the part is to render it pale and bloodless and insensitive; a continuance of the cold produces a dried, parchment-like appearance, and this is the time to operate. The application of the spray must be guarded, as it is not without its disadvantages. If it is used too long it causes death of the part, with vesication and eschars according to the depth and extent of the injury. Frequently, where the action has been only of short duration, the part remains red and tender for several days, Dr. S. E. Berezovsky made a number of experiments upon dogs to determine the local effect of the spray. They showed that, 1, a spray of two minutes' duration, when directed against intact integuments, produces complete anæsthesia lasting from fifteen to twenty seconds, the tissues remaining sufficiently soft to allow cutting; 2, a spray of five seconds' duration, while inducing a somewhat longer anæsthesia, freezes the skin to an inconvenient degree; 3, a seven-seconds spray gives rise to consecutive local congestion and inflammation; 4, a twenty-seconds spray causes sloughing of the tissues down to the muscular layer; 5, a convenient and harmless anæsthesia, induced by a two-seconds spray, can be easily prolonged up to five minutes by repeating the spray at short intervals; 6, sufficient anæsthesia of exposed bones can be produced in the same way; 7, the spray does not cause either gangrene or thrombosis of blood-vessels.

Methyl chloride is a decided improvement upon ether spray as a means of producing local anæsthesia, but it has a powerful rival in the recently introduced ethyl chloride, which is milder in action but equally efficient. The disadvantage of methyl chloride is its powerful and rapid action, which is difficult to control both in extent and degree.

It has also been suggested as an anæsthetic, and a mixture of ether and chloroform, saturated with the gas, was suggested by Richardson, but no advantage was apparent, and it has failed to receive much recognition.

Beaumont Small.

METHYLENE BLUE (Tetra-methyl-thionine Chloride). An aniline derivative, its formula being $(C_6H_3N(CH_3)_2CL)_2NS$. Chemically pure methylene blue occurs in small indigo-colored scaly crystals, with a bronze-like tinge and dark green in transverse fracture. Slightly soluble in water, forming a deep blue solution, which is changed by sulphuric acid to a dark green, and from which a strong potash solution throws down a dark violet precipitate. The methylene blue of commerce (ethylene blue O) is a double chloride of zinc, and tetramethylthionine.

This aniline product was introduced into medicine in 1890, by Drs. Ehrlich and Lippmann, as an analgesic of some value. Professor Ehrlich had investigated the action of the drug on nervous tissue as a staining reagent, and had demonstrated that it had a peculiar selective action on the axis cylinders of motor and sensitive nerves. Further experiments showed that when taken into the stomach, or introduced subcutaneously, it rapidly spread throughout the system and gave relief to all neurotic pains, and the pain in rheumatism of the muscles, joints, and tendons. A two per cent. solution was used, by means of which one grain was given hypodermically. It was also used in capsules, the powder being given in doses of 1½ to 4 grains; as much as fifteen grains were given in one day. No ill effects accompanied its administration, and no change in appetite, digestion, pulse, or any of the normal functions. The drug was absorbed very quickly, and a quarter of an hour after the smallest dose the urine be-

came a bright green, after two hours a dark green, and after four hours a dark blue. No albumin was present. In the saliva a bluish tinge was detected, but there was no discoloration of the mucous membranes or conjunctiva. The anodyne effect began in about two hours, and was gradually produced; it had no effect on any fever or inflammatory condition. When administered in full doses it is liable to produce symptoms of strangury and increase the amount of urine, for which powdered nutmeg has been used with success in Germany. Other observers have found it of value in nervous headaches, herpes zoster, alcoholic depression, migraine, and in the pleuritic pains of tuberculous patients. Doses of 2 to 5 grains have been given three times a day.

In the following year, 1891, Ehrlich and Guttman announced that the drug was also a remedy for malarial troubles. They were led to experiment upon this disease from the fact that the plasmodia of malarial disease was readily stained by this body, not only in prepared specimens but also in fresh blood. They used the remedy in two cases of malarial fever—one quotidian, the other tertiary. They found that the drug had a decided curative power over the disease; the periodical attacks ceased within a few days, and at the end of eight days all plasmodia had disappeared from the blood. A dose of 1½ grain was given ten or twelve hours before the expected attack, and repeated every two hours until five doses had been taken. The treatment should be continued for seven or eight days after all malarial symptoms have subsided. Other European observers have reported the results of a trial of this remedy, generally with less beneficial results; its action was uncertain and frequently failed. It, however, produced a cure in many instances with different observers, and proved particularly useful in neuralgic pains of a malarial origin. Laveran experimented with it without obtaining any success. He injected it into the blood of pigeons affected with the hæmatozoön, and although the color was seen in the blood no effect was exercised upon the parasites. He also treated two patients affected with the disease, without influencing the paroxysms or destroying the malarial organism.

Dr. W. S. Thayer, in *Johns Hopkins Hospital Bulletin*, May, 1892, gives a detailed report of seven cases treated by this method. He concludes that—1. Methylene blue has a definite action against malarial fever, accomplishing its end by destroying the specific organism; but it is materially less efficacious than quinine, failing to accomplish its purpose in many cases where quinine acts satisfactorily. 2. Reaction appears to be rapid, the chills disappearing on the temperature, in remittent cases, falling to normal during the first four or five days; but later, however, if a sufficient number of organisms have resisted the drug, they appear to develop again directly under its influence, causing a return of the symptoms. 3. Methylene blue seems to have no advantages over quinine which would warrant its further use.

Methylene blue has also been given in tuberculous conditions. In pulmonary phthisis a dose of 1½ grain was given the first day, increased on the second day to 3 grains, on the third day to 4½ grains, and so on until 24 grains were given in the twenty-four hours. The usual improvement of symptoms is said to follow its use. In tuberculous pharyngitis the powder may be applied to the affected part, and in scrofulous glands of the neck, and for irrigating empyemic cavities a ten per cent. solution has been used. A solution of the same strength has also been recommended in diphtheria.

Beaumont Small.

METHYLOL. This compound is the dimethylate of methylene, $CH_2(OCH_3)_2$. It was first prepared by Malagati, in 1839, and suggested as an anæsthetic. Its use as such has not been adopted on account of its rapid evaporation, and its less agreeable effects than chloroform and ether. It is prepared by distilling a mixture of methylic alcohol, sulphuric acid, and peroxide of manganese; the product is formiate of methyl and methylol. By agitating this with caustic potash the formiate of methyl is destroyed without attacking the methylol. It is a limpid, very mobile liquid, specific gravity, .855, with a burning, aromatic taste. Its odor is penetrating, and recalls that of chloroform and acetic ether. It dissolves in three parts of water, in alcohol, ether, and the fixed and volatile oils. It boils at 107.6° F. and its vapors are not inflammable.

It has recently been introduced as an hypnotic. Its first effect is a transient period of excitement, followed by a deep and quiet sleep. It augments the heart-beats, slightly lowers the blood-pressure, and causes slower and deeper respirations. It leaves no bad after-effects. It is advised in all cases of insomnia and restlessness due to cerebral anæmia or inanition, and is contra-indicated in cerebral hyperæmia. It has been suggested that its hypodermic use is superior to other methods of administration—one and one-half minims in ten minims of water—but this has been found to prove irritating. The dose is from fifteen to thirty minims, which may be increased to one or two drachms; it is very pleasantly combined with syrup of orange-flower and water.

It has been employed extensively as a soporific in mental diseases, and found to be very useful in all conditions, except the commencement of simple mania. A tolerance is established, if its use is persisted in for any length of time, and the dose must be increased or the medicine stopped for a few days. It has also been found of service in the insomnia of delirium tremens. Professor Richardson found it of service in angina pectoris, when combined with amyl nitrite, in the proportion of nine parts to one. It lessens the rapid action of the amyl nitrite and prolongs its effect. It has been found to relieve the spasms of strychnine poisoning; its antidotal action is of no value if large quantities of the poison have been taken, but it is said rather to hasten a fatal termination under this condition.

It is used as a local anæsthetic in the form of an ointment—one part to six of almond-oil in simple cerate.

Beaumont Small.

MICROCIDINE. An antiseptic preparation introduced by Dr. Berlioz, of Grenoble, which is prepared by adding to fused naphthol-beta half its weight of caustic soda, and allowing the mixture to cool. It should contain seventy-five per cent. of naphtholate of soda, the remainder consisting of mixed naphthol and phenol compounds. It is a whitish powder, soluble in three times its weight of water, yielding a brownish solution. It is a powerful antiseptic, very slightly toxic, is not caustic, and does not injure instruments or clothes. It is said to be weaker than sublimate, but is ten times more powerful than phenol, and twenty times more powerful than boric acid. A solution of three parts to the thousand is used as a lotion and to prepare dressings. Under its influence, ulcers and suppurating wounds heal quickly, and disagreeable odors are checked. A solution of the same strength may be used for irrigating the bladder, uterus, and suppurating cavities.

It may be employed as an internal remedy in doses as high as thirty grains a day. It does not produce any irritating effect. The urine is rendered strongly antiputrescent, its action being similar to that of salol, but less irritating to the kidneys. *Beaumont Small.*

MICROSCOPY, CLINICAL. This article is intended to supplement the article "Microscopy, Clinical," by Dr. George Wilkins, Vol. IV., p. 775. As a large number of staining methods, etc., for bacteria are described in the articles "Histological Formulæ, etc.," and "Bacteriological Technology" (in the present volume, pp. 77 and 424), the reader is referred to these for further information.

Microscope and Accessories.—Bacteriology forms so important a factor in clinical medicine that a microscope provided with some sort of sub-stage condenser and homogeneous immersion lens has become indispensable. Wide-angled dry lenses, such as AA and DD Zeiss, on account of their superior illumination, are gradually replacing those with narrower aperture. For clinical work

the expensive apochromatic objectives are not necessary.

With the increasing demand for accuracy of methods, the habitual use of the micrometer, camera lucida, polariscope, microspectroscope, etc., is becoming more general.

A rack-and-pinion coarse adjustment and mechanical stage are very convenient adjuncts in working with high powers. In selecting a mechanical stage, one which can be manipulated by the left hand alone is to be preferred.

Of nose-pieces (revolvers), one with sockets for three lenses should be selected when both bacteriological and anatomical work is to be done, as then some combination of lenses like AA, DD, and $\frac{1}{12}$ Homog. will suffice for all purposes without having to change objectives.

Microphotography has not yet become sufficiently simplified to be of much use in clinical work. It is preferable to have a separate microscope stand, with sliding nose-pieces, constantly set apart for this work alone, and kept always ready for use, as the amount of time required in adjusting and centering the apparatus before a single negative can be taken is greater than that required to photograph a dozen different objects when everything is in readiness.

Light.—None of the substitutes for daylight, so far available, can be considered satisfactory, but the incandescent light, the electric light, the albo-carbon light, or the use of a blue glass screen sufficient to neutralize any excess of yellow rays, renders working with artificial light less fatiguing to the eye.

Reagent Bottles.—The dropping-bottles recently introduced, where a pipette stopper is ground into the bottle and fitted with a rubber cap, cannot be too highly recommended for convenience and cleanliness (Fig. 424).

Fig. 424. Dropping-bottle with Rubber Cap for holding Reagents.

Labels.—Small sheets of gummed paper, which can be cut or torn into any shape or form desired, effect a great saving of time and trouble as compared with ordinary labels.

Forceps.—The blunt-pointed, self-closing, forceps, devised by Cornet, are extremely convenient for working with cover-glass preparations. With these it is impossible to lose track of the smeared side of the cover slip (Fig. 425).

Fig. 425. Cornet's Forceps for Cover-glass Preparations.

Reagents. — *Fixing and Hardening.*—For giving accurate results, two fluids are specially to be recommended: 1.—Alcohol in the strength of ninety to ninety-six per cent., and 2.—Flemming's fluid, made by mixing 4 parts of two per cent. osmic acid solution, 15 parts of one per cent. chromic acid solution, and 1 part glacial acetic acid. This fixes in two to four days, when, after thorough washing in water (five to twenty-four hours with frequent changes), hardening can be completed in alcohol.

Corrosive sublimate in a saturated watery or alcoholic solution also gives good results, but does not penetrate deeply into the tissues.

Pieces of tissue to be treated by Flemming's solution should not be more than one-twelfth of an inch thick. The use of *bichromate* solutions is to be avoided where the structure of nuclei is to be studied, as these become materially altered in solutions like Müller's fluid.

Section Cutting. — Sections may be cut fresh in the freezing microtome, in which case it is best to avoid the use of gum, etc., for embedding. The sections can be received in one-half per cent. salt solution, and either examined unstained or else placed for one to two minutes in Loeffler's methylene blue, washed, and mounted in glycerine. To fix the blood in tissues the specimens should be thrown into boiling water for a few seconds previous to freezing. It is better to keep a small microtome specially for cutting frozen sections than to use the freezing attachments furnished with the sliding microtomes.

For obtaining sections of hardened tissues, a sliding microtome of the Thoma-Jung or Weigert-Schanze model is necessary. Those made by Bausch & Lomb are cheap, and give excellent results.

For sharpening microtome knives the attachment furnished by Jung will be found invaluable to those who (like the writer) have not naturally the gift of sharpening instruments. By having the razor blade mechanically held at a proper angle, no one, however unskilled, can fail to sharpen his knife satisfactorily.

Fig. 426.—Attachment for Microtome Knives, by which the blade is held at a constant angle while stropping. (Jung.)

Under proper conditions, sections of tissue only 10 to 15 μ in thickness should be obtained at each cut. When time is of value, the tissue, after a few hours' hardening in strong alcohol, may be clamped between pieces of hardened amyloid liver or elder pith, or, better still, glued to a cork by *Meyer's glycerine jelly.* This is prepared by mixing 1 part of gelatine, 2 parts of water, and 4 parts of glycerine, over a water-bath till thoroughly dissolved. Take a lump of the jelly as large as a pea, melt it upon the blade of a hot knife, and after transferring to the surface of a cork, press the tissue to be cut into it. As soon as the surface hardens place in absolute alcohol for a few hours. This method is preferable, as a rule, to the use of the freezing microtome, when a few hours' delay is admissible, as fixed tissue stains far better than fresh, and the definition of the nuclei is much sharper.

For delicate tissues, or very thin sections, embedding in paraffine or celloidin should be employed. (See "Histological Formulæ, etc.," Supplement, p. 424, and "Histological Technique," vol. iii., p. 658.)

In *staining* specimens the method of staining each section or series of sections upon the slide has come into very general use. A few drops of the (filtered) dye are poured upon the slide and allowed to remain until under a low power the nuclei can be distinctly seen as deeply colored points. Then, after washing with water, a few drops of absolute alcohol are allowed to remain for a few seconds in contact with the section, and then replaced by a few more. In this way the section becomes dehydrated in less than a minute, and can be clarified by dropping on a little xylol before mounting in xylol-balsam. Should the xylol produce turbidity, it is due to the fact of some moisture being still present, and alcohol must again be dropped on. With complete dehydration after treating with absolute alcohol the section may be rapidly dried with blotting-paper, and xylol-balsam applied at once, omitting the step of clarification. With picro-carmine apply a drop of glycerine without washing the section. By carrying out the staining on the slide itself all unnecessary handling of the specimen is avoided, and time is saved.

With *sections cut in paraffine* it is well to first attach the section, still in paraffine, to the slide (or cover-glass) by smearing on the thinnest possible film of a filtered solution of equal parts of egg-albumin and glycerine, (which may be kept indefinitely in a stoppered bottle by adding a small piece of camphor). On the slide, or cover-glass so prepared, the section is spread out with a soft brush. By heating the slide for a few seconds over a flame or water-bath, till the paraffine is seen to melt, the albumin will be coagulated and the section will adhere firmly to the glass, and can be manipulated with the same ease as cover-glass preparations. Staining can only be accomplished after removing the paraffine by xylol followed by alcohol and water, in the following order: (1) xylol, (2) alcohol, (3) alcohol again, (4) water, (5) stain. Sections cut in celloidin can be fastened to the slide by simply pressing upon them firmly with folded filter-pa-

per. When a series of sections has to be attached in a definite order, a slide should be first coated with a thin layer of collodion and allowed to dry; then the sections, moistened with alcohol, are placed in position and are partly dried with blotting-paper and covered with a second layer of collodion, the section thus lying between two layers of collodion.

A useful method of obtaining very thin (1 to 5 μ) sections from objects embedded in paraffine, is to coat the surface of the block with a layer of thin collodion just before each section is cut. This thin film of collodion will prevent even the thinnest and most brittle sections from falling to pieces.

The methods mentioned above for paraffine and collodion have long been practised in connection with normal histology and embryology, but are only now beginning to be appreciated by pathologists.

Examination of Blood.—The estimation of the percentage of hæmoglobin present is a point which should never be neglected in connection with the microscopic examination of blood. The hæmoglobinometer or hæmometer of von Fleischl has come into very general use, owing to its simplicity as compared with those of Hayem and Malassez. In estimating the amount of hæmoglobin the cell is filled with water, and one of the small capillary pipettes, filled with blood, is mixed with the water on one side of the partition in the cell. The colored glass plate is then moved until when beneath the uncolored half of the cell it gives the same depth of tint

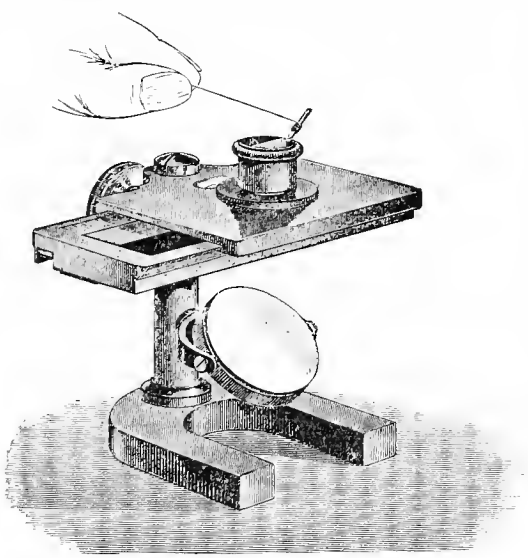

Fig. 427.—Von Fleischl's Hæmometer.

as the diluted blood; the reading on the scale then gives the percentage of hæmoglobin. The light used should be gas or petroleum, not daylight. The instruments usually record a little too high, but are accurate within about ten per cent.

A more exact and scientific method would be to determine the intensity of both the red and the yellow tints separately in the blood, by the use of standard tints (Lovibond's scale), as is done in water analysis, but no apparatus has yet been contrived for this purpose.

Graeber has arranged the following table as giving the diagnostic results of blood examination, but it is looked upon by other observers as being too arbitrary:

Hæmoglobin.	Number of red cells.	Diagnosis.
Reduced.	Reduced.	Simple anæmia.
Reduced.	Normal.	Chlorosis.
Reduced, but increased relatively to number of red cells.	Greatly reduced.	Pernicious anæmia.

Poikilocytosis and occurrence of nucleated red cells is commoner in cytogenic than in secondary anæmias but may occur in all forms of anæmia, leucocytosis, or leukhæmia.

Hæmatokrit.—Daland (*Univ. Med. Magazine*, March, 1892) has described a method of estimating the volume occupied by the corpuscles and deducing their number from this. He employs a centrifugal machine. The blood, diluted with an equal volume of 2.5 per cent. bichromate of potassium solution and thoroughly mixed in a watch-glass, is drawn into a glass tube 35 mm. long and having a calibre of 1 mm. The tube is closed at each end by a rubber cap and rapidly rotated until the mass of corpuscles which collects at the periphery attains a constant volume (with the above solution a constant volume is reached after about ten thousand revolutions, requiring about seventy seconds' time).

The tube is scaled in fifty parts, and therefore to express the volume of corpuscles in percentages, it is necessary to multiply the number shown on the scale by four. The volume per cent. in normal blood is 51.6 for red, and one per cent. for white corpuscles, making the value of each volume per cent. about 100,000 red cells, so that $51 \times 100{,}000 = 5{,}100{,}000$ per cubic millimeter, a number corresponding closely to that obtained by means of the hæmocytometer.

Ehrlich's Method.—A new method of examining blood is that of Ehrlich, based upon the affinity for basic and acid anilin dyes, of certain minute "granulations" found in the colorless corpuscles. The blood must be spread in a very thin film upon cover-glasses, and fixed by heating at a temperature of 120° C. This is best attained by using a flat brass bar placed over a petroleum oil stove, and, when a constant temperature is attained, placing the cover-glasses a little nearer to the flame than the point at which a drop of water is found to boil. To give good results, heating for from one to two hours is necessary. The writer has employed a mercury bath upon which the cover slips are floated, the temperature being controlled by means of a thermometer.

In staining, Ehrlich at first employed a solution composed of aurantia, indulin, and eosin, each 2 grammes; glycerine, 30 grammes; but the stain he now recommends is composed of saturated watery solution of orange, 125.0; concentrated solution of acid fuchsin in twenty per cent. alcohol, 125.0. Mix, and add alcohol, absolute, 75; saturated watery solution of methyl green, 125.0 (*Biondi's reagent*).

As the action of this stain is very variable, and as it is very difficult and tedious to obtain the right proportion of each dye, it is advisable to obtain it ready made, either in powder or solution, from Grübler, of Leipzig, or from his agents, Eimer & Amend, New York.

The staining is complete in from two to five minutes, when the superfluous dye should be washed off, the cover-glass dried with blotting-paper, and the specimen mounted in xylol balsam. In a successful specimen the nuclei are stained greenish, the red corpuscles orange, the eosinophilic granules red, and the neutrophilic granules violet. As the results of the stain are uncertain and depend upon the exact temperature at the time of fixing, it is best to lay several cover-glasses on each side of the line which represents the boiling-point on the heated bar, in which case some of the specimens are sure to turn out well.

Ehrlich has described five forms of granulations found in blood which have each a specific staining reaction. They were named empirically at first as α, β, γ, δ, and ϵ granulations, but the only ones having pathological significance for human blood are:

The α or oxyphilic granulations, which have affinity for acid anilin dyes, such as eosin, acid fuchsin, or picric acid.

The γ or basophilic granulations, analogous with those found in plasma cells (Mastzellen). These stain with basic anilin dyes.

The ϵ or neutrophilic granulations, which stain of an intermediate tint in a mixture containing both acid and basic anilin dyes. This form is the one most abundant in normal human blood.

The β or amphophilic granulations represent an ill-marked form intermediate between α and γ; the δ granulations, a transitional step between γ and ϵ.

In blood the following forms of colorless corpuscles occur:

1. Lymphocytes, 7 to 9 μ in diameter, about the size of red-blood corpuscles, with relatively large nucleus and small surrounding protoplasm. They resemble the white cells of the lymph glands, from which they are probably derived. They contain no granules.

2. Polynuclear leucocytes (neutrophiles), diameter double that of the lymphocytes; somewhat smaller than the mononuclear leucocytes; nuclei irregular in form, curved, S-shaped, or multiple; protoplasm filled with fine neutrophilic granules. Derived from bone-marrow.

3. Mononuclear leucocytes; larger than those last named; nucleus large, round, or oval. No granulations.

4. Eosinophilic leucocytes (eosinophiles); of same size or larger than the polymorphous neutrophilous nucleus; round or polymorphic. Protoplasm filled with coarse eosinophilic granulations. Derived from the bone-marrow.

Normal blood contains the above-mentioned varieties in about the following proportions (Erlich): Lymphocytes, twenty to thirty per cent.; polymorphic or neutrophilic leucocytes, sixty to seventy-five per cent.; mononuclear, six per cent.; eosinophilic, two to four per cent. (From 100 to 1,000 leucocytes should be counted in each case.) In addition, a few transitional forms are seen having a polymorphic nucleus, but with non-granulated protoplasm.

As far as has yet been determined the pathological significance of these cells is that—

1. In simple leucocytosis, or in leucocytosis accompanying the severe secondary anæmias following large losses of blood or other exhausting discharges, the number of white cells is simply increased, both absolutely and relatively to the red, without any marked disturbance in the relative proportions between the different forms of leucocytes.

2. In lymphatic leukhæmia the lymphocytes preponderate.

3. In splenic and splenic-myelogenous leukhæmia, there is no absolute increase of the lymphocytes, whose proportion, relatively to the total white cells, may fall to one or two per cent. Great absolute and relative increase of polynuclear forms. Great absolute but little or no relative increase of the mononuclear and eosinophilic leucocytes.

4. In purely myelogenous leukhæmia, great increase in eosinophile cells.

5. In splenic and myelogenous leukhæmia a special form of mononuclear cell appears, known as the myelocyte. This is larger than the ordinary leucocyte, and is filled with fine neutrophilic granules. It does not possess the power of amœboid movement.

6. In all forms of leukhæmia, and in both primary and secondary anæmias, the red corpuscles may show, besides diminution in number, irregularities in size and form (poikilocytosis = increased plasticity), and nucleated red corpuscles may be present. Erlich's method is admirably adapted for demonstrating nucleated red cells.

7. In slight degrees of splenic myelogenous leukhæmia, and during the remissions which occur during the progress of the disease, the condition may be diagnosed with certainty by (*a*) the relatively small number of lymphocytes, and (*b*) the presence of myelocytes.

There are now some bacteriological grounds for supposing that leukhæmia is an infectious disease due to a specific micro-organism.

When the blood is simply examined in the fresh or unstained condition it should be spread in the thinnest possible layer by using a perfectly flat slide and very thin cover-glass, and examined with a $\frac{1}{12}$ immersion lens. The presence of roulcaux of corpuscles shows that the film of blood is too thick to be of service.

A very good account of the application of Erlich's method is given by Dr. W. S. Thayer,* of Johns Hopkins University.

* Johns Hopkins Hospital Bulletin, 1891, and Boston Medical and Surg. Journal, 1892.

Biondi has introduced a special method for examining blood in sections. He recommends collecting a few drops of blood in 5 c.c. of a two per cent. osmic acid solution. After twenty-four hours the supernatant fluid is withdrawn by a pipette and the sediment embedded in liquefied agar-agar (five per cent.), which, after solidifying in a mould, is hardened in eighty-five per cent. alcohol and cut in the microtome. For staining, Biondi's reagent (see above) is suitable.

Malaria.—For the detection of the plasmodium malariæ Plehn recommends fixation of the cover-glass preparations in absolute alcohol for a few minutes, and staining in concentrated aqueous methylene blue solution, 60 c.c.; one-half per cent. eosin solution in seventy-five per cent. alcohol, 20 c.c.; distilled water, 40 c.c.; add 12 drops twenty per cent. caustic potash solution. The flagellate forms are stated to be stained by this method.

Laveran's method is as follows: The cover-glass is fixed by heating in the usual way, and stained first in a saturated watery solution of eosin, which is then dried off with blotting-paper, and a saturated solution of methylene blue allowed to act for about one-half to one minute. The flagellate forms do not stain well.

By either of the above methods the parasites are stained blue and the blood-cells pink. Care must be taken to avoid mistaking precipitation of the blue pigment in the red cells for the endoglobular parasites.

Some clinicians with large experience in the diagnosis prefer the direct examination of unstained specimens under a $\frac{1}{12}$ immersion lens to the staining methods (Osler, Celli). A striking feature in these unstained specimens is the very pale anæmic condition of those red cells which contain the parasites.

The method of making microscopic observations at body temperature by surrounding the microscope by a water-jacket having a glass front, which has recently become very general in laboratories, is simply a modification of a method in use by Sachs, many years ago (Fig. 428).

Sputum.—*Tubercle Bacilli.*—Of the large number of new methods published in the last few years, probably the most satisfactory is that known as Gabbett's method, by which the decolorizing and counter-staining of the specimen is combined in a single act by the use of a solution of two per cent. methylene blue in twenty-five per cent. sulphuric acid. After staining with Neelsen's carbol fuchsin (fuchsin, 1; alcohol, 10; carbolic acid, 5; water, 100), putting a few drops of staining fluid on the cover-glass and boiling it, by holding directly over a low flame for one-half to two minutes. The cover-glass is dipped in the acid methylene blue for one-half to one minute, washed, and examined. Although it is claimed that this method is practically the same as that of B. Fränkel, who decolorized and counter-stained simultaneously in a mixture of methylene blue, alcohol, and nitric acid, I have found that the Gabbett method invariably gives clean preparations free from granular precipitate, while Fränkel's method does not do so. The contention of Czaplewski, that fluorescin dissolved in alcohol or oil of cloves tended less to decolorize the tubercle bacilli than the treatment by alcohol, has been shown by Nuttall to be erroneous.

Nuttall * has devised an extremely ingenious and accurate method for estimating numerically the number of tubercle bacilli in sputum, but, unfortunately, the details and precautions to be observed are so numerous as to prevent it from being applied for ordinary diagnostic purposes. McFadyean and others recommend, where the bacilli are very scanty, that the film of sputum should be smeared upon a glass slide, instead of a cover-glass, as a larger field for examination is obtained in this way. The writer has found this modification of considerable service.

When only a very few bacilli are present the sputum should be liquefied either by Biedert's method of boiling with soda, or by allowing it simply to putrefy till quite fluid and then examining the sediment.

* Johns Hopkins Hospital Bulletin, 1891.

Heart-failure Cells.—In sputum of persons suffering from heart disease, with red induration of the lungs, E. Wagner has described as heart-failure cells certain large epithelioid cells containing brown hæmatin granules, and whose presence is significant of chronic pulmonary congestion, with dilatation of the capillaries. Recently other writers have made observations showing the diagnostic value of this sign. Although undoubtedly of service in establishing the fact of organic pulmonary change, when they can be found, the general utility of this phenomenon as a means of diagnosis is greatly diminished by the fact that it is impossible in nine-tenths of the cases of chronic heart disease to obtain any sputum at all.

Leprosy.—In cases of genuine leprosy a scraping from a leprous nodule, or a drop of blood from it, is invariably found swarming with enormous numbers of the lepra bacilli, which take the stain characteristic of the tubercle bacillus. There is no danger of confounding this condition with lupus, as in the latter disease the bacilli are extremely scanty or may be entirely absent.

The value of microscopic methods alone in the detection of tetanus, glanders, and diphtheria is limited, as

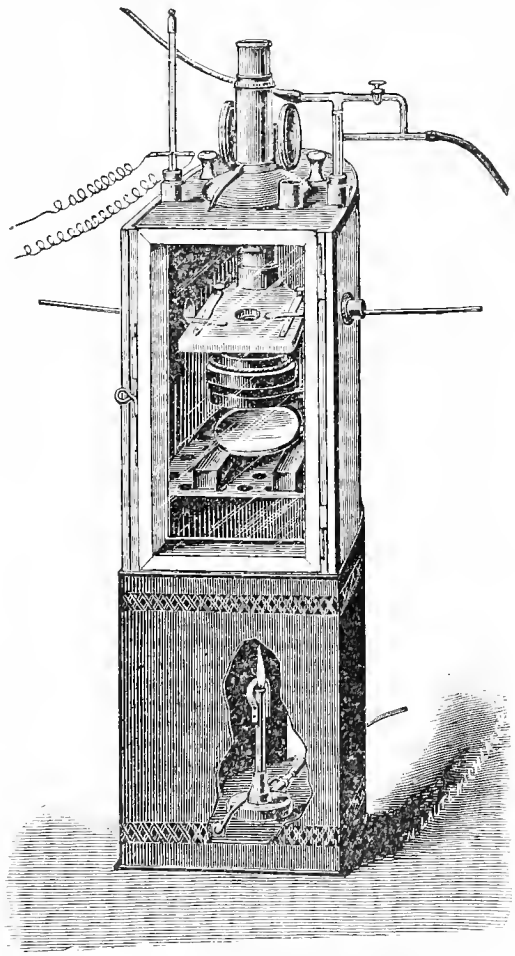

Fig. 428.—New Form of Warm Stage (Lautenschläger's), regulated by means of a thermostat.

the microscopic characters in these are not of themselves sufficiently distinctive to enable the diagnosis to be made with certainty, and culture methods must be employed.

Quite recently peculiar organisms have been described as occurring in typhus by Hlava, and other authors have described monad and coccidia forms in scarlatina, measles, small-pox, and syphilis, but their significance is still uncertain, owing to the want of uniformity in the observations of different independent observers.

Urine.—The recognition of casts, blood, etc., in the urine has been greatly facilitated by the introduction of Litten's centrifugue.

A small test-tube filled with urine is rapidly rotated for

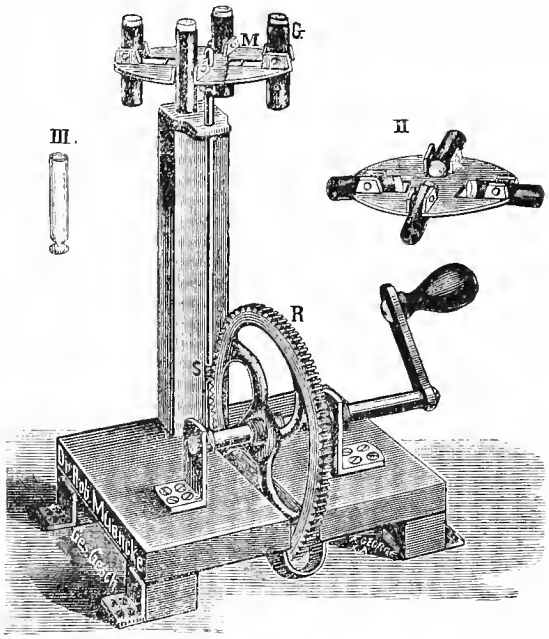

Fig. 429.—Litten's Hand Centrifuge.

about two minutes, at the end of which time the sediment will be found collected at the bottom. Where a deposit is very scanty the sediment of a quantity of urine may be collected by using tubes having a small constriction near the bottom. After rotating, so as to drive the sediment into the bulb at the bottom, the fluid in the upper part of the tube can be poured off, replaced by fresh urine, and again concentrated. The original contention that bacteria could in this way be collected from urine has not been found to be the case.

The recognition of tubercle bacilli in urine can be accomplished by the ordinary fuchsin and staining methods, but is very difficult when a small number only are present.

Fæces.—The recognition of the amœba coli has proved of great service in the diagnosis of tropical dysentery. This organism is found not only in stools, but in abscesses forming in different parts of the body, especially in the liver. Councilman and Lafleur, in a case of severe anæmia, without any intestinal symptoms, found enormous numbers of amœba coli to be present in the stools.

An important medico-legal bearing of the examination of fæces was recently brought out by Austin Flint, who, in a case of murder, where the interest centred on the question as to whether stains found on the clothing and beneath the fingers of the suspected criminal were derived from ordinary fæces or from the contents of the small intestine, proved the latter to be the case, by demonstrating the presence of bilirubin and tyrosin, which are normally found in the small intestine, but become decomposed in their passage through the colon.

The detection of typhoid bacilli in the stools has been found too uncertain and difficult to afford a sure indication of typhoid fever, even where culture methods are employed.

The detection of the cholera spirillum in the stools of acute cases can sometimes be made by the microscope alone, as this organism may be present almost in pure culture in the small, flocculent particles which occur in

the rice-water evacuations; but of course for scientific accuracy the use of culture methods is always necessary.

From the parallel arrangement of the comma bacilli Koch found (Zeitsch. f. Hyg., xiv., p. 319), in his laboratory, that a microscopical diagnosis was possible in fifty per cent. of the cases. In no instance was this shown to be erroneous by the result of the cultures.

Sporozoa in Malignant Tumors.—Besides the organism found in the blood of malaria (see above), lowly organized animal forms were found by Darien associated with Paget's disease of the nipple and molluscum contagiosum. The pathological significance and the precise position which these organisms occupy in the animal kingdom are not yet decided, in the absence of culture methods.

Cancer has been stated to contain sporozoic-like organisms, but their nature and significance are still a matter of dispute. For their detection sections should be prepared from tissues fixed in alcohol or sublimate, and stained with logwood and eosin or by anilin dyes, preferably saffranin. In sections fixed in Flemming's solution good results are obtained by Biondi's reagent.

Examination of Tissues.—*The microscopical diagnosis* of the tissues obtained at operations or autopsies has become an important part of clinical microscopy. In addition to the examination of teased specimens, sections prepared by the freezing microtome form the chief means of diagnosis.

In recognizing parenchymatous degeneration it is important to distinguish it from the granular appearance which is simply the result of post-mortem changes, and, as pointed out by O. Israel, the differential point to be attended to is the fact that the cell elements are swollen (cloudy swelling, but different from that observed as post-mortem change) and increased in size.

Virchow has recently called attention to certain pathological changes which can only be recognized with certainty by the use of the microscope. They are as follows:

1. Diffuse fatty metamorphosis of the interstitial cells in the brain, spinal cord, and nerves.

2. Parenchymatous and fatty metamorphosis of the muscles, heart-fibres, kidney, liver, and the parietal cells of the peptic glands.

3. Fragmentation of the heart muscle. This forms an extremely common and hitherto unrecognized alteration, which directly accounts for sudden death in a large number of cases. It can be best recognized in rather thick sections, either fresh or hardened in Müller's fluid.

4. Ganglion-like swelling of the nerve-fibres. Best recognized by drawing out the nerve-fibrils from their sheath and examining either directly in water, or in glycerine, after fixing in one per cent. osmic acid.

5. Calcification of the ganglion cells. Recognized by the presence of highly refracting, lumpy, angular, or rounded masses, which dissolve in weak mineral acids, with the evolution of gas.

6. Fat embolism of the lungs and kidneys. Recognized either by examination of fresh specimens, which can be prepared by snipping out small portions of the tissues with scissors, or better, by cutting sections of the tissues, after hardening twenty-four hours in Müller's fluid to which one-fourth bulk of osmic acid has been added.

7. White hepatization and red induration of the lungs. Recognized by the filling of the alveoli with small round cells in the first case, and by the presence of brownish hæmatin pigment in the walls of the alveoli in the latter.

8. The early stages of proliferation of the tissues. Recognized by the increase in the number of nuclei, especially the swelling of the endothelial nuclei of capillaries.

9. Slight degrees of amyloid degeneration. Recognized in sections by red reaction with methylene violet, or by a brown stain when iodine solution is employed.

In addition to these microscopical features the examination of tissues, fluids, etc., for bacteria, by both staining and culture methods, is often of very great importance. In many cases of otherwise unexplainable death the fatal issue is caused by septicæmia, due to the presence of one form or another of the septicæmia organisms (occasionally of the bacillus coli communis) in the blood. This auto-infection by bacillus coli is common in the later stages of both acute and chronic exhausting diseases, especially in those affecting the intestinal tract.

Thrombosis.—The presence of thrombi in the capillaries, with or without hyaline degeneration of the vessel walls, is a matter to which, recently, much pathological significance has been attached. The occurrence of the so-called liver-cell thrombi, detected first in the vessels of the brain by Jurgens, afterward in the smaller vessels of the liver by Klebs, is a phenomenon the explanation of which is by no means clear. It has been looked upon as explaining the fatal issue in cases of eclampsia.

Rabies.—Babes has recently stated that a rapid microscopical diagnosis of rabies may be made by cutting sections of the nerve-tissues which have been hardened in alcohol for several hours. The appearances considered by him to be characteristic consist of swelling of the nerve-cells, granular condition of the protoplasm, enlargement of the endothelial cells, and the occurrence of capillary ecchymoses. Although in the hands of an expert accustomed to histological examinations of rabic tissues, these appearances may be sufficiently striking, it is doubtful if the observations of ordinary microscopists, on this head, could be received with confidence. In any case, the inoculation methods should not be omitted, and diagnosis by the microscopic appearances alone should only be resorted to where the material at disposal has been received in spirit. The rapidity of the process, by which the diagnosis is completed in the course of a few hours, is, of course, a great point in its favor compared with the delay and uncertainty of inoculation.

Frozen sections of fresh brain or cord may be fixed by leaving for one hour in pure piridin (Goodall).

In the diagnosis of tumors which have been extirpated a chemical reaction has been described which appears of value. This consists in smearing the tissue with strong nitric acid, which causes connective tissues to swell up and become translucent, while epithelial tissues become an opaque yellowish-white color. As in this way infiltration of carcinoma in muscles, etc., can be definitely established in the course of a few moments without any microscopic examination, the method should be of valuable assistance to surgeons in extirpating cancers. Sarcomata do not show the characteristic reaction.

The diagnosis of decidual remnants in cases of suspected abortion is a matter of considerable importance. The villi of the chorion, when present in their typical branched form, with clump-shaped extremities, are highly characteristic. Sections of suspected tissues may show large, flattened endothelioid cells with distinct round nuclei.

The diagnosis of malignancy of tumors from the microscopic examination of small portions excised, is a matter which should always be undertaken with considerable caution. Although such fragments are usually sent to pathologists for diagnosis, far more valuable results could be obtained if the examination were made by those in charge of the case, as the signification of the microscopic appearances often depends more on the relations of the parts than on their histological type. In cases of suspected squamous carcinoma (epithelioma) it is well to bear in mind that, on the one hand, infiltration of the epithelial cells into the deeper interstitial tissues is not pathognomonic of epithelioma, but also occurs at the margins of lupoid ulcers; and, on the other hand, cases of malignant epithelioma occur, in which, in the early stages, no deep infiltration of epithelium has taken place. Butlin insists that chronic ulcers, occurring about the mouth, in which the surface is covered with squamous epithelium, should be regarded as malignant and treated as such. The writer had the opportunity of examining a case where the tongue was excised for a suspicious ulcer in a very early stage, and where, out of some hundreds of sections from all parts of the growth, none showed deep infiltration of the epithelium, though

the patient subsequently died from secondary epithelioma commencing in the submaxillary gland. Klebs insists upon the diagnostic importance of dilated lymphatic spaces in the submucosa beneath the epithelial layer for the diagnosis of cancer of the larynx.

Cornil is less inclined to place reliance, in the case of specimens obtained for diagnosis from suspicious erosions of the uterus, upon the relation of the epithelial tissue to the deeper parts than upon absence of the basement membrane, which he considers to be highly characteristic of carcinoma. In order to place reliance upon the absence of the basement membrane or the arrangement of the cells, however, it is necessary that the portions of tissue should be placed, immediately after removal, in strong alcohol and well hardened before cutting, as a delay of a few hours will so alter the appearance as to make an accurate diagnosis impossible.

The study of the cellular changes, especially the mitotic appearances of tumors, though of great interest, does not afford any reliable information as to the malignancy or otherwise of the tumor; possibly in the future, by great care in the employment of proper methods of fixation, our knowledge of the microscopic appearances of cells may become more extended.

Literature.—Out of a large number of works on medical microscopy which have recently appeared, the older standard works of Peyer, Friedländer (edited by Eberth), and Bizzozero still hold their place. Von Jaksch, "Klinische Diagnostik;" Klemperer, "Grundriss der Klinischen Diagnostik;" v. Kahlden, "Technik der Histologischen Untersuchungen," and Ranvier, "Technique d'Histologie," may be mentioned as among the best productions of the recent literature on the subject. Behrens, "Hilfstabellen für Mikroskopische Arbeiten," and the latest edition of the "Microtomist's Vade-Mecum," contain valuable recipes, embracing all the common formulæ. For details of the bacteriological methods, special works upon the subject should be consulted. On the subject of the blood, besides the imposing monograph of Hayem, which contains over one thousand pages, shorter monographs have been written by Graeber and von Limbeck. The publications of Erlich, especially the collection of reprints entitled "Farben-analitische Untersuchungen zur Histologie und Klinik des Blutes," presents, in a compact form, a good deal of information upon its author's peculiar methods, which was formerly very widely scattered. Unfortunately this work is not yet completed. Most of the important literature upon medical microscopy, however, still lies scattered through the medical and microscopical periodical literature.

Wyatt Johnston.

MILITARY HYGIENE. The principles of military hygiene have undergone no change during the last six years, but there have been some modifications of its application to United States troops which deserve notice here and consideration by those who may be intrusted with the care of State troops and of armies yet to be raised. Some points omitted in the original paper may also be stated.

Clothing.—*Duck.*—The issue of white cotton-duck sack-coats, trousers, and overalls is now authorized as uniform in extreme Southern latitudes in summer, at the discretion of department commanders. The anticipated theoretical objections to the use of cotton do not seem to have been realized, and the increased comfort to the men by the relief from the oppressive woollen is a sanitary advantage. But light mixed woollen and cotton underwear should accompany cotton uniform. The effort to have authorized a dust-colored uniform, one-third wool and two-thirds cotton, should be encouraged for those regions where long-continued high temperature enervates.

Collars.—Among the disadvantages of tight collars, sometimes worn in uniform, is the very serious military one of affecting the vision through disturbance of the cerebral circulation. This is not apt to occur frequently, but it should be guarded against as a possibility.

Leggings of brown canvas duck, to be worn on the march or in campaign, are now required for all foot troops. Their utility in a prolonged campaign is yet unproved. The disadvantages are those of extra pieces of clothing to be looked after, a slightly additional weight, and, particularly, difficulty of adjustment, especially when most required, in wet and mud. When tight enough to remain in place, they are liable to be too tight and to cause the feet and ankles to swell. Cotton and light canvas wrinkle into bands, and light leather becomes harsh after wetting.

Boots.—All mounted troops spend more time on foot than in the saddle, and in this country cavalry will doubtless, as heretofore, continue to fight much dismounted—to be veritable dragoons. The cavalry boot is only suitable for the horseman when mounted, for it is apt to chafe in walking. The comfort and efficiency of the cavalry would be increased by substituting for the boot a shoe, with a heavy detachable leg and stiff brace, to be worn only when mounted.

Barrack Shoes.—Shoes with canvas uppers are now issued for barrack use. They are much lighter and more comfortable for this purpose than the marching shoe.

Carriage of Weights.—As set forth in Vol. III., the transportation upon his person of the clothing and accessories necessary for the independence of the modern soldier in the field has only been accomplished with great personal discomfort and fatigue, and by the expenditure of so much vital force as seriously diminishes his effective strength. An equipment devised by Colonel Merriam, Seventh Infantry, practically solves the problem. By it rations, underclothing, extra ammunition, and blanket can be conveniently carried by one piece of equipage, without constriction of the chest or of the arm-pits. The weight is supported by the hips, with some assistance from the collar-bones, and there is practically no pressure upon the back, and absolutely none upon the breast. Numerous actual trials have demonstrated its efficiency, and there can be no question as to the practical value of this device, and its great superiority over the official blanket-bag. But it has not yet been formally adopted, and experimental issues continue to be made.

A very recent device of Lieutenant Dodge, Twenty-fourth Infantry, to support the blanket-roll, havresack, and canteen, is a flexible wooden strip to which the roll is lashed. It passes over the shoulder and rests against the opposite side, as the blanket would. The presumed advantage of this wooden support or yoke is that it very slightly interferes with motion, and that its elasticity takes all pressure from the chest and back. Where the curve passes over the collar-bone, a leather strap, like that used on a crutch-head, takes off the rigid bearing. How far it will comply with the conditions of active service is yet undetermined. Trial samples are to be issued.

Food.—The unwritten custom of the service that served three meals a day in garrison, is now formally recognized in the regulations. The Quartermaster's Department now supplies certain cooking utensils and table furniture, thus relieving for food money formerly diverted from the company fund. A greater improvement has been the abolition of the post fund (Vol. III., p. 755), and the direct division of the profits of the bakery between the various companies, in proportion to the number of flour rations turned into the bakery by each. This releases the ration from an indirect tax for articles other than food.

Bread.—The standard ration of bread remains at eighteen ounces, where fresh vegetables can readily be obtained. But it may be increased to twenty-two ounces by post commanders, on the recommendation of councils of administration.

Fresh Vegetables.—A recent law adds one pound of vegetables to the ration, an allowance ample for all sanitary requirements. This may be issued as 100 per cent. fresh potatoes; or, 80 per cent. fresh potatoes and 20 per cent. fresh onions; or, 70 per cent. fresh potatoes and 30 per cent. canned tomatoes or other vegetables. No savings from these are purchased by the Subsistence Department. Partly on account of their bulk, and partly from their perishable nature, there will be great difficulty

in the actual issue in campaign or under adverse climatic conditions; that is to say, just when most needed will be the greatest risk of failure. But the recognition of their importance and the attempt to supply them constitute a sanitary advance. In receiving canned tomatoes it is to be remembered that the contents of the so-called two- and three-pound cans fall short of their nominal weight.

Vegetables shrink about ten per cent. in cooking, exclusive of waste.

Cheese.—Cheese is no longer supplied as an alternative part of the travel ration. It is, nevertheless, recommended as an occasional addition by purchase to the mess table.

Beef.—The beef ration is estimated as the raw issue. There is a waste of 5 per cent. in cutting up the carcass, and a shrinkage of about 25 per cent. in cooking. Beef should be killed twenty-four to thirty-six hours before issue in temperate, and eight to ten hours in hot climates.

Bad and Diseased Meat.—Decomposing meat should not be eaten, although some abnormal palates and educated digestive organs regard it as a delicacy. Diseased animals ordinarily should be condemned as food, but such emergency issues may be made in the prolonged absence of other meat. Cattle dead of the rinderpest and horses dead of glanders have repeatedly been eaten with impunity. But it is essential that such meat be thoroughly cooked, and it is much safer that all the blood be drained. Tuberculous meat and milk may affect the consumer; but it is probable that actinomycosis, a less communicable disease, is often mistaken for the former. Animals with malignant pustule are always dangerous, and their carcasses should be burned, not buried. Beef and pork may communicate tape-worm, and pork, trichina, when imperfectly cooked. Thorough cooking of all doubtful meat is very necessary. Sausages and meat-pies sometimes become toxic from the development of a substance not yet isolated; and hash prepared over night in warm weather, and stale mixed dishes, are liable to induce intestinal disorders.

Baking and Cooking.—*To Bake Bread.*—In the field, portable ovens will probably be used for large commands, but baking will generally be done by company cooks for brigades or less. Flour grown on soil deficient in lime may make bread that, after rising well, becomes heavy and sour on cooling. The use of strong lime-water in making-up such dough corrects this defect. Of the various methods of baking in the field, the simplest is to fill a small hole in the ground with a wood fire, and when this has thoroughly burned out to place therein, on a stone, a mixture of flour, salt, and water, covered with a tin plate and surrounded by hot ashes. Unless the heat is kept below 212° F. the bread will be tough. Or, two mess-pans may be taken and the rim of one be cut down all round, so as to leave a jagged border. Fill the cut pan two-thirds with dough, and invert over it the perfect pan. Place both in a hole eighteen inches deep, where a wood fire has burned several hours and from which all the embers except two or three inches have been removed. Cover them with hot ashes and with earth, and leave them five or six hours. The rough edges of the cut-pan allow the gases to escape.

To Cook Meat.—For boiling, the piece should be as large as possible and be plunged in boiling water, to remain five or ten minutes. This coagulates the albumin in the outer layers and thus retains the inner juices. As at above 170° F. the meat would become hard and indigestible, the temperature of the water should be reduced to 160° F., and the meat should remain in it fifteen minutes for every pound of its own weight. Baking, which is not roasting, as it is ordinarily called, is treating meat exactly similarly to boiling, and for the same reasons, except that a dry heat is used. In frying, so called, the slowly heated fat exudes acids, generally injurious, that envelop the particles of meat with an indigestible coating. Stewing, properly conducted, is admirable. Small pieces of meat should be kept for about two hours in a little water at not far from 134° F. This partly extracts the juices, keeps the albumin semifluid, and enriches the accompanying liquid which must be served with the meat. Stewing is the exact opposite of boiling or baking, both in theory and practice. For cooking or baking in the field, the Buzzacott field-oven is well adapted for company use.

Habitation Sites.—Soils to be avoided are those that hold moisture. Granite and the metamorphic rocks are usually healthy. So are clay slates, but drinking-water will be scarce. Deep gravels, unless dominated by adjacent ground, are always healthy; and gravel hillocks are the best of all sites. Sand, when pure and deep, is healthy, but such a site soon becomes charged with refuse, which passes through it laterally as well as perpendicularly. Water is sometimes held by clay under dry sand and becomes hurtful. Clay and alluvium are generally suspicious from the contained moisture, but well-cultivated soils, rice-fields excepted, are desirable.

Topographical Sites.—Enclosed valleys, ravines, or the months of ravines, any ill-drained grounds, the neighborhood and especially the lee of marshes, the northern side of mountains or high hills, and in warm latitudes the northern banks of rivers, are to be avoided.

Vegetation in Relation to Sites.—Close-lying grass, kept well trimmed, is always healthy. Rank vegetation should be cut in the heat of the day and be burned before decay; but the soil should not be disturbed, nor heavy brush near a marsh. Belts of trees and tall shrubs are a barrier against malaria, but decaying vegetation is harmful. The eucalyptus by its evaporating power antagonizes the production of malaria in frostless climates, and the sunflower guards against it in others. Trees break cold winds in cold climates, and cool the ground in hot climates; they are hurtful only when they cut off the light and air from a domicile, making it dark and damp.

Quarters.—Ordinary houses when used as quarters may be estimated to accommodate, in rooms fifteen feet wide, one man to the yard in length; in those between fifteen and twenty-five feet in width, two men; in those more than twenty-five feet wide, three to the linear yard.

Marches.—The latest drill regulations abandon "common" time, and require the "double" step to be 36 inches instead of 35 inches. Unless otherwise directed, all movements are in "quick" time, at the rate of 120 steps, 30 inches in length, a minute.

Water-Supply for Military Purposes.—In the field, on halting for camp, the water-supply should be immediately protected against waste, against pollution, and against the turbidity that follows trampling the margin into mud. The less the supply the greater the care, and an officer should be in charge when the quantity of water is disproportionately small. In the case of a small spring the supply will be increased by digging it out and sinking a barrel or other casing. In a shallow stream immediately create a small reservoir for drinking by a temporary dam, with one lower down for the horses and one still lower for washing. When the camp is permanent and the supply relatively small, preserve the water that flows by night in reservoirs, conduct the overflow into a succession of half-barrels, all connected by little gutters to avoid waste, for the horses, and detain the surplus in a still lower reservoir. Horses drink better and more rapidly when the water is five or six inches deep, each horse taking about a gallon and a half at a time and requiring three minutes for drinking. If allowed all they will drink they consume six to eight gallons a day, according to season and work, and about three gallons a head is needed for grooming and police. On the march a man requires for drinking and cooking six to eight pints a day, according to climate, and an equal amount for washing the person. In barracks the allowance should be ten gallons a head for all purposes except water-closets and baths; with these, twenty-five gallons. The foregoing are minima figures, requiring to be increased in hospitals by several times as much, depending on the character of the cases.

Ice.—The sources of domestic ice-supply for military posts, as for other settlements, should be carefully se-

lected and guarded; for water by no means parts with all its impurities in freezing.

For the special discussion of sewers and the disposal of waste water-supply, disinfection, the avoidance of disease in permanent posts, and similar subjects that affect civil as well as military life, reference must be made to the papers devoted to them. But it is always to be borne in mind, and to be impressed upon commanding and other officers, that deodorants are not necessarily disinfectants, or that to replace one bad smell by another rarely antagonizes the poison that may sap health. Especially are those in control to be taught that polluted water is practically without remedy—that the only safety is in keeping the water-supply inviolate.

Alfred A. Woodhull.

MILITARY NURSING.—In military practice the nursing of the sick is placed in the hands of privates of the hospital corps. These soldiers are either transferred to the hospital corps after one year's service in the line, or they may be enlisted from civil life and instructed for a short period in one of the two schools of the hospital corps before being sent to the various army hospitals for duty. By these methods there is secured for nurses a body of men who have been disciplined by a military training, and who are thus supposed to be fully alive to the necessity of subordination to authority and implicit obedience to orders.

These soldiers when received into the hospital corps are entirely ignorant of the duties of a nurse, and they must be instructed by lectures, demonstrations, and actual experience in the ward. This combination of military instruction and training school for nurses results in methods of nursing somewhat different from those found in civil life. In the theoretical rules for nurses in time of peace there can be no difference in civil and military practices, but it is more in the details that changes arise. Many of these changes are due to the peculiarities of military life, as, for instance, the necessity of having the nurses under complete control in case of active service in war, or in time of epidemics. In such times service must be compulsory, for it is not practicable to depend on nurses volunteering in the cause of humanity, as would be the case in civil life. This article will not deal therefore with things common to the two, but will be confined to pointing out the differences, where such may be supposed to exist. The matters to be discussed will be presented under the following headings: 1, The Nurses; 2, The Management of the Ward; 3, The Management of the Patient; 4, Nursing in the Field.

1. The Nurses.

Qualifications.—Before a man can be transferred to the hospital corps he must have the following qualifications: He must have served at least one year in the line, must desire the transfer, must be unmarried, under forty years of age unless he is a good cook or nurse, must be in good physical condition, of good habits, and possess a good character; be able to read and write, have good general intelligence, and an aptitude for his duties, and must give assurance that he intends to serve out his full five years of service, and not seek his discharge beforehand, in any of the numerous ways now available.

The pay of the private of the hospital corps is eighteen dollars per month, which is five dollars higher than that of a private in the line, and his money allowance of clothing is that of a corporal. This inducement of slightly increased pay and allowances should be the means of getting a very good class of nurses, particularly as the above restrictions are thrown around the matter of transfer in order to exclude undesirable men. The constant instruction that these men receive is slowly but surely building up a good class of nurses, notwithstanding the frequent changes by discharge and re-enlistment. Should all the plans in this direction prove successful, the United States soldier, when sick, should receive the constant supervision of trained nurses whose efficiency should be excelled by none in civil life.

The military nurse is a soldier, and as such is subject to all the rigid discipline of military life. This has its advantages as well as its decided disadvantages. Such discipline enables the surgeon to exact the most punctilious attention to the details of nursing and the execution of orders, under penalty of court-martial for neglects and disobediences. Every physician knows how advantageous this is in certain critical cases where he is desirous of having his plans carried out to the letter. In such cases where the faithfulness of the attendants is not above suspicion, the physician's anxiety is far greater than it should be. If the nurse can be depended upon, there is no doubt that lives are often saved where it is a matter of good nursing.

There is a bad side to the discipline which exacts an implicit obedience to orders. The private soldier is usually under someone's orders, and has all his thinking done for him. This course of life undoubtedly weakens his independence of thought and action in emergencies. He is too apt to be on the lookout for orders, and unless some are forthcoming he may be entirely at sea. Modern methods of military instruction are trying to overcome this by teaching each soldier his individual importance in battle. On the same plan, the instruction in nursing aims partly to undo the results of the discipline that turned the man into a machine. The nurse is taught to observe his patients closely, watch for unfavorable signs, think for himself, make frequent reports to superiors, and to prepare the way for changes of treatment his teaching tells him have been made necessary by the change of symptoms.

In civil hospitals when a nurse proves himself to be unfitted for his duties by reason of inappropriate temperament, viciousness, or incorrigible stupidity, he can be unceremoniously discharged, but not so in military life. Courts-martial are extremely conservative, fight shy of all innovations, and not being composed of medical officers they are difficult to convince in the matter of the offences of nurses. The disadvantage of military custom in this respect cannot be avoided and must be tolerated. Thus it happens that not infrequently improper nurses are retained when their absence from the hospital would be more desirable than their presence in it.

The military nurse has the same kinds of difficult, fatiguing, and disagreeable duties as in civil hospitals, and must possess the necessary qualifications of good health, patience, forbearance, kindness, and great self-control. Truthfulness, honesty, habits of punctuality and order, and the ability to work according to a system and not hap-hazard, are also important, as well as the ability to keep secret his confidential knowledge of the patient's private affairs. Many of these qualifications are brought out and strengthened, if not generated, by the military training which every military nurse receives before his transfer to the hospital corps.

Not every man has the temperament necessary for a good military nurse. Nervous and excitable men are entirely unfitted for such work in any hospital, either civil or military, because they worry and excite the patients by their manner, and they may do irreparable mischief. The sanguine, hopeful man is unfitted for military nursing because he is too apt to be depressed by misfortunes, rebuffs, thoughtless and unjust reprimands from immediate superiors, and the thousand and one annoyances inseparable from military life. He so loses heart under adversity that he will neglect highly important duties while suffering from these annoyances. The man of phlegmatic tendency, whose sensibilities are not too acute, and who is hard to excite, comes nearer to the ideal nurse than the others. He is not especially annoyed by the most exasperating circumstances, and is cool and collected in times of excitement.

In military practice the surgeon is often unable to obtain professional assistance of other surgeons. It is absolutely necessary for him to have skilled assistants in operations that are not only exceedingly difficult, but made far worse by the adverse surroundings of military life. The nurse must be relied upon, and for this reason the lectures and other instruction to the hospital

corps must go much further into the details of the theory and practice of medicine and surgery than is usually deemed necessary to qualify nurses for work in civil life.

Though military custom steps in to prevent any marked confidences between surgeons and nurses, and though there is an official barrier between the two that cannot be broken down, yet it is true that the surgeon must be brought much closer in contact with the men under his orders than is the case in the line. This close relationship comes from the necessity of the surgeon receiving from the nurse confidential reports of the patients, their actions, symptoms, and conversation. Soldiers are very apt to malinger for the purpose of escaping duty or of obtaining discharge from the service and subsequent pension. Of course they will hide everything they can from the surgeon; but the nurse, from his intimate association with the patients, learns the true state of affairs, and is often depended upon for true reports. The surgeon must know the truth in these matters, for upon his report depends in great part the action taken in each case, as to compelling the malingerer to do his full duty. In other cases false reports may have been the cause of such action on the surgeon's part as will result in great injustice to a worthy soldier. It will be impossible for the surgeon to be informed, unless he can induce the nurse to feel that there is a confidential relation between them that is necessary for the proper performance of duty. The nurse must therefore be sufficiently intelligent to be able to hold such relations without detriment to himself, the surgeon, or the United States service.

From all that has been said it can easily be understood why so much is expected from a military nurse, and why such great efforts are made to obtain a desirable class of men. The pay and allowances, including board, clothing, lodging, free medical attendance and medicines, are the equivalent of about $55 to $60 per month to a city laborer in civil life. This is not small pay when it is considered that the Government has taught the man his trade whereby he earns this amount. Nevertheless the actual money allowance, $18, is not great enough to attract that high class of men which the foregoing shows would be the ideal army nurse.

Duties.—The nurse in charge of the ward of a military hospital in peace times has numerous duties to perform, some of which are purely military, while others are police duties requiring him to keep the ward and everything connected with it in a cleanly and orderly condition. These duties are exactly the same as those of soldiers of the line as far as the barracks are concerned, and the nurse is supposed to go about these duties without special instruction. Beyond his military duties as a soldier, and his combined duties as a room orderly and in charge of the ward, there are his more important duties relating to his care and treatment of the patients. These duties as a nurse are the most responsible, and therefore the most important ones he has to perform while on hospital duty. In the field, and occasionally in the hospital, he may have the important duty of rendering first aid to the sick and wounded in emergencies during the absence of steward or surgeon. The necessity of having efficient men who can perform these two duties of nursing and giving first aid, is one of the most important reasons for the establishment of the hospital corps. It is just as important for the wounded soldier to be attended by trained nurses as it is for wounded civilians, and the army, in this respect, is following directly in the path of civilian practitioners, who have long ago found out the necessity of having elaborate training schools for the special instruction of nurses.

Instruction.—A system for the higher theoretical instruction of army nurses has not yet been completed, as sufficient time has not yet elapsed to see how much can be done in the short period of service. The nurses are apt to leave the service at expiration of the period of enlistment and not return. If two or even three years of constant instruction are requisite to make a thoroughly competent trained nurse, it is evident that as soon as the army nurse becomes proficient his services are lost. Nevertheless much good work can be done, and there is no reason why the military nurses should not in time become as proficient as any others.

The instruction is by lectures on elementary anatomy, physiology, the rules of hygiene, and such knowledge of medicine and surgery as will enable the nurse to perform efficient emergency or first aid service. Then there are series of lectures on such topics as the observation of symptoms, thermometry, temperature charts, pulse, administration of medicines, counter-irritants, disinfectants, preparations for surgical operations, the giving of anæsthetics, instructions in special diseases, and indeed the large number of topics usually found in the manuals for the theoretical instruction of nurses. In times of peace it is not possible to give nurses the varied practical experience that is desirable, but it is found that they learn quickly and remember fairly well the methods used in each case attended. Every opportunity is seized to impress upon them any practical points in nursing each case, and many medical and surgical cases serve as material for clinical instruction to the whole detachment of the hospital corps present.

The military nurse is not expected to be expert in methods of massage, of giving inunctions, fumigations, electrical applications, baths, and kindred special subjects, although they may be included in a general way in the system of instruction. The cases requiring such special treatment are too rare to give sufficient practical experience. When a case does occur, special instructions must be given to the nurse in charge of the case.

He is taught the importance of his duties by explanations of cases in which it is not so much the medical treatment as it is the careful attention to the patient's wants, and efficient nursing, that carries the patient through his illness. It is also sought to impress on him the high professional attainments he is expected to acquire, if he is to be depended on to assist the surgeon in different operations in certain circumstances already mentioned.

There is a threadbare proverb, which is repeated with nauseating frequency by military men, "In times of peace prepare for war," and to no one is this any more applicable than to the military nurse. In peace he has ordinary routine cases, with but little to do, but he may be aroused from this with startling suddenness. An Indian war may arise, and he find himself loaded with work, with far more patients to look after than he ever imagined, and it is necessary, therefore, to have his work so well systematized that he can do the greatest good to his sick and wounded charges. The system that is aimed at in the above instruction should be so designed as to be applicable to the sudden emergencies when each hospital is loaded down with wounded.

Women are more careful and tender in their attentions to the sick, and on that account are said to make better nurses than men. On account of woman's instinctive tact, which is the knowledge of what to do for the sick and how to do it, there is not so much written or said on this part of the subject of nursing as might be. It is all left to her instincts. Now, female nurses cannot be obtained for army hospitals, and indeed in small hospitals where all kinds of cases are put in one ward, the presence of women would be undesirable, and perhaps quite indelicate. The army nurses must, therefore, be men, and not being possessed of those instincts of gentleness and sympathy with sufferers that go so far to make the sick well, or rather hasten their recovery, they must try to make up for their deficiencies by careful attention to all the little details of nursing that come so naturally to women, and which, taken all together, go to make up what is called a good nurse. In times of war, where large numbers of sick and wounded are collected into immense hospitals, there can be a separation of cases, and in the majority of wards women can be admitted to perform all those necessary attentions to the sick, leaving the male nurses in charge of the wards free to devote their time and energies to the general management of the cases and the performance of those duties that the women cannot do. In times of peace and in small hospitals the privates of the hospital corps must

learn to do all. The instruction of the army nurse must therefore include such matters, pointing out as well as a man can, the humane thoughts and feelings which prompt women to do those things which are so grateful to the sick.

In peace or war the army hospitals do not fall into that serious error sometimes seen in civil hospitals, of placing women nurses in complete charge of men's surgical wards. This error comes from the natural swing of the pendulum of public opinion, for when the training of women nurses became popularized, nothing would do but that the women should take full charge, even of cases that their modesty and sense of decency forbid them to touch, which they could not attend to, and which were therefore neglected, often to the serious detriment of the patient. Men must be in charge of men's wards, let the women assistants be around as thick as bees if they want to. To depend on refined women to uncover men and inspect dressing of the groin for instance, to see that everything is undisturbed, is entirely out of the question.

Personal Appearance.—A nurse should always be neat and clean in appearance. It would seem unnecessary to call a soldier's attention to this fact, yet it is unfortunately true that occasionally a nurse has to be warned that his personal appearance is enough to make a well man sick, and a sick man worse. If the nurse is clean and neat he certainly has an effect for good upon the patients he attends. If his hands are dirty, and his clothing dirty or disorderly, and in this condition he hands patients their food, or in bad cases feeds them, they are apt to be nauseated by the presence of so much dirt near their food, and thus recovery may be interfered with.

In hospitals where there are many patients in one ward, one nurse cannot do all the work, and therefore scrubbers and helpers do all the cleaning up and the heavy work generally, leaving the nurses who come closest in contact with the patients freer to keep themselves as clean as possible. In small military hospitals the nurse in charge of the ward must do all the work, and he must, therefore, exert special care to keep himself clean. After doing any work that would soil his hands, he should hasten to clean them, even if he do this dozens of times each day. By carefully arranging his work a nurse may manage to do at one time most of his dirty work of cleaning up the ward, and thus save himself much unnecessary trouble. In such small hospitals where one man does all the work of a ward, it is found by experience that his hands and finger-nails are not in the condition that makes perfectly aseptic surgery possible, if he is to handle instruments and dressings. This state of affairs gives considerable worry to the surgeon who is compelled to exert himself to avoid even the slightest possibility of wound infection, and he is further compelled to attend to many details which in civil hospitals are looked after by the nurses.

The habits of cleanliness which are instilled into soldiers as a duty come to the nurses' aid as far as personal cleanliness is concerned, and make it easier for them to comprehend the instructions as to the precautions to be observed to prevent infecting themselves or other patients. Nurses are taught to keep and use a tooth-brush, and keep the mouth in as clean a condition as possible. Beards are not worn, as they certainly increase the dangers of infection.

As a means of furthering personal cleanliness and neatness, nothing is better than a white jacket, with or without a white apron extending from the waist to the knees. These always look neat, and as soon as soiled can be cleaned. When clothed in them the nurse is carrying around with him a far less number of disease-germs than if he has on his military blouse that he has been wearing in the ward for several months. A dirty old blouse is a danger in any ward, and it would be far better for each nurse to have white clothing that can be washed as soon as soiled.

Care of Nurse's Health.—Everyone knows that a strong healthy man is far less liable to contract diseases than one who is weak and run down in health from any cause. It is therefore important for nurses to keep themselves in as perfect a condition of health as possible. Particular care is necessary in the case of nurses who in times of epidemics are apt to be closely confined and much overworked. People who are called upon to nurse near relatives who are prostrated by illness usually make a very great mistake by supposing that they are doing the greatest good by giving unremitting attention to the patient's condition and none to their own. They usually break down, and then there are two patients to be taken care of instead of one. The nurse can do the greatest good to his patients by attending to his own health. In a general way it may be said that he should avoid all excesses, either of eating, drinking, exercise, or anything else; he should cultivate the most regular hours and try to get a half hour or hour's exercise in the fresh air every day. The last direction is of great importance, for although the ventilation of wards is made as complete as possible, it can never be made perfect, and the inmates are sure to breathe air that is impure to at least a slight extent.

A drunken spree so lowers a man's vitality that he is extremely liable to contract the diseases with which he comes in contact. This lowered vitality and the exposure to cold during the drunkenness fully explain the great prevalence of pneumonia among drunkards, and its mortality. From a medical standpoint it cannot be said that a very small amount of alcohol does any particular harm to a man in ordinary employment, but for a nurse, whose health should be perfect without any stimulants, it can be truly said that a small amount, usually called "moderate drinking," is very apt to do him harm, and on the score of his health alone he should be a total abstainer. If he attends cases of a contagious disease, his total abstinence may be his salvation by aiding him to escape infection. Of course this refers to his conduct when off duty. When on duty, even the slightest drinking can never be tolerated. But on or off duty there are various other reasons that make it impossible to tolerate drinking in a nurse. If but slightly under the influence of liquor he is too dangerous to have near the sick, for he is liable to make very serious mistakes. If he is addicted to drink, no liquors can be placed in his care, and he is useless from this point alone. It is therefore a rule in civil or military hospitals to discharge as soon as possible any nurse who is found to have been drinking while on duty. If he gets drunk while off duty, he is too undesirable to be re-enlisted.

Sleeping Rooms.—In civil hospitals it is a recognized principle that the nurse should not be compelled to spend all his time in the sick-room. He must have hours out of doors, and, most of all, he must have an entirely separate sleeping apartment. Perfect health is supposed to be incompatible with any other arrangements. Upon this principle it is now the rule to have in military hospitals a dormitory or barrack-room to be used by the members of the hospital corps. The small number of patients that require attention at night does not necessitate the detailing of a night nurse. Consequently it has become the usual custom for the day nurse to sleep in the ward, an objectionable custom that can scarcely be obviated with the present arrangements.

2. Management of the Ward.

Quiet.—One of the strictest rules for the management of a ward is that referring to quietness and order. No boisterous conduct, loud talking, or disorder of any kind is allowed under any circumstances. This is essential for sick men, who usually require perfect quiet and rest. Now the first step toward accomplishing this must be taken by the nurse. He should never talk in a loud tone of voice, nor should he be noisy in any of his actions. One of the rules in training-schools for nurses is that forbidding the use of starch in their clothing, in order that they may move around quietly without making a noise that would disturb the patients. Another rule governs the kind of shoes, which must be of such soft material that squeaking noises will not be heard. Now male nurses should remember these two rules, although that

referring to starch in the clothing is not applicable to them. As far as the shoes are concerned, there should be no trouble in military hospitals, where slippers are supplied for the purpose. When on duty the nurse should use the regulation leather slippers. These permit him to move around at his work without the least noise or disturbance that could annoy the most irritable patient he may have. In everything he does, whether cleaning up the ward, sweeping, moving bunks, administering medicines, or giving directions to patients, he should keep constantly in mind the utmost necessity for order, quiet, and the general peacefulness of the ward.

Visits of Friends.—When people are very sick they are excessively annoyed by the visits of friends, who are well meaning and make their visits under the impression that they are doing good. If the surgeon orders that no one is to be admitted to the sick-room, the nurse understands that such an order is given to protect the patient's life, and that the order must be carried out to the letter. Should an intruder force his way into the ward, and by his presence endanger the lives of patients, by making them worse, he should be ejected by force, if he does not leave when ordered. The nurse is there to protect his patients and preserve absolute quiet and order, and he must do it if he has to exert force. Of course this responsibility is great, and he must never think of using force until he has exhausted other means, and even then he must think whether or not the disturbance would be increased by any forcible means used to stop it. In all cases where it is practicable he should not depend on his own judgment but report the matter without delay. During convalescence the visits of friends may be looked at in an entirely different light. At this time a short visit may be very acceptable, as it introduces a pleasant change into a monotonous life, providing the visitor is an agreeable friend. Should the patient's condition be made worse by such visits, the surgeon will at once forbid repetition of them for some time.

The situation and surroundings of large civil hospitals make it difficult, if not impossible, for intruders to enter the wards and produce disorder; it is different at military posts where the small hospital may be entered by visiting soldiers. The military nurse therefore has to look after the matter of visits of friends of patients, and must have definite instructions.

In small army hospitals it is impracticable to have regular visitors' days as is the case in large civil hospitals.

Visits of Clergymen.—The visits of clergymen to the sick come under a slightly different rule, as they are privileged visits. As a usual thing the consolation they offer to the sick is decidedly quieting and soothing in its effects, providing, of course, that the patient understands the visit is made merely to help him bear his trials. On the other hand, if the patient imagines that he is in danger of death, the visit of a clergyman may confirm his worst fears and have a depressing effect. It is only in very rare cases, that are chiefly nervous, that the clergyman is excluded along with everyone else. This whole subject is so exclusively under the control of the surgeon that it may be said to be entirely beyond the sphere of the nurse's duties, except that report should be made if anything goes wrong. As the army chaplain is required by custom and regulations to visit the hospital, the visits are encouraged, and the nurse, no matter what his individual religious opinions are, should make it his duty to show every courtesy possible to all clergymen, and assist in making their visits as profitable as possible.

Inspection of Ward.—A hospital ward must be ready for inspection at all times, but as it is a rule in military hospitals to have a rigid inspection of the whole hospital in the morning, the greatest cleaning is done right after breakfast. This morning inspection should never be made the excuse for allowing a ward to get dirty or disorderly at other times. A nurse should so fully appreciate the importance of his work, and attend to it so well, that there never should be any necessity for an inspection.

Temperature of the Air.—The nurse is absolutely responsible for keeping the proper temperature of the room. What this temperature is depends upon circumstances. In windy, cold climates, it may be necessary to keep the temperature up to 75° or even 80° F., but in places where it is calm a lower temperature, 65° or 70° F., may be allowable even in winter. Rooms full of colored soldiers must be kept warmer than others, for the negro seems to require a higher degree of heat for comfort than a white man. Whether or not this higher temperature is proper cannot now be discussed, but as the sick man must be made comfortable as the first step toward recovery, it is allowable to have the room temperature slightly higher to suit the negro. This permission must not be imposed upon and made the excuse for carelessly or deliberately allowing the temperature of a room to rise to such an improper height as 90° to 95° F., as it has sometimes been found.

The nurse must carefully study in his ward the arrangements made for regulating the temperatures. There may be heating by means of hot water or steam from radiators in the room. There may be hot-air registers, the air being warmed outside the ward by coming in contact with pipes of hot water or steam, or the hot surfaces of furnaces. In all frontier hospitals there are stoves. Whatever method is used, the nurse should thoroughly understand it, and if there are parts beyond his knowledge he should ask for information without delay. If the room gets too hot or too cold, he should, by the simple turning of a valve, register, or draught, be able to remedy the defect.

Ventilation.—The ventilation of the ward is just as important as the heating. A nurse who does not know how to ventilate his ward and keep the air pure is not efficient. It is not necessary for him to understand and be able to explain all the different systems of ventilation that are in use in hospital wards, but by all means he should perfectly understand the particular system in the ward he has charge of. If there is any part of the system he does not understand he should inquire of steward or surgeon, and have thoroughly explained the whole apparatus, with its shafts, valves, registers, flues, the reason for the present positions, and the methods of stopping, increasing, or decreasing the flow of air.

Care must be taken that the apparatus is not interfered with by patients. Soldiers, whether in ward or barracks, will always shut up every opening in cold weather unless they are looked after. Indeed, in some barracks the ventilators are found closed at every inspection. These are closed on account of cold draughts or a low temperature of the room. In the latter case the fires must be looked after, and if it is found that the stoves will not keep the ward warm without closing ventilators, the matter should be reported to the surgeon for his action.

The construction of many army hospitals on the frontier, and their small size, make it somewhat difficult to manage the ventilating apparatus. In very cold weather—thirty to forty degrees below zero—no ventilating system yet applied is efficient. In the wooden temporary structures much more air can come in through the cracks in the walls than one would suppose, particularly in places exposed to the wind. The defects of the ventilating apparatus are balanced by the defects of the building. Many a nurse may have served a long time and never have noticed any necessity for looking after the ventilation.

The nurse is expected to follow the practical rule of noticing, every time he enters the ward from out-doors, whether or not there is a perceptible odor. If there is, some change in the ventilation is necessary. Cold draughts are to be avoided as specially dangerous for the sick.

Plumbing.—There should be, and usually are, no plumbing arrangements in the ward, except, perhaps, the pipes carrying gas when that is used for lights. All water-pipes, drains, urinals, wash-stands, and other plumbing arrangements are placed in adjoining rooms, separated from the ward by closed passage-ways. Yet these rooms are usually under the direct care of the nurse, and it is his duty to become familiar with them at

once. It is an easy matter to follow up the pipes and find their uses. In the case of traps in the soil-pipes and drains he should know how they work, how they are cleaned out, and how accidents to them are to be remedied. A little care to these appliances saves many accidents, much inconvenience, and great expense for repairs. The least appearance of foul odors from the drainage system, or anywhere else for that matter, must be reported without delay. It is rare, indeed, to find plumbing arrangements so complicated that an intelligent nurse cannot understand their uses and methods of working if he spends a little time and thought on the subject.

Amount of Light.—There is but little attention paid to the amount of light in the sick-room, although the subject is quite important and comes directly within the sphere of the nurse's duties. Formerly the sick in a private house were placed in a dark and ill-ventilated room, under the impression that it was quieter and better. There seemed to be an idea that if it was quiet at night, somehow or other it was the darkness that caused the quiet, and that therefore the darker the sick-room was kept, the better it would be for the patient. As this idea has been exploded for a long time, we find the new ideas reflected in the army hospitals, which are built with a profusion of windows, so that there are no dark places, and light enters on all sides.

This throws new duties on the nurse, who has a few points to attend to in regard to the lightness of the ward. While we have shown that darkness is to be avoided, this should not lead to the opposite extreme of making the room too brilliant. *Dazzling light* is painful to all sick men, and in certain nervous cases, too much light may make them worse. It is, for instance, very wrong to allow the sun to shine in the patient's face, or to turn his bed so that he looks directly at a brilliant white sky. The light must be evenly distributed and not brilliant at only one place. If the day is dark, cloudy, or rainy, all shades are rolled up and shutters opened. If it is hot, and the sun is shining brilliantly, the shades are all drawn down completely on the light side of the room. Those peculiar days when there are very bright white clouds in the sky are particularly trying to the eyes, and the shades must be drawn down for protection.

In the early evening only sufficient lights are kept to give a fairly good light to read by. When patients are very ill and it is deemed necessary to darken the ward in the early evening to favor sleep, the patients who wish to read must go to the reading-room, or, if confined to bed, postpone their reading until the next day. On hot summer afternoons it is quite agreeable to all sick men to have the room darkened for a short time so that they can have a nap—a habit that most old soldiers acquire. At night a dim light is kept burning so as to permit of walking around. A hand lamp is usually kept burning for this purpose, and if patients require attention it can be carried where more light is needed.

Army hospitals cannot be fitted up with a sun-room where convalescents can be exposed to the direct rays of the sun. In the rare cases that require such a sun-bath, the nurse must arrange the matter at some convenient window.

Many of the instructions given to the army nurse in the matter of the light may appear to be trivial, but much attention should be given to this instruction, because large numbers of the present hospitals are quite unfavorably situated on hot, dry, sandy plains in the West, where the light is very trying to the eyes. Unless these points are emphasized the matter is liable to be neglected.

Cheerfulness of the Sick-room.—The army nurse can have little to do toward decorating a ward to improve its general tone as to cheerfulness. A ward is doleful enough under any circumstance, but in military hospitals, which are greatly affected by the rigidity and sternness of military life, the conditions as to cheerfulness are doubly bad. Nevertheless, the nurse should understand the good to be accomplished by making the room cheerful and bright, even though he is not able to carry out the plan in military hospitals. The decoration of sick rooms is carried to its greatest extent in those charitable hospitals devoted to children, who are usually and greatly influenced by their surroundings. These rooms are in certain cases little treasure-houses of such ornamentation as can be made with the little money that is usually available for the purpose. It has its effect in making the little ones almost as happy and contented as though they were well, and this is a great aid in treatment. As sick adults usually relapse into a kind of mental childhood, they are also greatly influenced for the better by cheerful surroundings.

Cheap prints tacked on the walls, little bits of decoration by ribbons or hangings, a small bunch of flowers here or there, and a tasty arrangement of the plain and meagre furniture, are all great aids to the general cheerfulness. The neatness and cleanliness of the bedside tables must be looked after as directly tending in the same direction. The table-covers are usually towels, and they get soiled quite soon and must be replaced. Little articles on the table must be kept in order and ready for immediate use. Indeed, all the directions as to cleanliness, order, and neatness of the ward, though given with the special view of aiding treatment, have an additional value as enhancing the cheerfulness of the ward.

A word or two must be said about *growing plants* and *cut flowers* in the sick-room. The subject has caused great discussion as to whether or not it is injurious to the sick. We know that during the daytime growing plants give out oxygen and absorb carbonic gas, just the opposite of what man does. This has been the ground for arguing that they should be kept in the sick-room to help purify the air. It is not generally known that the amount of oxygen given out by the plants that can be kept in the sick-room is so small that in a week it would probably not equal the amount brought in through one good fresh-air register in one hour. On the other hand, during the night-time growing plants often act in the opposite direction, *i.e.*, give out carbonic acid gas and absorb oxygen, and flowers do the same thing all the time. Here, too, the action is so small that it can be totally ignored in a properly ventilated room. When plants are present in too great number they keep out the light of windows and keep the air too moist, and are therefore objectionable, though there can be no reasonable objection to a very moderate number. As far as flowers are concerned, it can be said that an atmosphere heavily loaded with the odors of cut flowers is distinctly and decidedly depressing to sick people, and to well people also for that matter. A profusion of flowers must be excluded, therefore, under all circumstances. As with growing plants, a moderate amount of cut flowers that does not appreciably laden the atmosphere cannot be objected to when tastefully arranged in places around the room, but is distinctly advantageous as increasing cheerfulness and brightness. In time of peace the army nurse may not have any occasion to exercise any discretion in the matter of cut flowers, but in time of war, in the large general hospitals, a possible occasion might arise. Charitably disposed women make it their duty to keep the hospitals supplied with flowers, and there may be an inclination to carry the matter to extremes, especially in the case of wounded men whose achievements in battle have made them heroes. Special attention to one man by his friends may call for interference.

Army hospitals having large wards do not permit of much separation of the sick, who must therefore be protected from everything of a dismal or depressing nature. It is particularly horrifying to be compelled to witness the actions of dying men or the sufferings of one in great pain. Therefore all such cases should be carefully bidden from view by arranging bed-screens around the bunk. For the same reasons, should a patient die, his corpse should be removed to the dead-house within a few minutes, or as soon as it can be done decently and without giving the impression of undue and unseemly haste. No one has the least desire to remain in the same room with a corpse, let alone sleep there. When *surgical operations* are to be done in the ward, all other patients must, as far as possible, be removed to another room. It will

make them worse to be witnesses to anything of the sort. Of course this refers to serious operations, but such things as lancing a boil or dressing a wound are not particularly horrifying, and can be done in the view of the others. Nevertheless, it is a good rule to have the screens ready when anything of that nature is to be done, for this gives a grateful sense of privacy and seclusion to the patient operated on. To most men of a very sensitive organization any unnecessary exposure of their persons is very disagreeable, and the protection of screens is almost essential. It is just as wrong to give patients the least unnecessary mental pain as it is to give physical pain that can be avoided.

The necessity for cheerfulness, neatness, order, and beauty in all the surroundings of sick people is not only the guiding principle in regard to the interior of hospitals, but also of their exterior. Wherever it is practicable, hospitals are found situated in large, open places, that are filled with trees, growing plants, grass-plots, flower-beds, and symmetrical gravel-walks, and the whole kept in the cleanest and most orderly manner. A special gardener is employed for the purpose when possible, but in the small army hospital a member of the hospital corps must be depended on for this work, and a detail as gardener, to keep the hospital grounds clean and with at least a respectable attempt at flower-gardening, is directly within the sphere of his duties.

3. MANAGEMENT OF PATIENT.

On Admission.—The military discipline maintained in army hospitals necessitates some change of the rules for the nurse's management of the patients. On admission to hospital the patient is to be undressed and put to bed at once. His valuables, watch, money, etc., are to be given to the steward to be placed in the office safe. His clothing is to be locked up in the closet supplied for the purpose, and under no circumstances should clothing be given to the patient until he is ordered out of bed by the surgeon. If he is dirty he is to be given a bath, if possible, and all his underclothing removed, and hospital clothing supplied in its place. In large general hospitals all the patient's private clothing is immediately sent to be disinfected in the large steam sterilizers built for the purpose, and the parts that need subsequent washing are sent to the laundry. After being cleaned they are packed away until the patient is convalescent. In small army hospitals no such disposition of the clothing is necessary, except in rare cases, where a soldier may accidentally bring contagious disease into the ward. In that case special instructions as to disinfection will be received. Ordinarily the clothing will be clean and can be locked up at once.

As soon as he is comfortably fixed in bed his temperature is to be taken, and note made of any noticeable symptom, such as chill, paleness of face, or difficult breathing. He will then be ready for the subsequent attention of the surgeon, and the further attentions of the nurse in carrying out instructions for treatment.

Kinds of Attention to Patients.—The kind of service that the nurse should render to the patient depends so entirely upon the degree and kind of illness that but few except the most general directions can be given applicable to all cases. Some of the soldiers sick in hospital are so slightly ill that scarcely any attention need be given them—they are fully capable of taking care of themselves. Other patients again are so sick that they cannot do a single thing for themselves. Beyond this there are cases of delirium, or patients in a very low condition, who not only cannot render themselves assistance but cannot tell their wants, and are so weak that they soil their bedding and clothing by involuntary discharges, and require constant supervision. Between these extremes there are all grades of cases requiring various degrees of care, and it is the intermediate cases which are often troublesome and irritating.

As a general thing the nurse is to consider that all the patients are under his immediate care and subject to his orders. This is a great responsibility, for sick men rely entirely upon the nurse. They lose courage, energy, and interest in themselves. They cannot, in severe illness, even think of themselves, all thinking must be done for them, and they must be managed as children. There is an indescribable feeling of perfect security a sick man experiences when he realizes that he is in the hands of a good doctor and a thoroughly reliable and efficient nurse. He knows that he is properly managed, and he begins to feel as contented as possible under the circumstances, and ceases to think of his troubles. These feelings bring with them the restfulness so important to recovery.

Cheerful Manner toward Patients.—It is expected of a military nurse to drop any disagreeable air of authority he may have assumed under the false impression that it is military. He is to cultivate that cheerfulness which experience shows is so necessary for the sick. With this cheerfulness there must go an assured manner which tells each patient he is sure to recover.

There is a great difference in this cheerful assurance of some nurses as contrasted with the dolefulness and timidity of others. Some have such a pleasing manner of doing all things that their very presence in a sick-room is a comfort.

As a general rule sick men are made worse by listening to the talk going on about other sick men and the dangers of such cases. This is one of the objections to having many sick people together where the melancholy or the sufferings of a few will make the others worse. Many invalids positively refuse to go to certain health-resorts because of the immense amount of suffering they would be compelled to witness.

As far as possible there should be no reference to any such subjects as dangerous and painful diseases. Of course it is impossible for the nurse to stop all such conversation, because men must and will talk of what is uppermost in their minds, and it would be foolish even to attempt to order them to stop. If the conversation is very evidently jarring on some sick man's nerves, of course it is perfectly justifiable then to order quiet in the ward, or better, report the matter for the steward's or surgeon's action. It is by his example that the nurse can do the most good. He should never allow himself to discuss these forbidden subjects in the hearing of patients who are still quite ill. The nurse's responsibility in this matter is just as great as the surgeon's, and we know that if the latter would speak in a patient's hearing of the dangers of his case, he would do very much harm. In civil practice a gossiping nurse is an abomination, and physicians always refuse to employ her as soon as they find her out, because they know that she does great harm by her imprudent talking.

Of course there never should be a word said to a sick man about the ability of the surgeon in charge. Such criticism is entirely uncalled for, and is not only a serious military offence in the hospital corps, but may do actual harm both to patient and surgeon. The nurse is not a doctor, and in his ignorance of what a good doctor really is, he can form only a worthless opinion on the subject. Often it happens that the surgeon is taking the best, and perhaps the only justifiable, course in a case, and because that course does not include some active measures, the patient may have a feeling of being neglected. Should this feeling be noticed the nurse's loyalty to his superiors should prompt him to soothe the patient as much as possible.

In military practice the attendance of the sick and wounded is purely an official duty, that must be performed by a certain person. Consultations are not recognized nor provided for in any way, and a change of physician is, of course, entirely out of the question. The surgeon must see the patient through to recovery. In view of this it is particularly improper for the military nurse to do anything, by word or deed, that would in the least affect the confidence the patient should have in his physician. This loyalty to superior officers must be inculcated as a part of the nurse's duty, though it is putting up too high a standard to expect it to be always observed.

There are tricks in all trades, and it seems to be a uni-

versal trick to criticise adversely every other man's work. It is hard to call in a mechanic in some lines, without having him say that the last work was a botch. Now nurses are prone to do this also by "running down" other nurses. The hospital corps is no place for any such practices, for no good can come of them. If a good word cannot be said of others, nothing should be said. If the soldiers get it into their heads that the nurses are careless and neglect their duties to the sick, the feeling of apprehension of getting worse may do more harm than the surgeon can do good. The nurses should understand this and have enough "esprit de corps" to feel that any disparagement of one reflects upon the others.

Confidential Relations of Nurses.—Should a nurse in civil life go to a new engagement and report her experience in her last engagement, divulge family secrets that have come to her knowledge, and make disparaging remarks about her employers or her patients, she is guilty of a most dishonorable action. She has been admitted to the house and treated as one of the family, and all her knowledge there gained is strictly confidential, and must be as closely guarded as the physician guards what is said to him.

Now all this is applicable to the army nurse in every respect. He knows of secrets about patients that the others constantly in the ward do not even suspect, and under no circumstances should he divulge these secrets. To be sure, it is impossible to get much privacy in army hospitals, and for this reason soldiers suffering from diseases which they wish kept secret will not come to the hospital, but will take any kind of treatment rather than run the risk of exposure. Now as it is desirable to do the soldier as much good as possible, it depends upon the nurse to aid the surgeon in keeping perfectly secret any confidential knowledge he may have, and try to mitigate that great publicity and lack of privacy which is inherent to the ward of an hospital. Worst of all, he should never boast of his knowledge of the patients as though he held them in his power. Such boasting is very low, and stamps the man as undesirable in the ward or anywhere near the sick. Nurses have been known to do this, and their influence is always bad.

The confidences between a patient and his nurse serve a very useful purpose in bringing to light certain symptoms that would otherwise be hidden. It occasionally happens that sick men, without either rhyme or reason, hold the doctor at such a distance that they are quite unwilling to talk freely to him. They have a false modesty in the matter although they have no hesitancy in talking to the nurse, hoping, and even knowing, that the matter will be at once brought to the attention of the doctor. The nurse thus becomes a medium through which valuable knowledge of symptoms is taken to the surgeon, who may at once act on this knowledge, and by tactful talking to the patients sweep away their unnecessary reserve and get a full and complete grasp of their cases. The above is not mere fancy, for every experienced nurse can remember instances of this natural modesty, though of course marked instances of it, except in venereal complaints, are quite rare among soldiers who have been living together for years with but little or no privacy.

It is curious also what persistence the sick will show in continually denying what they think reflects on their characters. Men will deny ever having had any venereal complaint when the scars of old chancres are in full view. The surgeon therefore is compelled to seek and get his information in all ways possible, for he cannot treat his patients by guess-work. It is the duty, then, of nurses to report facts coming to their knowledge confidentially, as they know such knowledge is a secret between them and the doctor.

Irritability of Sick Men.—The military nurse is particularly to be warned of the irritability of sick men. Everything in the way of insubordination is so quickly noticed in army life that the nurse is apt to misunderstand the natural peevishness of the sick. Special pains are therefore taken to explain the whole matter to the nurse, showing him why so many things are tolerated in the hospital ward which would not be tolerated in the barrack-room.

On the other hand, a nurse should not accept everything a patient will do, for such a course would be equally disastrous in certain cases. If a sick man sees that all his peevishness and restlessness is allowed to go unchecked he is apt to presume upon such leniency and get more peevish, unless he is too ill to have any thoughts in the matter at all. Therefore a gentle firmness is necessary in refusing requests that cannot be allowed. Without being cross, ugly, or mean, a nurse can give the patient firmly to understand that he must be quiet, as the orders are to that effect. Again, patients who are of an ugly, vicious disposition are apt to be deliberately bad in conduct. Where the nurse is sure that such conduct is deliberate, or has his doubts in the matter, he must report it at once to the steward or surgeon for action. Upon the nurse's tact and skill in managing these cases will depend in great degree his efficiency in the ward. Special care given to this point of the irritability of sick men is of so much importance that it is easy to see the greatest difference in the general order and contentment in the ward under some nurses, and the ill-feelings and unhappiness under others. The former are even-tempered men who understand the sick, while the latter are apt to be thoughtless or ignorant of this part of their duty. Occasionally a nurse will be so cross to the sick that he will actually retard their recovery. By giving thoughtful attention to the one item of irritability of sick men, a good nurse will be able to prevent much trouble in the ward and preserve that degree of order and quiet so necessary for men recovering from sickness.

Cleanliness of Patients.—It is a general rule that every patient, if his condition will permit, shall be given a bath upon his admission to the hospital. This rule is much less rigid in military than in civil hospitals, because soldiers are required to keep themselves clean by frequent bathing, and if they are not inclined to be clean about their persons their comrades are apt to compel them to be. It is very rare, therefore, to have a soldier admitted to hospital in a dirty condition, unless it is in the field after a long march without bathing facilities. In civil life the poor who are taken sick have probably had no bathing facilities, and when taken to the hospital are often in a filthy condition and must be bathed at once. In military hospitals in time of peace there is no need to be on the look-out for men who are dirty, but when one is found he must be attended to. In war times the reverse is true. After a long campaign, where the clothing has been limited in quantity, and changes could not be made, and bathing facilities were absent, the soldiers are apt to become indescribably dirty, and the heat, dust, and smoke of battle have made them far worse. The wounded are not infrequently brought to the hospital in a terrible condition of dirt, so that in war times the rule about bathing patients is of prime importance and is usually enforced wherever allowable.

After the patient has been in hospital for a few days the nurse is to look after his cleanliness, giving the necessary sponge-baths, looking after the hair and beard, and the condition of the nose and mouth. These duties are in no respect different from those in civil hospitals.

In war times it is quite common for soldiers to become infected with lice and "crabs," and on admission to hospital be an actual source of danger to the other patients. These cases may require the surgeon's care. It may be said that as a rule nothing will be of any use short of shaving hair from the face and head, under the arms and over the pubis. "Crabs" may be so numerous that the whole body, even the eyebrows and eyelashes, are infected. Though the eyebrows could be shaved off it may be requisite to pull out each hair of the brows or lashes having nits on them. The nits must be cut off and burned, for no drugs have any effect on them except such strong drugs as would injure the skin. Nits will hatch out in spite of all applications.

All matters relative to the cleanliness of the patient are within the personal duties of the nurse, and he should attend to them without special orders. The surgeon usu-

ally has many things to think of when he sees his patient, and must keep in mind dozens of different points in prescribing the treatment, so that his mind should not be distracted by finding the patient in a bad condition due to neglect by the nurse of those rules of cleanliness which he should carry out without special orders in each particular case. The same general directions are to be observed as in civil hospitals regarding cleanliness and neatness of the bed, bedding, and bedclothing. These are looked after, kept neat and clean, and protected from contamination by infective discharges. Very old army barracks are quite apt to become infested with bed-bugs, and the soldiers wage a constant warfare against them. Hospitals at such posts are liable to get the pests introduced by patients, and in such situations the nurse is taught to exert special vigilance and by frequent and ample use of insecticides to exterminate the pests as soon as their presence is known.

Observation and Report of Symptoms.—Military as well as civil nurses are required to observe the symptoms and report the facts to the surgeon. They must be taught that the patient is apt to exaggerate symptoms in certain cases and to hide them in others. The fact that a patient will make astonishingly erroneous statements as a result of dreams or slight delirium is to be kept in mind at all times. The military nurse is to be depended on in great part for that exact and detailed knowledge of patients necessary in military cases. In civil hospitals no special future harm may come to the patient, his relatives, or the community by the lack of records of any one case. It is entirely different in military hospitals, where every important fact in regard to each patient must be recorded for future reference. Years after a soldier's death or discharge from hospital his relatives may make claims against the Government, which may be grossly false on one hand, or deserving in the highest degree, and nothing except the most accurate hospital records will permit of justice being done. Thus it happens that the nurse is compelled to carry out the spirit of all those exacting detailed reports that are usually denominated "Red-tape."

Exaggeration of Symptoms.—There is a most important fact to be kept in mind by military nurses. In civil life where a man's pay depends upon the amount of work he does, and where he receives no pay if he is laid up by sickness, he is not apt to stop work for any trifling sickness. He goes on with his work willingly and cheerfully, even if he is slightly "under the weather," or suffering from slight injury. He knows that the matter is entirely in his own hands, and that no one can compel him to work. Laborers, therefore, become accustomed to working under difficulties, and it is astonishing sometimes to find under what disabilities they will go to their daily work. It is entirely different in military life, where every soldier knows that if he is able he must do his duty, whether he wants to or not. It would be a terrible state of affairs if, just before a battle, one-half of the soldiers would say that they are not feeling very well, and they guess they will lay off for a day or two. They must be excused by competent authority, and it must be made plain that they are not fit to work before they can be excused. The best soldiers never ask to be released from duty for any slight ailment, but there are a large number who feel very much aggrieved if they think they are working when they would "lay off" if they were their own masters in civil life. Under such circumstances it is human nature for a soldier to exaggerate his sufferings. It is not malingering, of which more will be said later, but is a natural and involuntary attempt on his part to make it clear to the surgeon that the ailment is enough to necessitate the man's name being placed on the sick report. Men who would not stoop to the meanness of malingering, and who would scorn a lie, will thus unconsciously deceive the surgeon as to the extent of their illness.

A man often thinks so much of his troubles that he thoroughly believes he is sicker than he really is. Now a man cannot always think of his troubles, and after he is comfortably fixed in the ward and excused from duty, and his mind is occupied with other things he cheers up if depressed, forgets his imagined pains, and shows by all his conduct that he is not very ill. If the nurse observes this man's actions in the ward he is able to give the surgeon accurate and reliable information that would be a great aid in determining the proper treatment. Without this aid the surgeon is apt to treat the man as more ill than he really is, and, by greater restrictions than are needed, he might be giving the patient unnecessary confinement and unnecessarily harsh treatment. It must be kept strictly in mind that it is not intentional on the part of the soldier to appear more ill than he is; and that he is an honorable man who wants to do his duty if he can.

By keeping these thoughts in mind the nurse is not apt to do him an injustice. As soon as the surgeon finds out the true state of affairs he can give the proper treatment and return the soldier to duty sooner than he otherwise would do. This course will save trouble and be far pleasanter to the soldier, who becomes satisfied he is better, and he returns to duty willingly in a very short time. This course is not only just to soldiers who suffer from slight ailments like all other human beings, but it is also just to the Government, because the man's labor is saved.

It must not be thought that the surgeon excuses a man only in cases of sickness that causes a civilian to stop work, for this is not so. For instance, a man with a bad sore throat may go to his work and get well, but a soldier in the same illness could not stand guard with the thermometer forty degrees below zero. So that men are often in hospital with trifling ailments that would get worse under the exposures to which they might be subjected.

Malingering.—By watching the symptoms of a case the nurse can often detect those mean men who deliberately state they are ill in order to escape duties which they are perfectly willing that their comrades should do for them. It is to the great credit of the American soldier that these cases of deliberate malingering are very rare, but now and then they do occur among the twenty-five thousand soldiers of our army. A malingerer occupies the valuable time of the surgeon, causes much unnecessary worry in trying to find out what is the real disease, causes a loss of valuable drugs and extra diet in the treatment, puts much unnecessary work on the nurses, and, if he goes undetected, causes better men of the company or troop to do extra guard or fatigue duty. It is only just to the good soldiers who are working extra that a malingerer should be detected and punished, and it is often due to an accurate, reliable, and just report from the nurse in charge that such detection is made possible.

In peace, soldiers very rarely try to keep themselves ill so as to escape duty. In war, so many men are being killed that a soldier is apt to welcome illness or injury that will enable him to get to a place of safety, and then go home, and possibly get his discharge. Hence it happens that occasionally a soldier may deliberately keep himself ill and refuse to take his proper treatment. To overcome this, it is customary to try such cases by court-martial. It may have to be shown to the court that the treatment was necessary to bring about a cure. Such trials are scarcely ever necessary in peace. In all cases the nurse may be an important witness to occurrences in the ward.

Administering Remedies.—In administering remedies there are usually no new directions for the nurse to observe, beyond the necessity for watching the patient to see that he actually takes the medicine that is ordered. Soldiers who come into the hospital for trivial complaints for the purpose of escaping duty, have an old, worn-out trick of pretending to take their medicines, when in fact they do not. They must be watched by the nurse.

As a rule, the stay of a soldier in hospital is made as pleasant as possible if he is ill. This is done in order to put nothing at all in the way of soldiers coming freely to the hospital for treatment as soon as they are taken sick. By such means it is possible to ward off serious illness, for it is highly probable that civilians who cannot easily stop work often suffer from serious complaints that could have been prevented by prompt treatment in the beginning. The old idea that the military

hospital should be made disagreeable and dismal to discourage malingering is brutal and not in accordance with modern methods. Nevertheless, in rare cases, just as in civil hospitals, disagreeable methods of treatment are resorted to, in the attempt to find out if there is malingering. In such cases bitter and disagreeable medicines may be ordered, and the nurse must exercise great care to see that the proper doses are actually taken. In all cases he is to be on the lookout for the standard tricks, and he must make it a habit to see that each dose of medicine is taken exactly as ordered.

Military hospitals are not furnished with all the modern conveniences for making medicines palatable, and the nurse must resort to various methods for overcoming bad tastes and odors. In the field there may be no facilities at all for fancy pharmacy. Pills may be covered with tissue-paper, powders mixed with sugar or clean drinking-water, citric acid lemonade be on hand for use after taking medicines, and various expedients resorted to as occasion arises. In the future no difficulty may be experienced, as the new field outfit contains medicines in tablet form ready for use.

4. Nursing in the Field.

Genera Convention.—Away back before the Crimean War there was started a crusade against the prevailing style of nurses. Before this time it was considered that such work must be relegated to widows and worn-out women who had partly failed in the struggle for existence. Indeed, the more ignorant and cruel the woman, the more apt was she to take up nursing in her decline. Perhaps Charles Dickens may have done much to start the reform against the Mrs. Gamps and Mrs. Prigs, by describing with such honesty their habits and ability. In the midst of this reform the Crimean War broke out, and to England was brought those horrible tales of the sufferings of the sick and wounded soldiers, from privations and poor nursing. That great woman, Florence Nightingale, who was then in the midst of the work of the great nursing reform, was sent to the Crimea and took charge of the hospitals. Her experiences in that war were written up, and the agitation resulting bore fruit in the Geneva Convention of 1864. This congress, composed of representatives from most of the civilized nations of the world, agreed to certain articles for the amelioration of the wounded in armies in the field. They were not concurred in by the United States until 1882, and even then with reserve as to the additional articles of 1868. The Convention is given in full below.

Original Convention.—Article 1. Ambulances and military hospitals shall be acknowledged to be neuter, and as such shall be protected and respected by belligerents so long as any sick or wounded may be therein.

Such neutrality shall cease if the ambulances or hospitals should be held by a military force.

Art. 2. Persons employed in hospitals and ambulances, comprising the staff for superintendence, medical service, administration, transport of wounded, as well as chaplains, shall participate in the benefit of neutrality, while so employed, and so long as there remain any wounded to bring in or to succor.

Art. 3. The persons designated in the preceding article may, even after occupation by the enemy, continue to fulfil their duties in the hospital or ambulance which they serve, or may withdraw in order to rejoin the corps to which they belong.

Under such circumstances, when these persons shall cease from their functions, they shall be delivered by the occupying army to the outposts of the enemy.

Art. 4. As the equipment of military hospitals remains subject to the laws of war, persons attached to such hospitals cannot, in withdrawing, carry away any articles but such as are their private property.

Under the same circumstances an ambulance shall, on the contrary, retain its equipment.

Art. 5. Inhabitants of the country who may bring help to the wounded shall be respected and shall remain free. The generals of the belligerent powers shall make it their care to inform the inhabitants of the appeal addressed to their humanity, and of the neutrality which will be the consequence of it.

Any wounded man entertained and taken care of in a house shall be considered as a protection thereto. Any inhabitant who shall have entertained wounded men in his house, shall be exempted from the quartering of troops, as well as from a part of the contributions of war which may be imposed.

Art. 6. Wounded or sick soldiers shall be entertained and taken care of, to whatever nation they may belong.

Commanders-in-chief shall have the power to deliver immediately to the outposts of the enemy soldiers who have been wounded in an engagement, when circumstances permit this to be done, and with the consent of both parties.

Those who are recognized, after their wounds are healed, as incapable of serving, shall be sent back to their country.

The others may also be sent back, on condition of not again bearing arms during the continuance of the war.

Evacuations, together with the persons under whose direction they take place, shall be protected by an absolute neutrality.

Art. 7. A distinctive and uniform flag shall be adopted for hospitals, ambulances, and evacuations. It must on every occasion be accompanied by the national flag. An arm-badge (brassard) shall also be allowed for individuals neutralized, but the delivery thereof shall be left to military authority. The flag and the arm-badge shall bear a red cross on a white ground.

Art. 8. The details of execution of the present Convention shall be regulated by the commanders-in-chief of belligerent armies, according to the instructions of their respective governments, and in conformity with the general principles laid down in this Convention,

Additional Articles.—Art. 1. The persons designated in Article 2 of the Convention shall, after the occupation by the enemy, continue to fulfil their duties, according to their wants, to the sick and wounded in the ambulance or the hospital which they serve. When they request to withdraw, the commander of the occupying troops shall fix the time of departure, which he shall only be allowed to delay for a short time in case of military necessity.

Art. 2. Arrangements will have to be made by the belligerent powers to insure to the neutralized persons, fallen into the hands of the army of the enemy, the entire enjoyment of his salary.

Art. 3. Under the conditions provided for in Articles 1 and 4 of the Convention, the name "ambulance" applies to field hospitals and other temporary establishments which follow the troops on the field of battle to receive the sick and wounded.

Art. 4. In conformity with the spirit of Article 5 of the Convention, and to the reservations contained in the protocol of 1864, it is explained that for the appointment of the charges relative to the quartering of troops and of the contributions of war, account only shall be taken in an equitable manner of the charitable zeal displayed by the inhabitants.

Art. 5. In addition to Article 6 of the Convention, it is stipulated that with the reservation of officers whose detention might be important to the fate of arms, and within the limits fixed by the second paragraph of that Article, the wounded fallen into the hands of the enemy shall be sent back to their country after they are cured, or sooner if possible, on condition, nevertheless, of not again bearing arms during the continuance of the war.

There are ten other articles, concerning the marine.

It is evident, therefore, that in the field, in civilized war, the military nurse is placed upon a very different footing than formerly. He is a privileged character because he is engaged in the work of humanity, and to proclaim his privilege he wears on his left arm the badge of his calling—the Geneva Cross—a red cross in a white field. When so employed, and so distinguished by his badge, he becomes neutral, notwithstanding his nationality, and he cannot become a prisoner of war. When his

work of bringing in or succoring the wounded is finished he must be sent back to his own army as soon as possible, unless he choose to remain and work among the wounded. In warfare with a civilized nation that has not agreed to the Geneva Convention, it plays no recognized part whatever, though its principles may be carried out by both sides on the general grounds of humanity. In war against savage people the humane principles of the Convention will be disregarded, and a nurse is apt to be killed in the very act of relieving the suffering. The hospital flag may be as much riddled with bullets as any other, and the very existence of medical help seems to be unknown to the savage. Thus it happens that as almost all the active operations of the United States army are against savages, the military nurse receives no benefit whatever from the Geneva Convention, and its provisions may not be taken into consideration at all.

On the March.—On the march the hospital corps detachment follows the regiment or brigade ambulances, the privates of the hospital corps being mounted. This is necessary to preserve their strength as much as possible, because their work begins at the end of the day's march, when the soldiers of the line can rest. Those that are not mounted are allowed to ride on ambulances or other wagons. The duties on the march are to look after the comfort of the sick that are being transported from camp to camp, give them their required medicines, prepare for them such food as may be practicable *en route* or on the short halts. On long, hot marches soldiers are apt to become exhausted and fall out of ranks to wait for the ambulances and the surgeon to come up. When such cases are met with the nurse secures their arms and accoutrements, places these in the ambulance, and then finds a seat for the patient and administers the remedies that have been prescribed. Cases of exhaustion are apt to be frequent when the campaign is proceeding under the difficulties of deficient and improper food and clothing, or the troops have been exposed to the severity of the weather. It can be assumed that in such circumstances the nurse may have much to do under great disadvantages.

In Camp.—On arriving at the end of the day's march the nurses all assist in making fires, preparing some light food for the sick, and making the latter comfortable in shady places, and attending to the usual routine duties of nurses. By the time this is finished the wagons with tents and rations have arrived; all hands must turn to and unload them as quickly as possible. The cooks secure the rations and start the preparations for the principal meal at once. All others erect the tents, prepare the cots or bunks for the sick, and carry the sick into the tents. This temporary field hospital is thus established, and can be placed in running order within a few minutes after the arrival of the wagons, and from this time on until the next day the duties of the nurse are essentially the same as in any permanent hospital.

There are so many things to be improvised in camp that it is almost useless to expect efficiency from the nurse unless he has had considerable experience as a camper-out, and has had much instruction besides. In the absence of bunks or cots he must know how to make a soft, comfortable bed of leaves or brush. He must know how to arrange the men in the tents so as to economize floor space. He must be thoroughly conversant with the methods of pitching tents, excluding draughts of air from patients, excluding rain, erecting and caring for the stoves in cold weather, and the thousand and one little details of camp life that altogether will turn a primitive way of living into one of great comfort. In the early morning, if camp is broken, some patients may have to be sent back as unfitted to proceed with the command. These must be prepared by the nurses, placed in the wagons with their accoutrements, and, if no nurse is to accompany them, they are to be given their medicines with instructions how to take them. The nurse is to do everything possible to make these men comfortable until they reach other hands. While this is being done the other patients that are to go forward are placed in the ambulances, and the tents are struck and everything loaded on the wagons and the march is begun.

In more permanent camps the nurses must be expected to devise conveniences for the sick. To go into this matter would only be to write an article on camping, which is not the intention here. It is sufficient to remark that in the months that might elapse before the camp is changed the nurses are continually making the field hospital nearer and nearer a permanent hospital of very rude construction. A nurse is expected to be handy with carpenter's tools, and ingenious enough to design from rough lumber and packing-boxes all the little appliances used in nursing. By a little ingenuity it is possible with the materials in camp to give efficient vapor-baths for the relief of spasmodic retention of urine, to make various forms of counter-irritation with hot water and hot stones, to practise the method of firing, to make poultices, and to perform numerous operations usually deemed to require special apparatus.

Battle.—When battle is expected the nurses are particularly busy in assisting to send the sick to the rear, and in getting everything ready for the work that is to come. Large quantities of fresh water are brought to hand, and as much water boiled as possible. The antiseptic solutions for irrigation are gotten ready, instruments and dressings brought out and prepared; indeed it is the whole routine of preparing for operation in a permanent hospital. It is a time of great excitement and hurry, and unless the nurses are well drilled and instructed there is apt to be abominable confusion. When the wounded are brought in, the nurse's duties are exactly as in permanent hospitals.

The arrangements made for succoring the wounded on the battle-field have been fully described in former articles in this work. Nurses detailed for duty at dressing, collecting, or ambulance stations have no new duties to perform that are not already described. Between these stations and the fighting line is an area where nursing ceases, and the privates are concerned in bringing in the wounded on stretchers, travois, etc., and in rendering first aid in the way of stopping hæmorrhage, reviving men from collapse, carrying water to the wounded, and all the other attentions to them that need not be detailed here.

In the rapid dusty marches previous to a battle there is no chance for cleanliness, and the soldiers become exceedingly dirty, as already explained. The wounds therefore are extremely apt to be infected, and the hurry, overcrowding, and lack of proper care, always make matters far worse. Thus it happens that wounds begin to suppurate or become gangrenous where they should heal kindly. This state of affairs is always seen in wars, and, as one of the means taken to prevent it, the nurses will be instructed to take the most particular pains to render everything aseptic and to be as cleanly as circumstances will permit.

In advances or retreats the nurse will be ordered to new fields of duty by his commanding officer, and in his work of humanity he will find himself greatly assisted by the provisions of the Geneva Convention which now come into play. From all the foregoing it can be assumed that the proper instruction of the nurse in field duties is to include all things that can be done for the sick, so that the wishes of the surgeon can be anticipated. By these means the corps of nurses will make it possible for a few surgeons to give medical and surgical care to a very large number of patients in such busy times as accompany and follow battles.

The future is to see a very great change for the better in the treatment and nursing of the wounded in the field. The advantage now taken by the concentrated medicines, extracts, compressed tablets, compact dressings, and intelligent methods of packing these in convenient shape has resulted in the magnificent new field equipment of the United States Army Medical Department. These are fully described in the last report (1892) of the Surgeon-General, and for convenience and efficiency this equipment is described as being in advance of that of any army in the world.

Going hand in hand with the advances in new medical

and surgical preparations is another advance, that of the preparation of food. This concerns us most here, as it is more intimately associated with the nursing of soldiers in the field. Ever since the most ancient times military men have been experimenting with the concentration and preservation of food for armies in the field. The results have not been of much service to the surgeon, as he could not utilize them to any great extent in the treatment of the sick. Recent years have seen the successful manufacture of a host of foods for invalids, and from these the soldier in future wars will derive incalculable benefit. It has been described above how soldiers are taken ill on the march, how they become exhausted and have to fall out, to be picked up by the ambulances. The great point in the treatment and nursing of these men is to give them rest, stimulants, and nourishment. The latter has always been lacking. In the future the ambulance will be fully equipped with some of the myriads of prepared foods now in the market. A cup of water will be heated on an oil or alcohol stove, and in a few minutes a cup of the most nourishing and stimulating soup can be prepared for the exhausted soldier. No doubt by such means it will be possible to restore to the fighting force numbers of men that in the past were sent to the rear or allowed to die in the roads. As soon as camp is reached the sick in the ambulances will be fed. This rest and nourishment will allow them to recuperate for the next day's work.

Again, it is known that for many hours, or perhaps days, the wounded on the battle-field may lie where they fall, and a large percentage of them die of exhaustion. Nurses and attendants will be enabled with these prepared foods to save a large number of such unfortunates. The nurse will therefore be instructed in the preparation and use of the foods that will be carried along with the ambulances, medicine wagons, or special ration wagons. Beef-extracts and prepared soups will, of course, be the main articles, but advantage will accrue also from the digested foods prepared for invalids, and indeed also from that immense list of specially prepared and concentrated vegetables and fruits for exceptional cases.

Chas. E. Woodruff.

MILITARY RECRUIT, PHYSICAL CHARACTERISTICS OF THE. The teaching in physical culture, and the encouragement that has been given to it by the various civil institutions of learning throughout this country and at the United States Naval Academy at Annapolis, Md., have, during late years, attracted much attention among army people, and have resulted in a revision, in certain particulars, of the standard of physical requirements for the admission of officers and enlisted men to the army, and of cadets to the Military Academy at West Point, N. Y.

The lax methods of examination that have heretofore been tolerated led to the acceptance of men with defects that were either latent or concealed, which, developed by incidents of the service, resulted in an early breaking down and consequent retirement of many officers, and to numerous discharges on disability certificates of enlisted men from the service. The remedy seemed apparent in the exercise of greater care when inquiring into the moral and physical qualifications of all classes of men, and in giving more explicit directions for the guidance of examiners in their work; to this end the recruiting regulations have been modified, the requirements for admission to the Military Academy at West Point have been more clearly set forth, and laws have been enacted by Congress providing for careful examinations into the physical condition of applicants from civil life for commissions in the army, and for similar examinations prior to the promotion of officers from one degree of rank to another. Many of the visual and aural defects that modern science has brought to light and defined are now officially declared as disqualifications, and tables of proportion, showing the relations which should exist between height, weight, and chest measurement and mobility in the normal man, are published as aids to the recruiting officer.

These several improvements in method are briefly outlined under the following headings:

THE LEGAL REQUIREMENTS FOR ENLISTMENT.—Any male person above the age of sixteen and under the age of thirty years, effective, able-bodied, and free from disease, of good character, who does not appear to be of intemperate habits, and who has a competent knowledge of the English language, may be enlisted, due attention being given to the restrictions in this article concerning minors. This regulation, in so far as it relates to age, does not apply to soldiers who may re-enlist, nor to those who have served honestly and faithfully a previous enlistment in the army. Applicants for enlistment are required to furnish such evidence of good character as they can obtain. With a view to determine their fitness and aptitude for the service, and to give them an opportunity to secure testimonials, as well as for the inquiry and deliberation contemplated by the Second Article of War, they may be retained and provided for at rendezvous, for a period not to exceed six days, after having signed the declaration of intention to enlist and passed the medical examination. Men so retained are known as *recruits on probation*. The enlistment papers of any such recruit who may be unfit or undesirable for the service, or who may not desire to remain in the service will not be completed. The enlistment papers of recruits who are accepted and duly sworn will bear the date on which the enlistment is *completed* by administering the oath (A. R., Art. LXXI., 908). . . . The Major-General commanding the army is of opinion that if satisfactory evidence of good character, habits, and condition cannot be furnished by the recruit, or be otherwise obtained, the presumption should be against him and he should *not* be accepted; and, further, that these views are concurred in by the Secretary of War and should govern in all cases (G. O., No. 1, Head-quarters Recruiting Service, 1890).

These rules and articles shall be read to every enlisted man at the time of, or within six days after, his enlistment, and he shall thereupon take an oath or affirmation in the following form: "I, A. B., do solemnly swear (or affirm) that I will bear true faith and allegiance to the United States of America; that I will serve them honestly and faithfully against all their enemies whomsoever, and that I will obey the orders of the President of the United States and the orders of the officers appointed over me, according to the Rules and Articles of War." This oath may be taken before any commissioned officer of the army (Article of War).

Every officer who knowingly enlists or musters into the military service any minor over the age of sixteen years without the written consent of his parents or guardians, or any minor under the age of sixteen, or any insane or intoxicated persons, or any deserter from the military or naval service of the United States, or any person who has been convicted of any infamous criminal offence shall, upon conviction, be dismissed from the service, or suffer such other punishment as a court-martial may direct (Article of War).

Under a recent Act of Congress fraudulent enlistment is declared a military offence, and is punishable by court-martial under the Sixty-second Article of War; the provisions of this law are fully explained to every applicant presenting himself for enlistment with the information that any person procuring his enlistment on or after the 25th day of September, 1892, by false representations or other fraudulent means, will render himself liable to trial and punishment by court-martial. "Fraudulent enlistment" is defined by the law officers of the department as "an enlistment procured by means of a wilful misrepresentation in regard to a qualification or disqualification for enlistment, or by an intentional concealment of a disqualification which had the effect of causing the enlistment of a man not qualified to be a soldier, and who but for such false representation or concealment would have been rejected."

The regulations above quoted sketch in outline the requirements for admission to the enlisted branch of the military service and the duties of officers in connection

therewith. For the recruiting officer an essential to success is a knowledge of men and their character, and for the medical officer a painstaking application of professional skill. The duty is a most important one, and in its faithful and thorough performance these officers share a grave responsibility. The influence of their judgment and discretion is felt throughout the entire military establishment, the efficiency of which depends in great measure upon the sound mental and physical condition and the intelligence of its enlisted force. From the varied classes and conditions of men presenting themselves for enlistment they are to eliminate not only those who are defective physically and mentally, but those who are defective morally, and if this duty be performed carelessly or indifferently, men will be admitted to the service with defects which will soon render them unfit for duty, or with moral obliquities that will induce malingering and desertion. Although the result of such perfunctory performance of duty may come to light during the probationary service of a recruit at a depot, it will certainly be shown in the company, from which his eventual discharge cannot fail to bring deserved censure upon the officers concerned in his enlistment.

Re-enlistments.—Soldiers who are unable to pass the required examination *in all respects* will not be re-enlisted without special authority from the Adjutant-General's Office, and then only for their former commands; application for such authority should be recommended only when it is shown that any existing defects will not prevent the full discharge of duty as a soldier, and that a continuance in service will be a positive benefit to the army.

Soldiers discharged as privates upon expiration of term of service and failing to re-enlist within one month, will not be again enlisted after they have passed the age of thirty-five years, unless for some good reason in the interest of the public service, and then only for their former commands upon special authority from the Adjutant-General's Office.

This limitation as to age will not apply to a soldier discharged as *a non-commissioned officer with excellent character*, and desiring to again enlist for assignment to a former command (not already full), either at the station thereof, or at a recruiting depot, provided he passes the required examination and furnishes satisfactory evidence in regard to character and habits since discharge.

Soldiers who have been discharged with good character under the provisions of law may be again enlisted without special authority after a period of two months from date of discharge, upon passing the required examination and furnishing satisfactory evidence in regard to character and habits since discharge, provided such enlistment is not barred by any of the above provisions.

Soldiers discharged before expiration of term of service for any other cause will not be again enlisted without special authority from the Adjutant-General's Office.

These restrictions, which are intended more particularly to govern re-enlistments for the line of the Army, need not necessarily be applied to the Hospital Corps; the approval of the Surgeon-General will be sufficient warrant for the re-enlistment of soldiers into that corps.

Height, Weight, and Chest Measurements.—"The *minimum height* of a recruit is at present fixed at five feet four inches for all branches of the service, although recruiting officers are allowed to exercise their discretion as to the enlistment of desirable recruits (such as band-musicians, school-teachers, tailors, etc.) who may fall not more than one-fourth of an inch below the minimum standard of height; the *maximum* height for the cavalry service is five feet ten inches; that for infantry and artillery is governed by the maximum of weight, to which should be applied the rule for proportion in height."

"The *minimum weight* for all recruits is 128 pounds, except for the cavalry, in which enlistments may be made without regard to a minimum of weight, provided the chest measurement and chest mobility are satisfactory. The *maximum* for infantry and artillery is 190 pounds; for cavalry and light artillery, 165 pounds."

The standards of height and weight are, however, subject to change, instructions to that effect being issued from the Adjutant-General's Office "from time to time as the requirements of the service may dictate."

These standards are based upon results obtained by skilled observers who, after careful study and the examination of large numbers of men in civil and military life, have established the fact that there is an *average proportion* in healthy, fully developed men between the height, weight, chest measurement, and chest mobility which will admit of slight variations without indicating a departure from health. The rules of this proportion may be formulated as follows:

For each inch of height from 5 feet 4 inches to 5 feet 7 inches, inclusive, there should be calculated 2 pounds of weight. When the height *exceeds* 5 feet 7 inches, calculate 2 pounds of weight for the *whole number* of inches of height; add to this product 5 pounds of weight for each inch of difference between 5 feet 7 inches and the actual height; the sum will be the normal weight in pounds.

The *chest measurement at expiration* in men from 5 feet 4 inches to 5 feet 7 inches in height should exceed the half height about half an inch; in those from 5 feet 8 inches to 5 feet 10 inches it should *equal* the half height, while in those from 5 feet 11 inches upward it should be slightly *less* than the half height.

The *chest mobility—i.e.*, the difference between the measurement at inspiration and expiration—should be *at least* 2 inches in men below 5 feet 7 inches in height, and 2½ inches in those above that height.

The following table shows this concisely:

Height.	Weight. Allow for each inch of height:	Chest measurement.	Chest mobility.
5 feet 4 to 5 feet 7 inches.	2 lbs.	Half height plus half inch.	2 inches.
5 feet 8 to 5 feet 10 inches.	2 lbs., and 5 lbs. additional for each inch over 5 feet 7 inches.	Half height.	2½ inches.
5 feet 11 to		Slightly less than half height.	2½ inches.

For example, a man who measures 5 feet 4 inches should weigh 128 pounds—*i.e.*, 5 feet 4 inches = 64 inches; 64 × 2 = 128, the normal weight. He should have a chest measurement of 32½ inches at expiration, being half height; 32 inches plus ½ inch = 32½; the chest mobility should be about 2 inches.

A man who measures 5 feet 9 inches should weigh 148 pounds—*i.e.*, 5 feet 9 inches = 69 inches; 69 × 2 = 138; difference between 5 feet 9 inches and 5 feet 7 inches is 2; 2 × 5 = 10; 138 + 10 = 148, the normal weight in pounds. He should have a chest measurement of 34½ inches (his half height), and a chest mobility of at least 2½ inches.

It is not necessary that the applicant should conform *exactly* to the figures indicated in the rules, a variation of a few pounds from either side of the standard in the minimum, medium, and maximum weights, and of a fraction of an inch in chest measures being permissible if the applicant is otherwise in good health and desirable as a recruit. The rules are given to show what is regarded as a fair proportion, *but the weight must be at least* 125 *pounds*, except when less is especially authorized by the superintendent or the Adjutant-General.

In such cases the recruiting officer's reasons and the superintendent's order should be noted in full on the enlistment papers. Any *considerable* disproportion, however, of *height* over *weight* is cause for rejection; but a marked disproportion of *weight* over *height* does *not* reject unless the applicant is positively obese.

In order that an intelligent application of these rules and their variations may be made, the attention of recruiting officers is called to the manner in which a man's height is made up.

The chest, containing the heart and lungs, is the most important division of the body. It contains the vital

machinery and represents the *staying power* of the man. It must, therefore, be ample. The function of the legs is to transport the body; they should be well formed and sufficient, but not unduly long, for length of limb at the expense of the chest is a disadvantage. A long-legged, long-necked man with a short chest is objectionable as a recruit.

The average height of a youth of eighteen years of age, a "growing lad," is a little over 5 feet 4 inches, and increases gradually until he reaches the age of twenty-five years—the stage of physical maturity or manhood—when his average height is between 5 feet 7 inches and 5 feet 8 inches.

During the growing period the frame-work and vital organs receive their proper development, and considerable departures from the given average of proportionate height to weight indicate an impairment of these organs which may, and probably will, develop into positive disease after exposure to the hardships incident to the life of a soldier; hence they are of greater significance in men of these heights than in taller men, who are presumably of greater age and more mature growth.

After twenty-five years of age, the body being fully developed, the excess of nutritive material over and above that required for its maintenance in health is deposited in the tissues as fat, and it will be found that a disproportion of weight over height occurs usually in adults or men in middle life. It is rare to meet in the recruiting rendezvous with *very* fleshy *young* men.

The following table is given for convenience of reference:

TABLE OF PHYSICAL PROPORTIONS FOR HEIGHT, WEIGHT, AND CHEST MEASUREMENT.

Height.		Weight.	Chest Measurement.	
Feet.	Inches.	Pounds.	At expiration: inches.	Mobility: inches.
$5^{4}/_{12}$	64	128	32½	2
$5^{5}/_{12}$	65	130	33	2
$5^{6}/_{12}$	66	132	33½	2
$5^{7}/_{12}$	67	134	34	2
$5^{8}/_{12}$	68	141	34	2½
$5^{9}/_{12}$	69	148	34½	2½
$5^{10}/_{12}$	70	155	35	2½
$5^{11}/_{12}$	71	162	35¼	2½
6	72	169	35¾	2½
$6^{1}/_{12}$	73	175	36¼	2½

A deviation from the rules of physical proportions may be made in the examination of candidates for admission to the United States Military Academy at West Point, and for members of the graduating class, whenever this is deemed desirable by the Medical Examining Board.

THE EAR.—Recent instructions from the War Department require that all men enlisted for the artillery arm of the service at a military post, or assigned to that arm from a depot, shall, before such enlistment or assignment, besides undergoing the ordinary examination, be examined especially with a view to establishing the fact of the patency of the Eustachian tubes and the integrity of the tympanic membranes, in default of which the men are unfit for that arm.

PHYSICAL EXAMINATIONS OF CANDIDATES FOR APPOINTMENT AS CADETS AT THE MILITARY ACADEMY AT WEST POINT, N. Y.—The physical examination of candidates for appointment to the United States Military Academy will be made after the methods prescribed in "Greenleaf's Epitome for the Examination of Recruits, and as they are final for admission to the Military Academy special care should be given to determine the condition of the heart and lungs. Normal vision ($\frac{20}{20}$) as determined by the official test types is required, and color-blindness rejects. The following rule for proportionate height, weight, and chest measurement, is substituted for that on pages 26–28 of the "Epitome," but it should be understood that this rule is intended *merely as a guide*, from which deviations are permissible in the judgment of the medical officer:

Rule.—For each inch of height, from 5 feet to 5 feet 7 inches, calculate 1.85 pound of weight; above 5 feet 7 inches, add to this standard 5 pounds for each inch of height; minimum chest measurement at expiration, from 5 feet to 5 feet 7 inches, half the height plus half an inch; from 5 feet 7 inches to 5 feet 10 inches, half the height; from 5 feet 10 inches upward, slightly less than half the height; minimum chest mobility, 2 inches. In exceptional cases a minimum weight of 105 pounds may be accepted.

Under recent regulations the examinations are held at the military post nearest the residence of the candidate, and simultaneously with the mental examination.

Medical officers are instructed to record in each case, whether of acceptance or rejection, the results of their examinations on a form of which the following is a copy:

To be sent to the Surgeon-General, United States Army.

FORM FOR THE PHYSICAL EXAMINATION OF A CADET CANDIDATE FOR ADMISSION TO THE U. S. MILITARY ACADEMY, WEST POINT, N. Y.

This examination is to be made before the candidate is stripped.

Name; birthplace; residence.

Nationality of father; of mother. If either or both parents, or brother or sister have died, state the cause.

Do you drink intoxicating liquors, and, if so, to what extent? Do you use tobacco, and, if so, in what form and to what extent?

What diseases or injury have you had, if any?

Vision: Right eye; left eye. Color perception.

Hearing: Right ear; left ear.

This examination is to be made after the candidate is stripped.

Physique.

Age.		Height.		Weight.	Chest measurement.	
Years.	Months.	Feet.	Inches.	Pounds.	Expiration.	Inspiration.
					inches	inches

Nutrition and Diathesis.—Note anything unfavorable in the general appearance, such as sickly aspect or unduly full habit.

Integumentary System.—Note any skin eruptions, sores, or ulcers. Any tendency to catarrhs?

Nervous System and Organs of Sense.—Note any loss of faculties or other present derangement of function or any suspicion of serious lesion.

Respiratory System.—Note any hoarseness, cough, or other present derangement of function, or any abnormity discoverable by auscultation or percussion.

Vascular System.—Note rate and quality of pulse. [*If excited, re-examine till you assure yourself of the normal rate.*] Any intermittence or irregularity, or undue strength or weakness of heart-action? Any abnormity discoverable by auscultation or percussion? Any hæmorrhoids, varicocele, or varicose veins?

Digestive System.—Note any present derangement of function, any enlargement of liver or spleen, or suspicion of organic disease of any of the abdominal organs.

Remarks.

I certify that have personally examined the above-named candidate, and, finding him physically qualified for the military service, (accept, reject) him.

Surgeon, U. S. Army.
Surgeon, U. S. Army.

Dated at , this day of , 189 .

Charles R. Greenleaf.

MOFFAT. A watering-place in Dumfries-shire, Scotland.

LOCATION.—Moffat is a village charmingly situated among the lower hills of Scotland. It has a cold, sulphurous, and saline spring of small importance, but is popular on account of the exhilarating and bracing quality of its atmosphere, and its general salubrity as a summer resort. Mineral-water baths are much employed, and there is a hydro-therapeutic establishment of modest equipment. The water contains sulphuretted hydrogen and has a disagreeable taste. Fogs are said to be rare at Moffat, but there is plenty of rain. The place is patronized by the Scotch and English, and is by them very highly spoken of; but it has not yet acquired an international reputation. Summer season only.

Edmund C. Wendt.

MONOBROMACETANILIDE (Antisepsine, Asepsine). Very soon after the therapeutic value of acetanilide had been recognized, this bromine compound was introduced as an anodyne, analgesic, and antiseptic. It is

formed from acetanilide, $C_6H_5NHC_2H_3O$, by the substitution of one atom of bromine for one of hydrogen, its formula being $C_6H_4BrNHC_2H_3O$. It occurs in white acicular crystals, and is tasteless; it is insoluble in water, slightly soluble in glycerine, and very soluble in alcohol and ether.

In doses of five-sixths of a grain, four times a day, it lowered the temperature in phthisis, typhus, and typhoid fever, slowing the pulse at the same time, but not affecting the respiration. In pneumonia it was found liable to produce cyanosis. It was also used in neuralgia with success, in doses of five to eight grains.

The employment of this compound failed to become general, as it was found that prostration and cyanosis frequently accompanied its use. Several cases have been reported, in which two doses of five grains, taken at long intervals, produced very alarming symptoms. Lips, cheeks, and extremities became cyanosed, pulse rapid and small, noises in the head, and great restlessness and weakness. These symptoms diminished in a few hours and recovery followed in all the cases.

As an application to wounds and ulcers it is thought to promote healing in a remarkable manner. It also was used to allay the pain of hæmorrhoids and anal fissure, in the form of suppositories. *Beaumont Small.*

MONOCHLORPHENOL. A derivative of carbolic acid by substituting one atom of chlorine for one of hydrogen; its formula is C_6H_4ClOH. It is a very volatile liquid, giving off vapors which are heavier than air. Under the name of *chlorphenol*, a mixture of monochlorphenol, alcohol, eugenol, and menthol, has been recommended as an inhalation in phthisis and pulmonary troubles in which an antiseptic is likely to prove serviceable. Dr. Passerini, of Casate-Nuovo, Italy, who introduced it for this purpose, has used it in a number of cases with beneficial effects. He states that it is a powerful antiseptic, free from caustic and irritant properties. Fifteen to thirty drops are to be placed on a pledget of cotton in an inhaler, and the fumes inspired; being heavier than air they are supposed to penetrate deeply into the bronchioles and alveoli. In cases in the incipient stage of phthisis the sputa were found to diminish and lose their purulent character, and in two months the patients were apparently cured. The advantages he claims for it are: 1, The inhalations are easily borne in advanced phthisis, and they are convenient of application; 2, no injurious effects arise from the continuous use of the drug; 3, changes in the quantity and quality of the pus continue until pus and bacilli disappear, the cough diminishing, the fever being reduced, the appetite and sleep soon returning, the weight of the body increasing rapidly, and local improvement being speedily attained.
Beaumont Small.

MONTE CARLO. This Riviera resort is one of the most beautiful places along the north shore of the Mediterranean. It is also one of the best sheltered spots, and would probably be the leading health-resort of the whole coast if it were not for the notorious gambling palace erected there. Monte Carlo is part of the little principality of Monaco, and is only nine miles in an easterly direction from Nice, and about six miles westward from Mentone.

Although Monte Carlo is chiefly visited by the votaries of pleasure, real invalids have of late years been attracted to the place on account of its undeniable advantanges as a winter station. In connection with the institution of public gambling, the writer will here quote from his report on Monaco and Monte Carlo, which appeared in the *Medical Record* of July 23, 1892:

"My experience on the Riviera enables me to state as a positive fact that many more people go to Monte Carlo to gamble from the various resorts near it than from the town itself. Cannes, Nice, Mentone, and even San Remo, send their daily quota of gamblers there in uncomfortably crowded trains. And those who have no inclination for the silly game may just as well live within a stone's throw of the Casino itself as miles away. I cannot, therefore, quite agree with those who would warn people away from Monte Carlo merely on account of the gambling going on there. If they are so weak as to have to yield to this particular temptation, they are better off at home than on the Riviera. It has seemed to me, however, that Americans are abundantly able to take care of themselves wherever they may happen to be. It is necessary to state my views on this point, because I believe Monte Carlo can be made one of the best winter stations on the whole coast. Even now every possible accommodation is offered there, and the only criticism one can justly make on that score is that the hotel and restaurant rates are often exorbitant. But if it is not a cheap place, it certainly can claim to be a good one, at least so far as the provision of American comforts and luxuries is concerned. This is considerably more than can be said for some other winter stations that are scattered along the coast here."

In the same report the writer has also pointed out that Monte Carlo is one of the warmest winter stations on the Mediterranean coast. But it is not true that it enjoys a more equable temperature than all other resorts. Sudden thermometrical variations occur there just as elsewhere on the Riviera. Some parts of the principality are very well protected from winds, while others are decidedly exposed to them. The bare rocks rising up to a considerable height, immediately back of Monte Carlo, afford ample protection from cold northerly winds, and by reflecting the sun's rays appreciably raise the temperature in their vicinity. But when the sun has set, the succeeding chill is felt all the more violently, though the actual fall of temperature is less abrupt and less perceptible than our sensations appear to indicate. It would occupy too much space to go into details here concerning the physical configuration of various sections of the Monégasque territory, but the reader may infer from these general indications that some well-sheltered and warm nooks can be found at Monaco. For well-to-do invalids the place will doubtless be made increasingly attractive, on account of the large sums of money spent annually for improvements. But people don't save money by going there, even when they gamble and win.

The rainfall and the proportion of sunny days to cloudy ones are about the same as at Nice or Mentone, and need not be specially considered. One advantage in favor of Monaco is that less dust is found there than at Nice, Cannes, or Hyères.

The drinking-water of Monte Carlo was not good at the time of the writer's tour of inspection. But it was about to be changed for a better supply. As regards the sewerage of the place, although an elaborate and expensive system of street drains exists, it is not as perfect as the authorities claim. As Monte Carlo and Monaco are rapidly growing this is a matter of great importance to their future claims as health-resorts.

In the writer's article already alluded to, this point is referred to as follows: "Excepting the low-lying quarter called Condamine, Monaco affords every natural advantage for a perfect system of drainage. Yet so far from being in good shape, this essential sanitary requirement leaves much to be desired here. It is true, drains have now been established in all the principal streets, and most of them have a sufficient natural incline. But, as elsewhere on the Riviera, the house connections are insecure and dangerous. This applies more particularly to the old house-pipes that were subjected to the violent shaking up of the earthquake a few years ago. The authorities are only just beginning to realize that, in spite of the prevalent English closets, some radical reforms may be needed.

"Many of the old, poorly constructed, unventilated cesspools still exist, and receive the house-soil. As plenty of water is now used they would have to be emptied every two or three weeks. But house-owners, in order to avoid this expenditure, have, in spite of forbidding law, connected their cesspools by overflow pipes with the main sewers. Cut-off traps having been quite generally omitted, the obvious consequence is that sewer-gas is almost certain to enter all hotels, villas, and lodg-

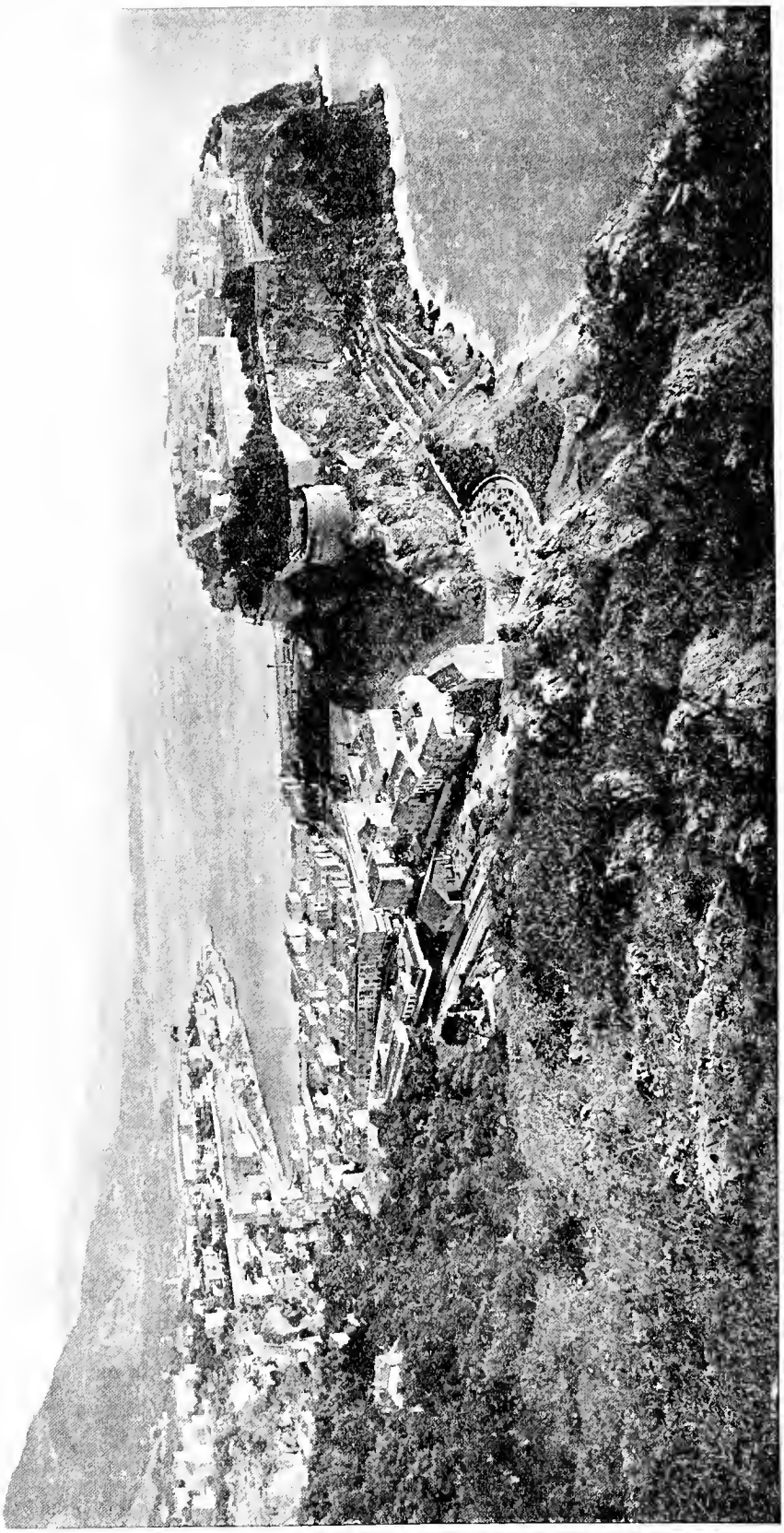

FIG. 430.—View of Monaco and Monte Carlo.

ing-houses provided after this obsolete fashion. The evils of so reckless a system are to some extent counteracted by the winds that cleanse the polluted atmosphere. But the night-air of such dwellings is bound to be dangerous, and, whenever possible, windows ought to be kept open all night. I am bound to state, however, that offensive odors, such as are so often justly complained of at Nice, are only rarely experienced at Monte Carlo. But Nice is eight times the size of Monaco, as regards population, and as the latter place grows, the present evils are sure to augment, unless proper precautions are taken.

"The sewers, intended only for surface waters, now discharge into the landlocked little harbor, which is an additional nuisance, fraught with potential danger for this place. In regard to the provision of amusements, more particularly concerts and theatricals, Monte Carlo stands without a rival on the Riviera."

Patients should always be warned against visiting the Casino, even as lookers-on, for the dust-laden, stifling air of the unventilated rooms is responsible for many illnesses which could have been avoided.

The indications for spending a winter season at Monte Carlo or Monaco do not differ from those which apply to the Riviera generally, and the reader is accordingly referred to the article on this subject which appeared in Volume VIII. of the HANDBOOK. With Americans Monte Carlo is a favorite resort, and one is sure to meet numerous countrymen there every winter.

Edmund C. Wendt.

MONTMIRAIL. A watering-place in the Department of Vaucluse, France.

LOCATION.—Montmirail-Vacquarais is a small village, possessing several purgative and one chalybeate spring. It is not well known outside of France, but as the really efficacious waters are now exported in large quantities, it will probably soon acquire more of an international reputation. The place is pleasantly situated between Orange and Carpentras.

ACCESS.—The village of Montmirail is reached by way of Orange, on the Paris, Lyons & Mediterranean Railroad. It is one and one-half hour's drive from the station.

ANALYSIS.—The principal spring of Montmirail is rich in sulphate of magnesium, and resembles the celebrated Seidlitz and Pällna waters. According to Mr. Henry one thousand grammes of the *Source verte* contain:

	Grammes.
Sulphate of magnesium	9.31
Sulphate of soda	5.06
Sulphate of lime	1.09
Chloride of magnesium	0.83
Chloride of sodium	0.18
Chloride of calcium	0.18
Bicarbonate of lime	0.37
Bicarbonate of magnesia	0.16
Calcareous phosphates, silica, alumina, sesquioxide of iron, and arsenical principle	0.39
	17.30

Traces of iodides, salts of potash and ammonia, and organic matter.

The sulphate of magnesium imparts a decidedly bitter taste to the water, but purgation is not accompanied by griping pains or other signs of intestinal irritation.

INDICATIONS.—These waters are chiefly employed in gastro-intestinal affections with a tendency to constipation, in dyspepsia, abdominal plethora, diabetes, and affections of the spleen, and in some of the constitutional effects of malaria. Season, May to September.

ACCOMMODATION.—There is only one bathing and thermal establishment with a fairly good equipment. The boarding arrangements are on a modest scale. There is an absence of fashionable life.

Edmund C. Wendt.

MOUNTAIN SICKNESS. Ger., *Bergkrankheit;* Fr., *Mal des Montagnes;* Sp., *Puna* (?). Mountain climbers have often described a peculiar train of symptoms from which they suffered in first ascents after reaching a certain height above the level of the sea, and which systematic medical writers have grouped together under the name of mountain sickness. The first mention we find of the ailment was made over two centuries ago, but for a long time no special attention was paid to it, as it was supposed to be due merely to the unusual exertion of climbing, and to be nothing more than a form of fatigue. Within the past fifty years, however, several writers have described the affection at length, and have even made ascents for the sole purpose of studying it, analyzing the symptoms observed, and endeavoring with more or less success to discover the true cause of their production. Notwithstanding that the facts upon which our knowledge of mountain sickness is based, and which have led writers to regard the affection as one *sui generis* and due to a specific cause, have, as was just mentioned, been accumulating for more than two centuries, and have been collected by scientists in special excursions made for that special purpose, they are even yet fragmentary and insufficient to warrant the formulation of a definite and satisfactory explanation of the symptoms.

Among the most recent observers of mountain sickness was Mr. Edward Whymper, who made ascents of some of the highest peaks of the Andes with the avowed object, among others, of gleaning some new facts bearing upon the effects of high altitude upon the human body. He did not accomplish this object as fully as he had hoped, for, although he made twelve ascents to various heights, he suffered from but one pronounced attack of the malady. This occurred during his first ascent, and appeared suddenly when his party had reached an elevation of 16,664 feet (barometric pressure 16.510 inches). He and his two Swiss guides found themselves suddenly incapacitated for work of any kind. Respiration was hurried and was accompanied by spasmodic gasps or gulps. All suffered from intense headache and a feeling of general malaise and exhaustion. The dyspnœa seemed to be the most marked feature of the attack, for the sufferers could breathe only with the mouth wide open; conversation was abandoned, being literally a waste of precious breath; smoking became distasteful, and was moreover too difficult of accomplishment to be indulged in, even had it been otherwise desired; eating was impossible, because of the interruption thereby occasioned to the one important occupation of breathing; and even fluids had to be taken sip-wise and as it were in stolen moments between gasps. The temperature was somewhat elevated (38° C., or 100.4° F.), and the pulse was markedly accelerated. Recovery was very gradual, and indeed was not complete until the party had descended to their camp, at some distance below the point where they had experienced the attack. Even after recovery seemed to have fully taken place, Mr. Whymper says, he remained very weak, became easily fatigued, and was troubled with shortness of breath on the slightest exertion. None of the party suffered from nausea or vomiting, but this may have been because they were all so "knocked out" that they were incapable of any exertion, and possibly they might have had some pronounced gastric symptoms had they been able to move about at all, and thus tax their little remaining strength.

This attack was experienced upon the occasion of the first ascent of Chimborazo, and, as before mentioned, at an elevation of a little over 16,500 feet. But it never recurred in any of the eleven subsequent ascents (one of them up Chimborazo again), although at one time they reached a height of 19,500 feet (barometer, 14.750 inches). They were able to remain at this elevation for twenty-six hours "without any serious inconvenience," although in all their ascents they experienced more or less lassitude and some dyspnœa, being always compelled, when in movement, to breathe with the mouth open.

In looking about for an explanation of the phenomena of mountain sickness, Mr. Whymper naturally finds it in the diminution of atmospheric pressure, in the operation of which, however, he distinguishes two factors, one permanent in its action and unavoidable, the

other temporary. The permanent factor, and the one for which he thinks it improbable that tolerance could ever be established, is the reduced value of the air that can be inspired by ordinary efforts in a given time. As a result of this it becomes necessary to inhale a much larger quantity of air, and therefore to make habitually a greater number of inspiratory efforts in a given time, in order to bring to the blood circulating through the pulmonary capillaries a volume of oxygen equal to that supplied to it by ordinary respiration nearer the level of the sea. The second factor is the reduced pressure upon the surface of the body, as a result of which the air or gas within the body expands and presses with more or less force upon the internal organs. The symptoms so produced are temporary, and pass away as soon as the equilibrium is re-established between the internal and external pressure, and they may even be avoided altogether by making the ascent very leisurely, and pausing at frequent intervals to permit of a modification of the pressure within the body sufficient to equalize it to that of the surrounding atmosphere.

Although Mr. Whymper's observations were carefully and intelligently made, they are less useful as a contribution to the literature of the ailment than they might have been had he not been an experienced mountain climber. Both he and his guides had made numerous Alpine ascents, and had thereby become more or less acclimated, if such expression may be allowed; and as a result the affection was not manifested in them to the same degree that it would have been in others unaccustomed to exertion at great elevations above the sea-level. One of the characteristics of the malady is that, as a general rule, it affects a person severely only upon his first ascent to a height of from ten thousand to fifteen thousand feet. The second time the symptoms are usually less pronounced, if too long a time have not elapsed since the first ascent; and when frequent excursions are made at short intervals, the system becomes so adapted to the changed conditions that the unpleasant symptoms of the malady are no longer manifested. Expert mountaineers seldom experience any inconvenience save under very exceptional circumstances, as for example when ascending to an unusually great elevation, or when suffering from the effects of some debilitating condition.

The first symptom noticed is an increased rapidity of respiration, with a feeling of constriction of the chest. The pulse is accelerated and there may be some irregular action of the heart; a sense of fulness and pressure in the head, increasing at times to a throbbing pain, is present, and the person complains of a peculiar weakness of the legs, sometimes accompanied by rather sharp pains in the knees. Ordinarily these early phenomena are of slight intensity, and may be dissipated by taking a few deep inspirations. Not so, however, if the individual persists in his determination to ascend beyond this point. Under the combined influence of increasing rarity of the atmosphere and of continued muscular exertion, the symptoms grow more and more severe, new ones of a more grave character appear, and finally the sufferer is compelled by sheer physical exhaustion reluctantly to give up the struggle and acknowledge himself beaten by the quiet but invincible forces of nature. Rest, especially in a recumbent posture, affords relief at once to the more pressing symptoms and gradually effects a cure of the ailment, even though the person do not descend to any lower level. The improvement is often, however, very slow, and the less distressing symptoms, such as moderate dyspnœa and a feeling of fatigue on slight exertion, may persist for days, or even weeks.

The severer manifestations of the malady are of two classes, the one seemingly due to insufficient oxygenation of the blood, and the other resulting from diminished atmospheric pressure. In the first category we find, in addition to the shortness of breath, drowsiness and lassitude, vertigo and the appearance of black spots before the eyes, intense cephalalgia, eructations, and frequently nausea and vomiting. There is usually also considerable thirst, accompanied by a feeling of dryness of the mouth and fauces. The weakness of the legs and sense of fatigue increase, until the patient becomes utterly exhausted and incapable of any further exertion. At the same time the reduction of atmospheric pressure causes a fulness of the venous system. The superficial veins of the exposed portions of the body are visibly swollen, and hæmorrhages frequently take place from the mucous surfaces. Epistaxis is common, and in aggravated cases bleeding from the stomach and intestines has been noted. Dr. Pöppig, who lived for a number of years at Cerro de Pasco, Peru, some 14,500 feet above the level of the sea, has stated that new arrivals there were often unable to shave for the first few days of their stay, owing to the extreme tendency of the skin to bleed. He mentions also an instance of a person who was forced to give up playing on the flute, as every attempt to do so caused him to spit blood. If all the inhabitants were similarly affected, it will be conceded that an exile at Cerro de Pasco would not be without its compensations.

The process of acclimatization is apparently a slow one, when the individual remains constantly at so great an elevation, for Dr. Pöppig says that no European is able, during the first year of his residence at Cerro de Pasco, to exert all his former strength, and it is only gradually, in the course of the second year, that he acquires ability to do so.

Mountain sickness appears much earlier and is more pronounced in those who are walking than in riders. Aëronauts can ascend to much greater heights without suffering than can mountain climbers, for they are sitting quietly in the car of the balloon and are husbanding their breath. So it is, in less degree, with riders or those travelling up the mountain side in wheeled conveyances. Thus Dr. Esserwein tells us of a journey he made by rail from Callao up to a town in the mountains lying at an elevation of about 11,500 feet above the sea. While sitting quietly in the car he felt no inconvenience, but immediately upon alighting at the station he was seized with dyspnœa, constriction of the chest, rapid and irregular pulse, and apparently some elevation of temperature, though he was unprovided with a thermometer and could not determine the degree of fever.

Animals, such as horses, dogs, pack-mules, etc., born in the lowlands, suffer in the same way as men when taken up the mountains, but animals born at high elevations are exempt. The native mountaineers are likewise untroubled by the malady, and can run, hunt, and labor hard in other ways at heights at which new-comers are utterly prostrated and incapable of the slightest muscular effort. Shepherds are found grazing their flocks in perfect contentment, both in the Andes and in the Himalayas, at elevations of about 16,000 feet, but they can seldom remain for any length of time at much greater elevations than this. The loftiest inhabited spot on the globe is said to be the Buddhist convent of Hanle, in Thibet, which is situated at an elevation of 16,533 feet. Here twenty priests pass their time in prayer and meditation. It is true, this occupation cannot be regarded as, physically, a very exhausting one, yet it must have required heavy labor to build the convent, and it would be interesting to learn the medical history of the laborers employed in its construction. The highest point in the Himalaya Mountains at which exercise was possible, was found by the Schlagintweit Brothers ("Reisen in Indien und Hoch-Asien") to be 21,982 feet. In the case of pack-mules driven beyond their powers, death from mountain sickness is not very unusual, and the malady has been known to result in death even in men, who were unused to mountain climbing, and who persisted in their upward struggles until the heart gave way under the unaccustomed strain. It is said that cats invariably die in convulsions if taken up much beyond 13,000 feet.

Alpine climbers seldom suffer acutely from mountain sickness, probably because they make graduated ascents, not often going to very great heights on their first trial. And, as was mentioned above, old and experienced climbers seldom experience any disagreeable symptoms, unless they have been living a long time on the plains, or happen to be run down by fasting, cold, or extraordinary fatigue. De Saussure, however, in an account of an

ascent of Mont Blanc in August, 1787 (" Voyage dans les Alpes "), says that the guides suffered severely, when attempting to put up the tent in which they were to pass the night, at the comparatively slight elevation of 12,763 feet. He himself suffered not a little from shortness of breath, weakness of the legs, and vertigo, but the distressing symptoms disappeared almost entirely when he turned so as to face the strong north wind, swallowing it, as he said, in great gulps.

M. Charles Martins made an ascent to the summit of Mont Blanc in July, 1844, going from Chamounix to the Grand Plateau three times. The third time he reached this point his guides had an experience similar to that of De Saussure's guides, half a century before, suffering quite severely from dyspnœa and weakness while engaged in shovelling away the snow in order to clear a space for the erection of the tent. Yet these same men had suffered no inconvenience of consequence in their two previous trips to the same spot. The reason why they were attacked more severely the third time was doubtless, as M. Martins says, because they had made the ascent with unusual rapidity. Dr. Auguste Lepileur, who accompanied M. Martins in this ascent, has described the physiological effects of the trip upon himself and the others of the party in an article in the *Revue Médicale* for 1845.

In August, 1869, Dr. L. Lortet, of Lyons, made two ascents of Mont Blanc, with the special object of studying the phenomena of the *mal des montagnes*. The first trip was made with a party of five, exclusive of the guides. The first night was passed at an elevation of about 10,000 feet. No special symptoms were noted at this station, except that M. Lortet had most pronounced anorexia and was unable to swallow a morsel of food. The first suffering was experienced after the party had ascended above 12,800 feet, the symptoms then complained of consisting of drowsiness, intense occipital headache, thirst, and dryness of the throat, complete loss of appetite, and nausea but no vomiting. In some of those examined the pulse ran up to from 160 to 172 per minute. There was a wretched feeling of malaise, and the sufferer had a sense of utter indifference concerning his own fate or that of his companions, very similar to the apathy of the sea-sick. On arriving at the summit this malaise passed away, but there was still shortness of breath and palpitation on the slightest movement. One of the party, who had not previously suffered, was taken suddenly, on arriving at the summit, with giddiness and vomiting of mucus and bile, which did not cease until the level of the Grand Plateau was again reached.

On the occasion of the second ascent, a few days after the first, M. Lortet felt only great drowsiness, but even this passed away under the stimulus of the cold wind, and of the snow beating against his face. He had no malaise during the trip, and could now eat with relish, having no return of the anorexia of the first ascent; but his shortness of breath was extreme.

An analysis of the symptoms manifested by the various members of the party developed some rather curious facts, especially in regard to the body temperature. Dr. Lortet made a number of observations on this point, and found that during the violent exercise of climbing, when near the summit of the mountain, the sublingual temperature fell in a remarkable manner. While sitting quietly the temperature was normal or nearly so (36.3° to 37° C. = 97.3° to 98.6° F.), but after a period of severe exercise it was greatly reduced, falling in one instance to a fraction below 32° C. (89.5° F.)! After a few minutes of rest the mercury again indicated a normal temperature. The writer remarks in support of the correctness of these remarkable findings, that subsequent experiments showed that violent exercise would reduce the temperature of the body from three-tenths to seven-tenths of a degree centigrade (one-half to one degree Fahrenheit), provided the individual were fasting. He explains the phenomena as follows: When a person in the lowlands exercises violently there is a transformation of heat into force, but by reason of the fact that a sufficient quantity of oxygen is available, the production of heat within the body keeps pace with its loss, so that the temperature is constantly maintained at the normal figure. In elevated regions, however, where the atmosphere is rarefied, the expenditure of force uses up the body temperature more rapidly than the organism can supply it. This loss of heat is further increased by the rapidity of the circulation, the blood not having time to become properly oxygenated while passing through the pulmonary capillaries. As the blood is also driven to the surface, it is probable that increased radiation aids in still further cooling the body. M. Lortet's explanation is quite ingenious, but not very plausible. A much simpler elucidation of the problem is that the reduction of temperature was only apparent, or rather that it was purely local. During exercise the members of the party were forced to breathe through the mouth and thus the parts were cooled off; after resting for a while the mouth could be closed, and then its temperature rose again to that of the body. The writer has repeated M. Lortet's experiment of exercising in the open air at a moderate elevation, actively and even violently, while fasting, and he has never found any appreciable reduction of the sublingual temperature as long as the mouth was kept closed.

The author of these observations was, however, so impressed with the startling fact of this reduction of temperature that he attributed the greater part of the phenomena of mountain sickness to it, although he was willing to concede that the vitiation of the blood by the accumulated carbonic acid might contribute to the results observed. He found that this loss of body heat did not take place in those who could eat regularly (possibly because these same ones who were able to eat suffered less from dyspnœa), and this observation afforded him an explanation of the utility of the guides' habit of eating every two or three hours. Unfortunately, he says, it is not usually possible to make use of this discovery in the way of prophylaxis, as the novice in mountain climbing has such an unconquerable repugnance to food that he finds himself unable to swallow a single morsel.

There are two other theories which have been advanced in explanation of the origin of mountain sickness. The more commonly accepted of these is that advocated by M. Paul Bert, who referred the production of the symptoms chiefly, if not entirely, to the diminished supply of oxygen. He believed that man ordinarily inhales more oxygen than he actually requires, just as he usually consumes more food than is absolutely necessary for the support of life; and just as one can accustom himself by degrees, and after more or less hunger and inconvenience, to a diet far below that which he ordinarily consumes, so he can gradually, at the expense of some dyspnœa and temporary suffering, habituate himself to dispense with this superfluity of oxygen. According to this theory the affection is due to the reduced oxygen pressure, as a result of which the red globules of the blood are able to absorb a smaller quantity of the gas than they do in the more condensed atmosphere of the lowlands. The process of acclimatization is accomplished by an increase in the number of the red globules, whereby larger amounts of oxygen, proportionately to the inspired air, are absorbed, little or none of the gas taken into the lungs being wasted, as it is in the case of individuals living at or near the sea-level. M. Bert examined the blood of the llama of the Andes, and found that it was capable of absorbing, for every one hundred volumes, at least five more volumes of oxygen than was the blood of sheep feeding in the plains. It has been shown also by Regnard and Müntz, in experiments upon rabbits, that a reduction of atmospheric pressure, either natural on mountains or artificial under a bell-glass, was followed by an increase of the hæmoglobin of the blood and a consequently greater power of absorption of oxygen.

The other theory is one advocated with much skill by Dr. Georg v. Liebig, who believes that mountain sickness is not essentially due to a diminished supply of oxygen in the air, but that it is rather a consequence of one's inability to breathe properly at first in a rarefied atmos-

phere. Similar symptoms, he says, are often observed under certain circumstances in the lowlands, as when one tramps, for example, in deep snow or in soft and yielding sand. In a person thus exerting himself one may see the veins swell and the face become purplish, his breath comes short and panting, his heart's action is labored and rapid, there may be even vertigo and momentary nausea, and he is forced to stop now and again as his legs refuse to do their duty. The origin of these symptoms is laid by v. Liebig to restricted respiration. As long as the severe exertion continues the abdominal muscles are tense and the belly is drawn in, the diaphragm is pushed up and cannot descend sufficiently to permit of full and deep inspiration, such as is needed to pump the blood out of the turgid veins into the right heart. The lungs also are more or less compressed, and while the bodily exertion creates a demand for an increased supply of oxygen, the impeded respiration permits of less being inhaled. The diminished supply results of course in imperfect oxygenation of the blood, and this in turn manifests itself in the muscular weakness, especially of the legs, and in vertigo and nausea. In this case the actual cause of the distress is to be found in the compressed position of the lungs, and although the malady is never so aggravated in the lowlands, disappearing always immediately upon the individual ceasing his exertion and resting, it is nevertheless the same in kind as mountain sickness. The origin of the ailment, in the one case as in the other, is to be referred to a disturbance of the respiratory function. In the lowlands the symptoms arise only upon great exertion, but at high altitudes they appear spontaneously or after moderate exercise and persist often even when the subject is at rest. In a rarefied atmosphere, v. Liebig claims, the lungs are compressed as a result of the diminished resistance to expiration, and full expansion is effected only by a conscious exertion. The result of this diminished respiratory power is seen in the gasps and hurried breathing, in the venous turgescence, and in the consequences of diminished oxygenation of the blood above detailed. Dr. v. Liebig therefore argues that it is to the change in the density of the air, rather than to the reduced quantity of oxygen contained in it, that the phenomena of mountain sickness are rightly to be attributed. He does not think that the hæmoglobin theory is sufficient to account satisfactorily for the facts of acclimatization, but holds that we can, in the course of time, so alter the rhythm of respiration as to accustom ourselves to breathe deeply and slowly, without being always conscious of the necessary expenditure of strength.

Neither of these theories seems to the writer to be sufficient in itself to explain satisfactorily all the phenomena of mountain sickness and all the facts of acclimatization. It would appear hardly probable, for example, that the absorptive power of the blood could have been so rapidly augmented, or that the respiratory rhythm could have been so quickly changed as to confer a practical immunity upon Mr. Whymper and his two companions after their single unpleasant experience. It is true that their former mountaineering may have brought about a permanent increase in the amount of their hæmoglobin, or that their past experience may have taught them to alter their respiratory rhythm unconsciously and rapidly to meet the necessities occasioned by the rarefied atmosphere; but in that case they ought not to have suffered so severely upon their first ascent of Chimborazo.

It is more easy to reconcile the second of these theories with the observed facts than the first, and it receives some support also in the writer's opinion from what has been observed in relation to sea-sickness. There are numerous points of resemblance between sea-sickness and mountain sickness, although in many respects they differ very greatly. One theory of sea-sickness is that the phenomena are the result of a disturbed respiratory rhythm, and a form of respiratory gymnastics has been proposed as an efficient mode of treatment for mild cases of the ailment. That the taking of prolonged and regular inspirations is useful in relieving a moderate amount of distress at sea, the writer can affirm from personal experience, though whether it would cure a pronounced attack of the malady he is inclined to doubt. The same procedure will relieve the first signs of mountain sickness also, but it may be permitted to doubt its efficacy in restoring a sufferer at fifteen thousand feet to his normal state.

It is most probable that both these factors—diminished pressure and lessened respiratory value of the air—are active in the production of the symptoms grouped under the name of mountain sickness, but it is possible also that there are certain meteorological or other conditions, impossible of detection by our present instruments of precision, upon the presence or absence of which variations in the intensity of the observed symptoms may largely depend.

The treatment of mountain sickness requires but brief notice. Rest is, of course, demanded, but even that is insufficient to bring relief in aggravated cases. No doubt deep and regular inspiratory efforts would be serviceable, but the immediate need for air is often so urgent that the sufferer can only gasp, and cannot be persuaded to take the time necessary for a prolonged inspiration. Oxygen would without question be of value for the relief of certain of the symptoms, whatever theory as to the causation of the malady may be correct, but ordinary mountain climbers are usually sufficiently encumbered with their necessary traps and cannot carry with them the apparatus necessary for making oxygen gas. Whymper made some trials of potassium chlorate, which might theoretically be thought useful in furnishing oxygen to the tissues, but his companions had an aversion to drugs and would not lend themselves readily to his experiments, so that it was impossible to determine what the effect of the remedy might be when given methodically and in proper dose. Fortunately, few people are called upon to ascend high mountains in the ordinary course of business, and those who do so from a love of adventure or ambition must make up their minds to take the unpleasant along with the agreeable. Of course, no one whose thoracic organs are not in perfect condition should ever attempt the ascent of a high mountain.

Thomas Lathrop Stedman.

LITERATURE.

The following are some of the more important works and journal articles on the subject of mountain sickness which have been consulted by the writer in the preparation of the preceding account of the malady:

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MYELITIS. Little advance has been made during the last few years in our knowledge of this disease. Hayem and Parmentier have reported several cases of myelitis of blennorrhagic origin, but they are doubtful in character. Dufour also reported a case which developed during the course of gonorrhœa, and the autopsy showed characteristic lesions in the spinal cord, but no bacteriological examination was made.

Oppenheim has come to the conclusion that true primary myelitis is a rare disease. He says that a revision of the clinical histories of the hospital cases under his observation shows that the large majority belonged to the category of so-called compression myelitis (generally from disease of the spine, latent caries) or, as in two cases, from a malignant tumor of the abdomen extending to the spine. In some other cases post-mortem examination showed syphilitic disease of the spinal membranes, which extended to the cord. Very rarely a case which had been regarded during life as myelitis was proved to be a neurosis, especially hysteria. Frequently a case which was first looked upon as myelitis was

found, in view of its subsequent course, to be a disseminated sclerosis. A specially interesting case shows that a transverse myelitis may be simulated by a combined columnar disease:

A woman, fifty-one years of age, was admitted to the hospital on October 24, 1888. Since August, 1887, she had suffered from weakness and pains in the legs, with formication, and has been paralyzed for the last three months. During the last few weeks there have been flexion contracture of the legs, disturbances of the bladder, and a cincture feeling around the abdomen. At the present time she suffers from complete paraplegia with flexion contracture, increased tendon and cutaneous reflexes, diminished sensibility to touch and temperature, incontinence of urine; the upper limbs are normal. This condition remained unchanged except that the knee-jerk was subsequently lost. The case finally terminated fatally. The autopsy disclosed combined disease of the posterior columns, the lateral and anterior pyramid columns.

The diagnosis of chronic myelitis was also made very rarely (in four cases) by Oppenheim. When the cerebral symptoms were taken into consideration, the large majority of the cases were found to be disseminated or multiple cerebro-spinal sclerosis.

Oppenheim concedes that there is no longer any doubt of the intimate connection of disseminated myelitis (myelo encephalitis) with infectious and toxic processes. It may develop: 1, in acute infectious diseases (variola, scarlatina, typhoid, erysipelas, gonorrhœa); 2, on the basis of syphilis, tuberculosis and malaria; 3, in the puerperal state; and 4, in the cachexia due to the growth of malignant tumors.

Leyden divides the infectious diseases of the spinal cord into the following groups:

a. Parasitic diseases in which the pathogenic micro-organisms develop directly in the cord. Such cases are very rare. They include acute myelomeningitis which occurs as the result of typical cerebro-spinal meningitis. Leyden has shown that in some cases the diplococci enter the cord along the connective-tissue septa, and produce inflammation of the latter which extends to the white substance of the cord. Furthermore, capillary emboli appear in the cord as the result of ulcerative endocarditis, the latter being due to the presence of staphylococci or streptococci. It is also probable that acute poliomyelitis is an acute infectious disease, although the pathogenic micro-organism is still unknown. Spinal affections occurring in gonorrhœa are probably due to direct propagation of the gonorrhœal process to the cord.

b. Infectious myelitis due to the action of toxines formed during the infectious disease. One large group includes sequelæ of acute infectious diseases. They generally appear as disseminated myelitis with coincident affection of the medulla and pons. This variety also occurs after traumatism, and after pregnancy and childbed.

c. Toxic myelitis which occurs after the excessive ingestion of ergotin and spoiled maize, and in zinc workers (?).

d. Anæmic or cachectic myelitis. Lichtheim found under such conditions myelitic processes in the posterior and lateral columns of the cord, but they did not possess a systematic character.

The question with regard to the real nature of the so-called compression-myelitis of Pott's disease has not yet been definitely settled. The weight of evidence is in favor of the view that this condition is primarily a degeneration of the nerve-elements, due to the ischæmia which is consequent on the compression, but that at a later period an inflammatory condition develops in the degenerated parts. *Leopold Putzel.*

MYRTOL. A constituent part of the essential oil, derived by distillation, from the leaves of *myrtus communis*, L. It is supposed to closely resemble eucalyptol. It is a clear liquid with a powerful but not unpleasant aromatic odor. It is recommended as a disinfectant and deodorant, but has no bactericidal action. In medicine it is used to replace the balsams in bronchitis, blenorrhagia, and vaginitis. In small doses it improves the digestion and stimulates the appetite, but in larger doses it irritates the stomach. It is recommended particularly to remove the fetid sputum of bronchiectasis, and in gangrene of the lung. It is administered in doses of two to five minims, in capsules, repeated two or three times a day. *Beaumont Small.*

NAIRN. A Scotch sea-side resort of growing popularity. Nairn is a royal burgh of great antiquity, not far from Inverness, and pleasantly situated on the shore of the Moray Firth, at the mouth of the river Nairn.

It is a healthy place, with a fine sandy beach, and is popularly referred to as the "Brighton of the North." According to Black ("Watering-places of England, Scotland, and Ireland"), the climate of Nairn is "dry and bracing, and such is the influence of the sea on the air surrounding it that the extremes of temperature experienced at places more inland are not felt here. On no occasion during the last twenty-one years has the thermometer in the shade risen above 78.3° F., or fallen below 11.2° F. The annual mean temperature, calculated from a series of accurate observations, would seem to be 47.9° F.; that of summer (April to September), 54° F., and of winter (October to March), 41.8° F.; the difference between the means of these two seasons being 12.2° F. August, on an average, is the hottest month in the year, and February the coldest. The air is driest in June and dampest in February. The mean annual height of the barometer, corrected to 32° F., and reduced to the level of the sea, is 29.810 inches. The highest elevation of the mercurial column thus corrected, during twenty-one years' observation, has been 30.881 inches, and the least, 27.998 inches; the range of this instrument is smallest in June and greatest in November; the annual average does not exceed 1.408 inch. The yearly rainfall does not amount to more than twenty-six inches; the greatest quantity falls in October and the least in April."

Nairn has been recommended as a winter-resort, but it has no just title to be so considered, as the meteorological data just given amply demonstrate.

Edmund C. Wendt.

NAPHTHALENE. In addition to the external use of naphthalene in the treatment of parasitic and other forms of skin disease, and as an antiseptic dressing, it has been extensively employed as an internal remedy in all conditions in which an intestinal antiseptic is indicated. Its insolubility makes it a very safe medicine, and enables its antiseptic action to be continued throughout the whole course of the intestinal canal. Professor Rossbach, of Jena, first employed naphthalene in acute and chronic intestinal catarrh, and its use has been extended to cholera infantum, summer diarrhœas of children, dysentery, and all forms of dyspepsia and intestinal indigestion, accompanied by flatulency and fermentative changes. It is given in doses of 2 to 6 grains to children, and from 15 to 20 grains to adults, repeated three or four times a day, its administration being preceded by a dose of castor-oil. Some have obtained good results in infants by giving it in ¾-grain doses every two hours. To adults it has been given in as much as 60 to 90 grains in the day. It has also been used as suppositories, 15 grains of naphthalene to 2½ drachms of cacao-butter, introduced after an evacuation. It has proved of service in dysentery and in ulceration of the rectum when introduced as an enema: naphthalene, 5 parts, olive-oil, 200 parts. This may be introduced by means of an ordinary syringe, and repeated three or four times a day if required.

Naphthalene has also been highly spoken of as an antiseptic for the treatment of typhoid fever. Its advocates claim for it a decided beneficial action in shortening the duration of the fever, a lessening of unfavorable symptoms and complications, and a lowering of the death-rate. Dr. L. Wolff reported (*Philadelphia Medical News*, May 23, 1891) a series of one hundred cases, with a mortality of only two per cent., excluding certain deaths from causes outside the fever, and a mean duration of the fever of

24.3 days. On admission calomel and soda was administered to empty the intestine, and this was followed by five grains of naphthalene every four hours, alternated with a few drops of hydrochloric acid; no other medication was permitted excepting chemical antipyretics and cold sponging for hyperpyrexia. Dr. Wolff found that although it has no direct effect in lowering the temperature, its continued use speedily produced lysis and a normal temperature; in cases in which it was at once discontinued the temperature rose again. It was found necessary to continue the drug for some time after the temperature became normal. He considered that at the onset of typhoid fever naphthalene may inhibit the development of the pathogenic microbes, so far that the disease could be aborted; and that at any period in the disease over-production of the chemical toxines may be prevented, and the fever made to run a mild course. Naphthalene has been widely employed in hospital and private practice, and still receives its share of attention with other intestinal antiseptics. The results of this treatment, however, has not been uniformly favorable, and this, together with its disagreeable odor and taste, has proved a decided disadvantage and tended to lessen its employment. Other antiseptics without these disadvantages, notably salol, have replaced it to a great extent.

Naphthalene has been recommended as an anthelmintic by Dr. Mirowicz (*The Lancet*, December, 1891). He considers it superior to all other remedies on account of the certainty of its action and the absence of all toxic effects. It has proved of service against all kinds of intestinal worms, and its action is prompt and effective. One dose has caused the expulsion of a tape-worm, the head included, and in thread-worms and ascarides it has proved equally beneficial. Previous to administering the drug the patient should be dieted with salted, acid, and spiced foods. It should be given on an empty stomach, and followed by a dose of castor-oil. The quantity for adults is from 8 to 20 grains; a dose of 15 grains has usually proved sufficient; children may be given from 4 to 8 grains. It has also been used as an injection for pin-worms, the drug being mixed with one and a half to two ounces of olive-oil.

The fumes of naphthalene have been employed with some success in whooping-cough. A small quantity is to be placed in a dish and surrounded with hot coals; it soon melts and fills the room with white fumes. To be effective the patient should inhale the fumes continuously until the cure is complete.

The disagreeable taste requires it to be given in capsules or rice-paper, or in pill form. It may be formed into pills by mixing with half its weight of powdered marsh-mallow root and forming into a mass with mucilage. When given as a powder it may be mixed with sugar, and its taste and smell disguised by a drop of oil of bergamot or peppermint. *Beaumont Small.*

NAPHTHOL CAMPHOR. CAMPHORATED NAPHTHOL.—The preparations and derivatives of naphthol, such as betol, beta-naphthol-benzoate, and microcidin, have in a great measure supplanted the drug itself, both for internal and external use. The combination of naphthol and camphor, although known for some time, has recently been recommended for the treatment of tuberculous glands, tubercular phthisis, diphtheria, and as a valuable antiseptic wherever such is indicated.

It is prepared by rubbing together one part of beta-naphthol and two parts of powdered camphor. A viscid liquid results, insoluble in water, but freely miscible with oils. It should be kept in well-stoppered, dark-colored bottles, as it readily decomposes when exposed to air and light.

Dr. Jules Reboul, of Marseilles, who advises its use in tuberculous glands, employs it by injecting eight drops directly into the gland tissue, and repeats the injection every second day. Should any matter have formed, it is first to be evacuated. In cases where the gland has been laid bare by ulceration, a tampon saturated with the naphthol camphor and placed in contact with the surface has produced a healing action, not only in the gland itself, but also in the other affected glands in the neighborhood. The drug is absorbed and produces a beneficial action, both local and general in character. Its effect is prolonged, and the drug can be detected in the urine for twenty-four hours after an injection. The treatment is absolutely harmless and simple. In forty-seven cases reported by M. Reboul, twenty-eight were said to be cured and nineteen improved. It was also used in cases of tuberculous disease of the testicles with equal success. He injected four or five drops every eight or ten days into the tuberculous nodules on the epididymis and testes. In tuberculous disease of the lungs it is employed by being injected directly into the parenchymatous tissue of the affected lung, two minims in two and a half drachms of olive-oil being used.

As a local antiseptic it is said to be most active and effective. In diphtheria it has proved of much benefit, as it removes the false membrane and leaves a healthy healing surface. When applied to mucous surfaces it is frequently accompanied by pain, and requires an application of cocaine previous to its use. *Beaumont Small.*

NARCOSIS, FROM ADMINISTRATION OF ANÆSTHETICS. It is not the purpose of this brief article to trench on the broad field covered by the subject "Anæsthetics," in this volume, nor to attempt to improve upon work there so ably done. Simply, in as practical and concise a way as possible, the writer will herein group, from the stand-point of clinical surgery, those methods of treatment of anæsthesia-narcosis in excess which seem to him valuable, beyond a peradventure; and which should be clearly formulated in the mind of every operator. Other modes of treatment, such as by electricity and by means of various drugs, of secondary or doubtful value, will not be touched upon.

This accident is so appalling when actually at hand, and demands so cool a head and such instant resource, that no apology seems necessary for devoting to it a special, though short, chapter in this work.

Following the teaching of Dr. H. C. Wood,[1] in his recently repeated experiments, we agree that the treatment of both ether and chloroform narcosis should be identical. And, while in experiments on dogs the respiration often seems first and chiefly at fault, experienced anæsthetizers know that the heart (at least in the human subject) often gives as early—sometimes earlier—warning of threatened failure. This is especially true of chloroform narcosis; and with either drug it behooves a careful operator to put an experienced man on guard, and not the usual tyro; and to see that both pulse and respiration are watched ceaselessly.

It is, of course, best to *prevent* the peril under discussion, if possible; and the writer firmly believes that with this idea in view it is always wise to administer, about fifteen minutes before the anæsthetic, as large a hypodermatic injection of morphine, guarded by atropine, as seems safe. For instance, gr. $\frac{1}{4}$ to $\frac{1}{3}$ morphine sulphate, and gr. $\frac{1}{120}$ atropine sulphate, in an adult.

The reasons for this course are elsewhere fully discussed (see Anæsthetics); one alone should be enough to determine the question, namely, that under this treatment much less of the anæsthetic is needed in order to keep the patient "under to the surgical degree." Consequently the dose of ether or chloroform being considerably lessened, the liability to poisoning is proportionally diminished. And incidentally it may be added, both morphine and atropine are agents of value to ward off shock due to the operation.

Because of its great value as both a respiratory stimulant and a heart tonic, and for the reason named in the last sentence, the writer approves of the use for a day or two, in moderate doses, prior to any severe operation, of *strychnine sulphate*. Perhaps, when shock is actually present, it is of more value, if pushed to moderate strychnization, than any other single drug; and if this be true, its use in *prevention* of that shock when anticipated would seem sensible.

As Dr. H. C. Wood has demonstrated,[1] it is of decided value when used by needle during anæsthesia-narcosis;

and here again its use in prevention seems occasionally indicated.

An ounce or two of whiskey or brandy, before the anæsthesia is begun, can have none but a beneficial effect; of this the writer is convinced. Being itself (in moderation) a cardiac stimulant, the alcohol is a safe addition to our narcosis; and, as is the case with morphine, will, though to a lesser extent, render unnecessary so large a dose of the anæsthetic as otherwise would be needed. But, during the operation, should excessive narcosis supervene—with or without the preliminary use of alcohol—*then* the writer can but agree with Dr. Wood in thinking that alcohol as a remedial measure would be folly, since it is a narcotic, and the patient is already suffering from too much narcosis. There are better systemic stimulants at hand which are not narcotics.

"Nothing can be more prone to produce fatal syncope than the commencement of the operation before complete anæsthesia has been induced; for here we have a lowering of the vital functions caused by chloroform, and the shock of cutting the skin, especially over a sensitive area, communicated along sensory nerves whose conduction is not yet in abeyance. Records of death under these circumstances (incomplete anæsthesia) show how often the fatality arises in cases where trivial, although painful, operations, such as reduction of dislocated limbs, circumcision, etc., are performed."[2]

Finally, under this heading (*prevention* of dangerous narcosis) let us discuss a plan little advocated in print, but which has only to be heard to commend itself; namely, as a measure of precaution in a patient of feeble vitality about to be subjected to operation, *maintaining a reserve-guard of pure blood*, by accumulating this in one or more extremities; to be released, however, in case of need from narcosis.*

Of course, accumulation of blood in this way in the members is not a new thing at all; but the *purpose* for which it is herein advocated is so, it would seem.

Dr. A. C. Post, of New York, was, I think, the first to use this device in anæsthesia. Dr. Charles McBurney read a paper before the New York Surgical Society, about a year ago, speaking of the plan as one neglected and worthy of more frequent use. He demonstrated it there and then upon a man brought for that purpose. The technique as described by Dr. McBurney was as follows: "Immediately before anæsthesia is begun an ordinary Esmarch bandage has been placed on each arm and thigh, close to the trunk, and sufficiently tight to obstruct the venous return. The radial and posterior tibial arteries have been carefully watched, and only when the limbs have become loaded with blood (distinctly swollen) has the constriction been increased to such an extent that all circulation, arterial as well as venous, has ceased in the limbs. Anæsthesia is then begun, ether having been used by me in every case, and the inhaler being an ordinary one made of muslin and paper, and containing a little cotton. The storage of blood in the limbs has not affected the patient's facial appearance at all, and no peculiar sensation has been mentioned excepting a little complaint in one or two instances regarding the bands. The method has been applied to ten operative cases (and many more since this paper was written). At the beginning of the anæsthesia from one to two ounces of ether have been poured into the inhaler from a measuring-glass. The patients have been remarkably free from signs of irritation; that is, congestion of the face has not occurred, and struggling has been nearly entirely absent. Complete anæsthesia, so that the conjunctiva could be freely handled, has been accomplished in from three to five minutes. Coughing has occurred only once, and then for a very short time. Trembling of the limbs has not occurred at all.

"The mouth has required wiping free from mucus only once. No mucous râles in trachea or bronchi have been heard in any case. During the operation the anæsthesia has been quieter and more perfect than is at all common with ether. . . . As soon as the operation has been terminated and the dressings applied, the bands have been removed, and all four limbs raised. The rapidity with which patients have recovered from the effects of the anæsthetic has been very noticeable. Most of them have been able to talk intelligently and answer questions correctly within three minutes. Vomiting has occurred but once, and then to a slight degree only. None of the usual stupor has been noticed after the ether-cone has been removed."

The purposes for which this device has heretofore been advocated are the relief of kidney and other overburdened emunctories, especially when these show signs of disease; speed of anæsthesia and of waking therefrom; less bleeding, during operations upon the head or trunk; avoidance of deleterious effect of the anæsthetic upon more blood than is absolutely necessary; shortening the period of bronchial and pulmonary irritation, which lasts until all the ether has escaped from the system; prevention of vomiting; and economy of anæsthetic.

To these should now be added Dr. Webster's suggestion, which the writer has several times made use of practically when feebleness of the patient has made him fear anæsthesia-narcosis. Not all four limbs, as just described, but for this purpose one thigh will suffice. This is corded at the groin, at first slightly, permitting it to swell with accumulated blood, and then tightly enough to obstruct all flow in either direction. The limb should now be kept wrapped in a blanket, with warm bottles or bricks about it. In case of dangerous narcosis, release the band, elevate, and pour the great quantities of pure blood contained in the limb into the body surcharged with ether or chloroform. The good result of this needs no discussion. Of course the other and more usual plans of treatment are also to be used.

Treatment of Narcosis.—Where respiration is mainly at fault, the heart being safe, Sylvester's method of artificial respiration is our best treatment, beginning always, as in drowning, by the expulsive effort. The passage-way to the larynx must be kept free from blood, mucus, and vomited matters; and either the tongue kept drawn well forward by a clamp on it (the mouth, meanwhile, being held open by a cork between the teeth, or any of the ordinary gags), or else Mr. Benjamin Howard's plan of raising the epiglottis should be employed, which is efficient if the nasal respiratory area is unobstructed. This latter plan is to over-extend the head as far as possible. The mouth is closed, and "a chain of three links" is made tense by this position; *i.e.*, the genio-hyoid muscles, the hyoid bone, and the hyo-epiglottic ligaments. Consequently the epiglottis cannot fall over the entrance to the larynx, and the air passes in freely through the nose.

Protrusion of the symphysis menti by the thumbs behind the rami of the jaw, is a plan often followed, in order to prevent obstruction of the larynx by the base of the tongue. The genio-hyo-glossi muscles are thereby drawn forward, in turn the glossi-epiglottic attachments are made tense, and the epiglottis thus lifted.

Koenig's plan, suggested in chloroform narcosis, is intermittent pressure upon the chest, one of the thumbs being placed in a space over the heart (differing simply in this latter respect from Nussbaum's method) between the apex-beat and the sternum. And Maas' modification of this plan is one whereby the pressure aforesaid is made very rapidly—one hundred and twenty times per minute. Both, it would seem, must act mainly by frequent expulsion of narcotized air, and admission of fresh; and consequently must come under this heading—artificial respiration. It is difficult to conceive that the thumb in an intercostal space over the heart can compress that organ appreciably or enough to excite it afresh to work, though we cannot deny the possibility.

Inversion of the Patient.—This, the plan of Nélaton, is generally regarded as our first choice when the heart is

* Dr. W. T. Aikens and Dr. L. M. Sweetnam, of Toronto, and Dr. Leonard Corning, of New York, have also all used and advocated this plan of sequestration of blood; but not for the purpose mentioned by the writer of this article. He has not heard of its actual employment by others beside himself, in prevention of dangerous narcosis. The credit of the suggestion belongs, however, with Dr. David Webster, of New York, who, as the writer finds, published a note upon it in the New York Medical Journal for October 29, 1887.

mainly at fault, although artificial respiration also aids a flagging heart. Dr. Chisholm, of Baltimore, depends exclusively upon this; and although his extensive record of operations under chloroform (ten thousand) without a death certainly makes his opinion deserving of respect, I think there are few who will, with him, refuse to use artificial respiration and other valuable aids to resuscitation in addition to inverting the patient.

The latter, upon the appearance of signs of suspended animation with failing heart, should be held from sliding off the table, which is meanwhile so tipped that the patient's head is downward, and almost vertical.

It has been taught that cerebral anæmia is hereby overcome through gravity, and, consequently, the nerve-centres controlling heart and respiration being better supplied with blood are enabled thereby to do more efficient work. To the writer it seems that this explanation is far from the true one. In only one way can blood from the lower part of the chest, the abdomen, and lower extremities, reach the brain, if the patient be inverted; *i.e.*, by being pumped through the heart. Certainly *not* by gravity alone. And since we know that mechanical distention of the chambers of the heart by the circulating fluid is a most important factor in exciting cardiac contractions, the proper explanation is not far to seek.

Rapidly repeated compressions of the chest, with both the surgeon's hands, in its lower—epigastric—portion, meanwhile, will aid expulsion of narcotized air; and following each such emptying of the lungs by the surgeon, the Nélaton posture (by dragging on the pectoral muscles through the weight of the arms hanging by the sides of the patient's head) causes a mechanical inspiratory act after Sylvester's principle. So that if the patient be held sufficiently inverted, this position, with Nussbaum's treatment (just mentioned) will render Sylvester's needless.

The writer prefers this combined method (Nélaton-Nussbaum) to Sylvester's, where both heart and respiration are failing; and this is certainly the rule rather than the exception.

Heat.—It cannot be questioned that among methods of exciting a narcotized heart to resume work, one of the most efficient is *heat*. A quart of hot water injected by syringe into the rectum, while the patient is inverted as just described, is standard treatment. The patient's body and limbs should not be left unclothed to be chilled, but should be wrapped in warm blankets. The late Dr. Sands, of New York, has stated that he valued most highly moist heat over the heart. The writer has seen not only this gentleman, but others of the best-known surgeons in New York, cause a blister several inches square on the præcordium by application of steaming hot cloths during daugerous anæsthesia-narcosis.

Dr. Charles McBurney has recently said in a letter to the writer, "When the heart flags seriously in ether and chloroform narcosis, I regard very hot applications directly over the heart as of decided value as a means of stimulating that organ to renewed activity. . . . I like the idea of your arterial saline injections very much, and shall use it at the first opportunity."

The latter sentence has reference to a plan, devised by the writer, whereby heat may, with infinitely more directness and efficiency, be brought to bear on the heart. This is, *to pump hot salt-water directly into the blood-current*, and thereby stimulate both heart and respiratory centre in the medulla.

This is so self-evidently a useful proposition as hardly to need argument in its defence. The wonder is that it was not long ago used for this purpose; but, so far as the writer can discover, it has not heretofore been suggested.

If, as is generally admitted, heat applied over the heart can stimulate that viscus—whether directly, by extension through the chest-wall until felt by the apex-beat, or reflexly—how much more efficient must be that stimulation when that heat is brought into the heart-chambers, in the circulating fluid!

The temperature of the salt-water used should be *as hot as the hand can possibly support*. This will be 49° C. (120° F.) or a trifle less; and therefore the thermometer need not be employed. A much higher degree of heat than this could safely be used; since globulin only coagulates at 70° C.[3] (158° F.), and serum-albumin at 72° C.[4] (162° F.); or about 40° F. hotter than the hand can bear. At the temperature first mentioned (120° F.) the writer has recorded[5] a number of cases of hæmorrhage so treated, with excellent results; and Dr. Edwin Sternberg, of New York, two more, with recovery; whereas others which he had treated also by saline infusion, but at bodily temperature, died.

It is demonstrated both by the writer's kymographic experiments, heretofore reported, and by the foregoing cases, that very *hot* saline infusion is not only safe but best, in severe hæmorrhage; and the same is true in the matter under discussion—heart-failure in narcosis from anæsthesia.

The strength of the salt-solution * is that normal to the blood-serum; roughly, a heaped teaspoonful of chloride of sodium to the quart of sterilized water. It is fair to assume that every operating-room, even in a private house, has water ready at hand that has been boiled and is still hot. This, some table salt, a Davidson syringe, and a coarse hypodermatic needle or a cannula are all the equipment needed. Remove the tip from the syringe, replace it with the cannula-hilt, and tie the latter in place with a thread. Disinfect this apparatus by pumping boiling water through it.†

As to the amount of the solution to be used, perhaps a pint may be called an average. In a case immediately threatening death I should inject still more, and hotter. The method is also of use in yet another way—by bringing added pressure to bear upon the heart-chambers, just as with the inversion plan (Nélaton's).

In hæmorrhage or in shock threatening imminent death, the writer has urged, in recent publications, the injection of the hot infusion *directly into the femoral artery;* the aspirating needle (not as yet attached to the syringe) finding it readily where, under Poupart's ligament, it is large enough in calibre to carry a lead-pencil, and a bright-red drop of blood welling up in the needle proving the latter to be in place; upon which the syringe-end is tied on and the injection begun.‡

But here, in anæsthesia-narcosis, there is not a moment to waste. The hot salt-water should reach the heart, in considerable amount, very quickly; more quickly than the hypodermic needle would permit. It is better therefore to use the cannula, and while the assistant is attaching the base of this to the syringe-end, and filling both with the hot solution, the surgeon opens a vein at the bend of the elbow—or the internal saphenous over the inner malleolus, or any other vein of fair size; perhaps one in the operation-wound. Now the cannula is tied within this vessel and the injection given. In a properly equipped room the injection may be begun within a minute or two of the time it is determined upon.

Of course if the patient is able to swallow, hot drinks—for example, black coffee—or other hot stimulants (save alcoholic), are indicated.

Cold.—Although in the writer's opinion not so efficient as heat, the application of a piece of ice over the heart will sometimes reflexly excite more vigorous contractions; and similarly, ice within the rectum aids respiratory efforts.

Use of Drugs.—Our syringe and cannula are still in

* We must never omit the salt—it would be fatal to mix plain water with the blood, as this at once dissolves out the hæmoglobin from the blood-disks; whereas even so small an amount of salt as that named—six parts per thousand—renders it safe.

† Of course well-equipped surgeons will not have to waste precious minutes by these steps, which may well be taken before the beginning of an operation requiring anæsthesia.

‡ The only objection—a self-evident one—to this device, in hæmorrhage, is the hesitancy naturally felt to pierce so large an artery; and this should vanish when one reflects that the most prominent plan now used by surgeons for aneurisms so placed as to be inoperable by ligation, and yet threatening rupture, is that of Macewen, of Glasgow, which is needling, and in which long needles are thrust—a dozen or so—into the sac, and left for many hours, to cause thicker deposits on the walls; and this with benefit, as a rule.

If a diseased vessel can safely stand such treatment as this, it seems a mild inference that a sound artery can bear a single needle for a single half-hour. And such has been the writer's experience thus far.

place—the latter tied within a vein. Either mingled with the hot salt-water, or preceding it, or following it, we may use properly diluted *aqua ammoniæ*, a remedy of unquestioned value. The latter, strychnine, and digitalis comprise all the drugs recommended as of real use in this condition by Dr. H. C. Wood in his Berlin Report in 1890, who however did not experiment with strophanthus and many other heart-tonics. He says: "From fifteen to twenty-five minims of the aqua ammoniæ fortior, diluted with four times its bulk of water, should be thrown directly into a vein of the arm, and repeated in fifteen minutes if necessary."[6]

The same drug may be exhibited by inhalation, with some caution, as it is capable of causing violent local inflammation where used in excess. The only hypodermic abscess for which the writer has ever been personally responsible was caused by an injection of aqua ammoniæ—and not the *fortior*—in a case of opium narcosis; not injected into a vein but into the subcutaneous connective tissue of the thigh. A slough more than an inch across resulted.

Regarding *amyl nitrite*, it is certain from Burrall's clinical cases that it must be of some value, although Wood found it inefficient on dogs. Paralyzing as it does unstriped muscle everywhere, and consequently completely dilating the blood-vessels, it must inevitably diminish the resistance caused by vascular tone against which the heart has to work in pumping blood. If that tone be lost from *complete* narcosis, then it is plain that in such case, at such time, this drug would be almost useless, since its *direct* stimulant effect on the heart is but slight, and the rapid action of this organ under amyl nitrite is due mainly to depressing the inhibitory centres; to which, in complete narcosis, the heart could hardly be expected to respond vigorously.

Strychnine has already been discussed. Both as a heart tonic and as a respiratory stimulant it is of great value.

Regarding *digitalis*, the testimony is equally strong, so far as the heart is concerned. The writer carries regularly to his operations a solution of strychnine sulphate in equal parts of the tinctures of digitalis and strophanthus, and has repeatedly used this combination by hypodermatic needle with benefit.

Strophanthus alone he has not employed. However, since it is more rapid in action than is digitalis, has less tendency to contract arterioles than has the latter drug, and stimulates the heart vigorously and very much like digitalis, it is obviously indicated.

Two remaining devices the writer has never seen used; but he cannot doubt their value in absolutely desperate cases. This has been repeatedly demonstrated on the lower animals. One of these is mechanical stimulation of the heart by a long, slender needle passed through the anterior chest-wall;[7] and the other, introduction of a finger through a cut in the præcordium, thus permitting intermittent pressure on the heart; to be repeated some twenty times, at the rate of seventy to eighty times a minute. It is not necessary to empty the heart thereby; a slight pressure will drive on some blood.[8]

In conclusion, it is perhaps needless to say that surgeons employ not one but as many as are deemed wise, at once, from this list of weapons against an enemy that comes unexpectedly and kills quickly if at all. Every moment is golden, and indecision or unwise choice may, in a matter like this, cost a life.

Robert H. M. Dawbarn.

[1] Berlin Report, 1890.
[2] Anæsthetics: Mr. D. W. Buxton, 2d edition, 1892, p. 122.
[3] Kirke's Physiology, 11th edition, p. 846.
[4] Dalton's Physiology, 7th edition, p. 80.
[5] Medical Record, January 2, 1892; also November 12, 1892.
[6] Wood's Therapeutics, 7th edition, p. 330.
[7] D. W. Buxton (quoted), p. 125.
[8] Mr. George Rowell, F.R.C.S., British Medical Journal, October 29, 1892.

NASAL SURGERY, ASEPTIC AND ANTISEPTIC.

The only reason why antiseptic methods have been employed so little in nasal surgery is because surgical operations in the nose have become frequent only within the last few years. It requires a few years for any line of surgery to develop antiseptic methods. In a very short time it is safe to predict that the rhinologist will be as particular in his methods of operating as is the abdominal surgeon of to-day. It would seem that either the general surgeon is over-careful in his attempts to secure perfect cleanliness, and over-zealous in the employment of aseptic and antiseptic agents, or nasal surgeons, so far as my knowledge extends, have paid too little attention to this matter of antisepsis in their operative work. If the germ theory of infection or of putrefactive fermentation of Pasteur, Koch, Lister, and Watson Cheyne—a theory which is firmly believed in by nine-tenths of the leading American surgeons to-day—if this germ theory is proven, nasal surgeons need to be as particular as other surgeons in their methods of operating.

In a discussion of a paper by the writer, entitled "Antiseptic Nasal Surgery," by the American Laryngological Association, at its Tenth Annual Congress, 1888, various opinions were expressed as to the necessity of employing antiseptic measures when doing nasal surgery. The discussion became very general. Several of the gentlemen said they did but little nasal surgery, because in their opinion there were but few cases that required surgical interference. A small number employed only the galvano-cautery in removing tissue, and were not favorably disposed toward cutting and drilling operations upon the bony and cartilaginous structures of the nose, so that, aside from the observance of strict cleanliness in treating nasal disease, they had had but little occasion to employ antiseptic solutions. I would like to add, in parentheses, here—and I shall refer to it again—that the application of the galvano- (that is, the actual) cautery to open wounds affords one of the most effective means of preventing the absorption of septic material. Gerster[1] says "the actual cautery is the most effective sterilizer." It may be true, therefore, that if only the galvano-cautery is used in removing nasal obstructions there is little need to employ other antiseptic precautions. Strict cleanliness before operations, and application of the actual cautery to the wound would perhaps satisfy most aseptic operators. While it is true, however, that the majority of rhinologists do make use of the saw, scissors, and trephine, so short a time has elapsed since these instruments were perfected, and also, indeed, since nasal surgery has assumed its present large proportions, that it is perhaps still too early to pass judgment upon the question whether perfect asepsis and antisepsis are attainable in nasal surgery.

A second reason for the lack of attention paid to the use of antiseptics in nasal surgery is that the wounds inflicted by operations are very small as compared with those which the general surgeon has to treat; but the advantage the nasal operator possesses in the loss of a smaller extent of surface tissue is more than equalized by the peculiar conditions of nasal wounds, and these conditions furnish the *third* reason why antiseptics have been held at so low a value by nasal surgeons. It is far more difficult to employ antiseptic methods effectively in the nasal cavities than upon the surface of the body or in the abdominal or pelvic cavities. Not only is it wellnigh impossible to obtain an aseptic condition before operations, as can be done on the surface of the body, by thoroughly scrubbing with soap and water, and sponging with a solution of carbolic acid or bichloride of mercury, but the nasal wound is subjected to all the conditions which are deemed most favorable to the generation and propagation of micro-organisms, viz., heat and an abundance of moisture and oxygen.

Watson Cheyne[2] says: "The ideal result of wound treatment is seen in the repair of subcutaneous injuries." He might have cited nasal wounds as the most unfavorable illustration of wound healing. The decomposing nasal secretions add to the fertility of the soil which is most favorable to the development of pathogenetic microbes. The swelling of the tissues within the bony nasal walls prevents effective drainage, one of the safeguards against septic absorption, and the pent-up secretions furnish ample septic material until the absorbents are satisfied. We find, therefore, in nasal wounds

caused by operation both varieties of the "obstacles to repair" which are recognized by writers—the mechanical and the chemical. The mechanical are present in the particles of bone, cartilage, or soft tissue, or in the atoms of dirt which remain in the nasal cavities unless great care is taken to wash them out, while all the usual conditions of nasal wounds favor putrefactive fermentation, which is the basis of the chemical obstacle to healing.

In endeavoring to mention all the difficulties lying in the way of the practice of aseptic nasal surgery, we must not forget that the peculiar anatomical structure of the nasal tissues and the peculiar physiological function they perform, furnish additional hindrances to the proper treatment of wounds. If an attempt is made to exclude all air from an ulceration on the septum, by covering it with a protective and sealing the nasal orifice, we have the evil results which are caused by the irritation of these packings in the nostril. The erectile tissues will not bear the contact of a foreign body with impunity, the dressings disturb the vaso-motor reflexes, and the nostrils are filled with mucus and serum, which wet the dressings and render them less effective.

In view of these difficulties the question may be asked, Is it possible to obtain an absolutely aseptic condition for the healing of nasal wounds? We think not. If this is true, is it the duty of the nasal surgeon to use all antiseptic methods possible? Are we depriving our patients of any degree of safety or comfort by treating nasal wounds as the general surgeons treated all wounds before antisepties were known? To make the question still more tangible: Do we see symptoms of septicæmia more frequently following those nasal operations where no antiseptic precautions are observed, than those which are protected by every effort to exclude disease-bearing germs? Our experience would say, yes, emphatically. We believe that few patients would die if nasal wounds were made with unclean instruments; but everyone is entitled to every safeguard which protects his life, and which adds to his comfort. Our patient must not be put to bed because of a small nasal operation. It is possible to do nasal surgery in such a manner that his business will not be interfered with. I shall not at this time discuss the point whether there is more surgical work performed in the nose than is requisite or judicious. There should be no debatable ground as to *how* it should be performed.

In 1888, before antiseptics were generally employed, when investigating the value of antiseptic methods in nasal surgery, I found that it was almost the universal testimony of those who used the knife, the saw, the scissors, and the trephine, that constitutional disturbance, more or less marked in character according to the amount of tissue removed or the extent of surface denuded, followed a certain percentage of these operations. These symptoms may be stated as commencing in from twelve to forty-eight hours, with slight chilly feelings, occasionally with a chill, and followed by a rise of temperature ranging from 99.5° F. in mild cases, to 103° F. in severe ones, headache, pains through the eyes, nose, and forehead, and in the back and limbs. The patient feels too ill to engage in any business. Men of nervous temperament remain at home for a day or two, and women stay in bed. These patients seem to be extremely nervous and irritable, and they do not thoroughly regain their equilibrium for some time. Some of the above symptoms occurred in some degree after, perhaps, twenty-five per cent. of the cutting, sawing, or drilling operations on the nose. Of the severe cases I have seen but one in my practice, and that was not in any sense grave. I may describe it.

In the spring of 1887 a young man came to me with his left nostril almost entirely stopped with cartilaginous deflection. I remember him as one of the most nervous patients I ever saw. The trephine driven by the electric motor was used. The operation lasted but a few moments. Hæmorrhage was not severe, but it was persistent, and I placed an ordinary cotton tampon against the wound. The patient came to the office the next day. I removed the plug and washed the nostril with a carbolized solution, but, as the bleeding continued, I put in a second tampon. I saw the patient at his house the next day. The tissues over the left nostril and cheek were swollen and red, the left eye was almost closed by œdema of the lids. The patient had had chilly feelings the night before, and I found his temperature 102.5° F. He exhibited the nervous irritability spoken of. I removed the plug and washed the nasal cavities with carbolized solutions. He began to improve the next day, and was about in four days. In another case, operated upon in 1886, after the use of the galvano-cautery on the septum, the patient suffered from constitutional symptoms; temperature, 101.5° F.; and on the second day after the operation an erysipelatous blush showed itself on the nose and for a short distance on the cheeks. This lasted only twenty-four hours and the patient quickly recovered.

I formerly saw numbers of cases where the patient felt uncomfortable the second day after an operation on the septum. There was probably some slight rise in temperature in all these cases. It used to be common enough in dispensary practice to have patients return a few days after a cautery or drilling operation on the nasal septum, and say that they had felt quite ill for some time after the operation.

My attention was most forcibly called to the serious results which may follow nasal operations by the uncomfortable experience of a prominent surgeon of New York. He was operated on by a physician of experience in nasal work. A cartilaginous and bony convexity of the septum was removed by a revolving drill The work was done under chloroform. The second day after the operation the nostril was closed by inflammatory swelling. The patient had a chill on the evening of the second day, and for seven days afterward the temperature ranged from 103° to 104° F.; slight chills were frequent, perspiration abundant, albumin in the urine. The nose, eyes, and face were considerably swollen. The patient lost flesh so rapidly and was so depressed mentally that fears were entertained at one time that he would not recover. He convalesced slowly, and was unfit for work for six weeks. In conversation with me about his case he criticised in strong language the lack of antiseptic methods employed by nasal surgeons. He himself, a strong advocate of all antiseptic precautions, and most particular in his practice as a general surgeon, styled the old-time methods by the more expressive than elegant term of "rotten surgery." There was no doubt but that he had suffered from a severe attack of blood-poisoning, the "septic intoxication" of Cheyne, the "traumatic infectious" disease of Koch. Absorption of putrid matter had taken place through the denuded cartilage and bone of the nose, and, as a consequence, he had almost lost his life. I have heard of other serious cases, but have no authentic history of them. But this all occurred from 1886 to 1888.

The constitutional symptoms which follow operations in the nasal cavities, even where no antiseptic precautions are resorted to, may not be severe nor long continued. The patient's life is rarely endangered, but his comfort may be seriously interfered with. There are a number of rhinologists who do not perform cutting or drilling operations upon the nose because they fear the constitutional disturbance that may follow such operations. As one physician expresses himself in regard to these operations, he "prefers to be on the safe side." Is it not possible to operate freely in any nasal case where good judgment advises, and, by employing strict antiseptic precautions, always be on the safe side?

General symptoms, which appear during the first twenty-four hours after a nasal operation, may properly be attributed to shock and the reaction after shock. The amount of shock will depend upon the temperament and general health of the patient. Sex seems to have little significance. Shock will be in proportion to the amount of tissue removed, the extent of surface laid bare, the amount of pain inflicted, and the quantity of blood lost. The degree of shock is also in direct ratio with the length

of time consumed in operation. Shock seems to be greater when the nasal septum is wounded than when the soft tissues are injured, but this perhaps is because the saw, scissors, or trephine are rarely used on soft tissues. All the symptoms which may be fairly attributable to shock following the small operations upon the nose should be over in twenty-four hours. For example, a cutting operation is performed upon the septum, and in a few hours the patient may feel generally shaken up—with headache, neuralgic pains about the eyes, nose, and teeth; he may feel weak and perhaps even faint; reaction declares itself in a slight rise of temperature, not more than 99.5° F., which subsides in twenty-four hours. We should not confound such constitutional disturbance with symptoms which begin later, last longer, and are more pronounced—symptoms which surgical writers formerly grouped under the names of "traumatic" or "surgical" fever.

The transitory disturbance called shock subsides as soon as the nervous system has had time to recover its equilibrium. But neither shock to the nervous reflexes nor mechanical disturbance of the nasal circulation is considered any longer competent to explain the systemic disturbance which was called "surgical fever" by the operators of twenty years ago. Thanks to the investigations of Pasteur and Koch, and to the antiseptic surgical procedures elaborated by Lister, traumatic fever is no longer a legitimate disease which follows all surgical operations. The presence of marked constitutional disturbance, chills, and high temperature after the severest operation now reflects unfavorably upon the methods employed by the operator, and the old "laudable" pus, teeming with germs of suppuration, has been proven to be an evidence of wound infection.

The belief that symptoms such as we have described were caused by the action of micro-organisms, and were not, as Billroth [3] has it, "the general accidental diseases which may accompany wounds," had been suggested at the beginning of this century; but, in 1831 Braconnet stated the opinion that micro-organisms produced virulent principles which acted as ferments. In 1836 Donne discovered microscopic organisms in the pus of chancres. In 1848 Fuchs spoke of the presence of bacteria in some of the septic diseases of animals, and Pollender, in 1850, discovered bacteria in the blood of cattle dying of charbon.

In 1861 Pasteur began his remarkable demonstrations, proving first that butyric fermentation was effected by an organism, and in the next year that there existed in the air countless organized corpuscles which were the germs of fermentation. In 1863 he stated that putrefaction was determined by ferments of the vibrio species. This theory of the relation of putrefaction to fermentation was quickly and naturally applied to pathological conditions, and the germ origin of splenic fever was soon demonstrated.

Pasteur was first to maintain that septicæmia was of germ origin. Koch has demonstrated, by inoculation in animals, that a number of diseases similar to those in men are caused by a specific microbe. Pathogenetic microbes have been demonstrated in erysipelas, gonorrhœa, anthrax, empyema, tuberculosis, osteomyelitis, etc. Rosenbach,[4] of Göttingen, after painstaking experimentation, denies the possibility of the formation of pus by mechanical, physical, or chemical means if microbes are excluded, and Ogston [5] has also quite clearly shown that all suppurative processes are caused by micro-organisms. Gottstein,[6] of Berlin, says that the microbes found in pus probably exist in a latent way on the skin, and in the mouth and nose, and become active only when a wound is produced which gives them access to the blood-tissues, or rather furnish an opportunity for the absorption of the *products* of the micro-organisms—the so-called ptomaïnes, or the sepsin of Bergmann, or the "putrefactive alkaloids," or the *excrementitous products* of the microbes mentioned by other writers. Gottstein further says that this absorption continues until an aggregation of leucocytes furnishes a barrier which prevents its further progress. This dam of leucocytes is the granulation tissue which is present in old ulcerations, and its presence explains why we have no symptoms of blood-poisoning in ulcerous coryza and other long-continued ulcerations of the nose. Gottstein asserts that these micro-organisms are the cause of traumatic infectious diseases. Cheyne [7] remarks: "The antiseptic method is based on the germ theory of fermentation and putrefaction, and not necessarily of infectious disease." Roswell Park [8] says: "The lowest forms of vegetable life are the cause of all forms of fermentation, only a certain number of which are putrefactive." This latter fact granted, antiseptic surgery has given its reason without discussing in detail the origin of surgical diseases. Some one has said that "antiseptics should be used to supplement cleanliness." Gerster [1] says in his text-book that "modern wound treatment is based entirely on the old and well-known principles of the preservation of organic substances." I cannot do better than to quote once more from Cheyne,[2] whose very intelligent writings make the subject of antiseptics a very attractive one. He says: "When a wound is large, and no antiseptics are used, absorption takes place, and we have in a few days *traumatic fever*, and that the symptoms of septic intoxication are due to the absorption from the wound is proved in that the symptoms subside when granulation takes place."

The bacteria which are found in the nostril may be harmful or harmless. Nature may or may not be able to prevent the entrance of septic germs through surgical wounds of the nose, or render them innocuous after their entrance. These considerations remain to be settled by bacteriological study, but the experience of some years in nasal surgery has fully satisfied us that our patients suffer far less after operation from constitutional disturbance, and the wounds heal more quickly, when they are somewhat protected from external influences. Dr. Jonathan Wright, of Brooklyn,[11] has made a careful study of the various kinds of bacteria which he found in the healthy nose, and if space allowed it would be of interest to quote largely from his article, "Nasal Bacteria in Health," but a few results must suffice. He found that the bacterial forms varied very much according to the dry or moist condition of the streets, and the amount of wind existing. The staphylococcus pyogenes was by far the most frequent variety found. The investigations of many workers in this field have demonstrated that this form of bacterial life is found upon all the mucous surfaces and upon different portions of the human body. Whether this particular germ is the one which is to be feared after nasal operations remains to be decided. The many conditions which are necessary to the growth of this, as well as to that of the many other forms of micro-organisms, leaves us in doubt as to the influence they exert upon a nasal wound. They must be in sufficiently large numbers to overcome Nature's resistance. Although the staphylococcus pyogenes is found in abundance in the mouth, it is a significant fact pointed out by Wright,[11] that infection never follows excision of the tonsils or uvula.

Nasal wounds, however, are apparently much more exposed to pathogenic organisms than are injuries of other mucous surfaces, for the nostrils filter them out of the inspired current of air, as has been proven by Aschenbrandt [13] and others. Wright conducted a series of experiments which showed that while ten litres of laboratory air contained four moulds and one hundred and twenty-five bacteria, it contained only one mould and twenty-four bacteria after its passage through the nose,

This is not the place to give the various opinions held by ardent students as to the manner in which nature renders the septic germs harmless, whenever they have obtained entrance into the circulation. It is enough for our purpose to state that the larger number of investigators believe that pathogenic germs are killed by the chemical action of the blood serum, while the minority, represented perhaps by Metschnikoff,[14] hold that the real enemy of disease-bearing bacteria are the leucocytes.

Those who argue against the value of using antiseptics in nasal surgery maintain that since it is impossible to

obtain anything like an aseptic condition of the nose, antiseptic precautions are almost valueless. They might as well say that since the nose cannot be made perfectly clean it is useless to employ any cleansing sprays whatsoever.

Were we ever so indifferent as to the importance of treating nasal wounds antiseptically, we cannot ignore the greatly improved results which surgeons have been able to obtain since they have employed antiseptic methods. The largest operations are so scientifically performed in our hospitals to-day that we have ceased to wonder when we observe that there is less constitutional disturbance after an exsection of the knee, an amputation of the thigh, or an abdominal section, than formerly followed the loss of a finger or toe. A most interesting paper was read at the New York Academy some years ago, which brought out an earnest discussion. The writer advocated external operation for deep urethral stricture on the ground that in performing internal urethrotomy proper drainage was obtained with great difficulty, and that urethral fever, the great bugbear of operators, was due to sepsis and not to nervous causes. The discussion was as to the causation of urethral fever. I believe only one surgeon who discussed the paper indorsed the older theory, that urethral fever was due to reflex nervous causes. In extirpation of the tongue it is found that there is much less danger of septicæmia where preliminary tracheotomy is done, and it is thus rendered possible to employ antiseptic solutions and to partially exclude air from the mouth.

There are two general methods of treating nasal wounds after operation, viz., the open and the closed methods. Among nasal surgeons of large experience there are strong advocates of each. Some operators believe that nasal wounds do well enough if left entirely alone. They do not fear infection, either from the germs which are habitually found in the healthy nostril, nor from those special micro-organisms characteristic of erysipelas, scarlet fever, etc. We should consider it unsafe to advocate such indifference to antiseptic methods. They claim that the blood-coagulum is ample protection against wound infection. There seems to us to be many disadvantages attending the "open" method of wound treatment, and 1st, the danger of hæmorrhage. Strong solutions of cocaine are always used in cutting operations in the nose, so that hæmorrhage immediately after the operation may be slight, for the reason that the cocaine has expelled the peripheral circulation. The bleeding ceases and the patient is allowed to go on the street. The circulation in the nose is restored after a little, and profuse bleeding from the uncovered nasal wound may take place, if not to the danger, at least to the discomfort, of the patient. 2d. If it is granted that there is no danger of infection from the ordinary germs that are commonly found in the nose and in the atmosphere, should we leave nasal wounds exposed to the germs of erysipelas, scarlet fever, diphtheria, etc. ? To dispensary patients such exposure must be common enough. 3d. We have found that nasal wounds heal more quickly when covered by some antiseptic protective.

We believe the majority of writers advocate some modification of the closed method of treatment after operation. We repeat what we have said before, that we think it is impossible to hermetically seal a nostril either by the method proposed by Kitchen[15] or the very similar one proposed by Roe.[16] This plan is to cover nasal wounds with flexible metal, such as tin, copper, or aluminium, the metal shield to be fitted accurately to the wound, after it has been covered with antiseptic cotton or gauze. Our experience with all such appliances is that they are very difficult to adjust, and that most people cannot, or will not, wear them, because of the pain and discomfort they produce. Dr. Roe calls this the "aseptic method as applied to intra-nasal surgery," because he claims that the metal covering entirely prevents the access of pathogenic germs to the wound.

A method advocated by Dr. L. Freudenthal, in a paper read before the Academy of Medicine, in November, 1892, seems to us to promise more encouraging results. He covers the wound with a specially thick collodion, and he expresses the hope that this obtains for the wounded surface an aseptic condition. We have had no experience with this method.

It is wise, we think, to follow some *routine method* in our attempts to secure as nearly as possible an aseptic condition of the nostrils and wound. The success of all antiseptic methods depends upon methodical detail. The methods which are advocated both before and after the operation are in no sense new, but I state them, because, as I have said, it is well to have a detailed routine. Something may be accomplished in the right direction if the patient is instructed to wash out his nostrils twice daily for some days before the operation, with a tepid saline or alkaline spray, such as a modification of Dobell's or Seiler's antiseptic tablets. I like a prescription of peroxide of hydrogen, twenty per cent., containing one per cent. of cocaine muriate in solution. The peroxide of hydrogen cleanses to better advantage after the swellings have been partially effaced by the cocaine. A solution of salt and water, generously and carefully used, does more than cleanse—it acts as an antiseptic. A solution of mercuric bichloride, 1 to 4,000, sprayed with an atomizer is beneficial, but is apt to be irritating. Freudenthal sprays with sterilized water. Tavel's fluid, composed of salt, seven and a half per cent., and natr. calc., two and a half per cent., is recommended on the ground that it is a physiological fluid. The operator can wash out the nose with some one of these solutions just before operating. A sterilized ten per cent. solution of cocaine may be applied to the portion of the nose to be operated upon. All instruments should be sterilized or placed in the usual carbolic surgical solution, and the hands of the operator made aseptic.

I am in the habit of covering the portion of the nostril to be operated upon with clean absorbent cotton, wet with a solution of mercuric bichloride, 1 to 2,000, after the cocaine has been applied, and just before operating. This cotton is only left in position for a moment or two.

After operating, whether with knife, saw, scissors, or trephine, care should be taken to remove all loose pieces of tissue, cartilage, or bone, with forceps ; the patient can assist by blowing the nose thoroughly. A layer of cotton wet with a solution of mercuric bichloride,1 to 2,000, may then be loosely placed over the wound, *not packed* into the nostril. Such a loose layer of cotton becomes a sufficiently tight plug to check bleeding when the effect of the cocaine has disappeared, and the tissues of the nostril have become somewhat swollen. Plugging the nostril tightly for the purpose of stopping hæmorrhage is usually unnecessary, and it causes painful irritation. We are in the habit of keeping patients at our office for ten or fifteen minutes after the operation. At the end of that time the loose cotton layer is removed, and if the bleeding has ceased, iodoform, iodol, or aristol may be dusted over the wound, and the wound again covered with a layer of iodoform gauze, or antiseptic cotton. Usually there is bleeding enough, to render the application of any powder impracticable, and the first layer of bichloride cotton is simply replaced by a second one, or by iodoform gauze, which is left in position for thirty-six or forty-eight hours. We have not been in the habit of washing out the nose with any antiseptic solution after operation, but have been satisfied to allow the patient to blow it thoroughly. We believe somewhat in the protection afforded by the blood coagulum. Roe advocates irrigation of the nostrils after operation with a hot solution of salt and bichloride, 1 to 4,000. It may be wise to check all bleeding by hot antiseptic irrigation, so that an antiseptic powder can be placed upon a fairly dry surface.

Dr. O. B. Douglas, of New York, recommends the use of the solution of aluminium acetotartrate, ʒ j. to ʒ iv., as a substitute for other antiseptics. Cotton may be saturated with this solution and placed upon the wound, and left in position for several days, it is claimed, without danger of wound infection.

After all covering has been removed from the wound at the end of forty-eight hours, the nostrils may with advantage be thoroughly cleansed with some one of the

antiseptic solutions already referred to, and the patient can accomplish all that is necessary by spraying the nostrils twice daily with a proper cleansing prescription. While there is little danger of infection through nasal wounds after the lapse of forty-eight hours, they require considerable attention for many days, to hasten healing and to prevent the outgrowth of granulation tissue, which will again block the nostrils.

Our belief may be stated briefly, in conclusion, that while it is impossible with our present knowledge and present methods to obtain a perfectly aseptic condition for nasal wounds, yet experience has demonstrated that patients suffer far less from constitutional disturbance after nasal operation, that bleeding is more surely controlled, and that nasal wounds heal much more quickly, when all reasonable antiseptic precautions are employed.

Clarence C. Rice.

[1] Gerster: Aseptic and Antiseptic Surgery, p. 3.
[2] Cheyne: Antiseptic Treatment of Wounds, p. 7.
[3] Billroth's Surgical Pathology, p. 396.
[4] Rosenbach: Mikroorganismen bei der Wund-Infection.
[5] Ogston: Report upon Micro-organisms in Surgical Disease, British Medical Journal, March 12, 1881.
[6] Gottstein: Die Verwerthung der Bacteriologie in der klinischen Diagnostik.
[7] Cheyne: Antiseptic Surgery, p. 359.
[8] Park: Antiseptics in Surgery, Wood's REFERENCE HANDBOOK, etc., Vol. I., pp. 257, 258.
[9] Gerster: Aseptic and Antiseptic Surgery, p. 5.
[10] Cheyne: Antiseptic Treatment of Wounds, pp. 15, 16.
[11] Wright: Journal American Medical Association, September 21, 1889.
[12] Wright, loc cit.
[13] Aschenbrandt: Die Bedeutung der Nase für die Athmung. Würzburg, 1886.
[14] Metschnikoff, Elias: Ueber eine spross pilskrankheit der Daphnien, Virchow's Archiv, Bd. cvii., S. 209.
[15] Kitchen: Medical Record, January 7, 1888.
[16] Roe: Medical News, March 28, 1891.

NEPHRORRHAPHY. During the past ten years two hundred and fifty cases of nephrorrhaphy have been reported. The operation may now be said to rest upon a secure basis. The number of cases reported has been sufficient to enable us to determine what danger attends the operation, and what benefits result from this procedure. The details of the operation have been perfected, and experience has proved that certain methods may be rejected as unsatisfactory. Several new methods for the firmer anchorage of the movable organ have also been introduced. Considerable light has been thrown on many of these procedures by experimentation on animals, which in recent years has been pursued, especially in France, with extreme care.

A movable kidney is no longer looked upon as a rare condition. It is difficult to determine exactly in what proportion of cases this abnormality occurs. A marked difference exists in statistics on this point. Thus Lindner claims that one woman in every six has a movable kidney, while most other observers estimate the proportion among females as one in two hundred or three hundred. In males it is a much more uncommon occurrence. I feel sure, however, that it is a condition which is often overlooked, as, unless especially sought for, it will rarely thrust itself upon the examiner's attention. I feel sure also that often symptoms are attributed to other causes which in reality are due to the mobility of the kidney. It is certain that in many cases no symptoms will be caused by this condition. It may be asserted, I think, that in the great majority of cases it is the cause of but little discomfort. In other cases it may cause considerable discomfort, but yet the suffering is not severe enough to demand resort to operative procedures for its relief. It is only in exceptional cases that the pain experienced by the patient is so severe that operation is demanded. There are a few cases where the symptoms produced are of considerable gravity, but which are not suitable for operation, because of the probability that the nephrorrhaphy will fail to relieve these symptoms. In such patients the mobility and displacement of the kidney is dependent on the general laxity of all the abdominal tissues, where an enormously pendulous abdomen has, by stretching the various ligaments, dragged down and displaced the various viscera. In such cases the displacement is so general that the symptoms complained of should not be attributed to the mobility of the kidney alone. I have seen two such patients on whom the operation of nephrorrhaphy had been performed by skilful operators without the slightest benefit.

It is only just to state that a few careful observers, both physicians and surgeons, are still rather sceptical as to the existence of movable or floating kidney, and a certain number of others who doubt the significance of this abnormality as a cause of severe symptoms, and who are still more doubtful as to the necessity or efficiency of any operation for relief of this condition. There is scarcely a man, however, who has devoted special attention to abdominal diseases, who questions the occasional occurrence of movable kidney, and while a few of such specialists do not look with favor upon nephrorrhaphy, yet this number is rapidly diminishing,

The existence of both movable and floating kidney has been proven by thousands of observations on the examining, operating, and autopsy tables. It is equally certain that such mobility is frequently the cause of painful, and in a few cases of grave, symptoms. It has been frequently proven that it is possible to secure fixation of the kidney by operation, and as a result of such fixation the patients have been entirely relieved of their sufferings. It certainly seems reasonable to conclude that with the methods now at our disposal we ought to be able to fasten the kidney so securely that it cannot break loose from its new attachments. If the sutures are passed directly through the substance of the kidney, and then through the muscles of the loin, it seems most rational to believe that such anchorage will, in the majority of cases, be permanent. The numerous cases where relief from all distressing symptoms has directly followed the operation, and where after a lapse of years there has been no return of the symptoms, would certainly seem to prove, almost beyond a doubt, that the permanent fixation of the movable organ has been accomplished. Still further proofs of the satisfactory results obtained are afforded by the patients with thin and lax abdominal and lumbar muscles, through which the kidney can be distinctly felt so firmly anchored in place that strong manipulation fails to move it from its bed. In one of my own patients this condition is very manifest, and on examination three years after operation the kidney can be felt firmly anchored in a situation which, it is true, is rather lower than is normal, but which is sufficiently correct to free her from all pain, which formerly had entirely incapacitated her from work. More than this, several cases have been reported where the firm anchorage of the kidney has been demonstrated both by autopsy and at secondary operations. Langenbuch reports a case where, several months after the original operation, he reopened the lumbar wound on account of a fall which the patient had received, and he found the kidney firmly anchored. Tillman has observed at autopsy, two months after operation, the kidney, which formerly had an extensive range of motion, firmly fastened by newly formed connective tissue permeated by numerous blood-vessels, and intermingled with masses of cicatricial tissue.

Nephrorrhaphy is a justifiable operation in any patient whose life is made miserable by the distress caused by the movable kidney. Indeed in such cases operation should be urged. In other cases where moderate discomfort only is experienced the nature and dangers of the procedure, and its chances for relief or complete cure, should be explained to the patient, and she should then be allowed to decide whether or not she prefers to undergo the operation. In all cases it is a good rule to insist on the trial of some form of bandage or support before nephrorrhaphy is undertaken. In comparatively few of the severe cases will a bandage be of benefit, but it is worthy of a trial. In no case, if the kidney is otherwise healthy, should nephrectomy be advised until nephrorrhaphy has failed.

Mortality.—The operation is a comparatively safe one. In more than two hundred reported cases only three

deaths can be attributed to the operation. One of these occurred in the practice of a surgeon who does not believe in antiseptic surgery, and another occurred in consequence of a dangerous method used in the fixation of the kidney. The mortality can be estimated as about one to two per cent.

In what proportion of cases may we expect to effect a radical cure? This is a difficult question to answer categorically. The majority of cases cannot be watched for a sufficient length of time to be of much aid in this calculation. Certainly eighteen months or two years should elapse before we can decide that a permanent cure has been effected. The proportion of permanent recoveries ranges from fifty to seventy-five per cent., and of the cases operated on during the last four or five years it certainly will reach this latter figure and perhaps exceed it. By permanent cure I mean fixation of the kidney and permanent relief from all bad symptoms. A certain proportion of cases are improved, while in others the kidney appears to be fixed and yet the symptoms persist. In this latter class of cases the diagnosis has probably been incorrect. Out of my own 11 cases of nephrorrhaphy 2 have been complete failures, 6 have resulted in complete cure, 1 has been improved, and 1 has disappeared from view.

Operation.—The object is to firmly anchor the kidney in as near its normal situation as is possible. A number of different methods have been and are employed, but all procedures are alike in one point, that they aim to fasten the kidney to the lumbar muscles by means of sutures. They differ in two points, the nature of the suture material and the tissues which the sutures penetrate. The patient should be placed in such a position as will make the space between the last rib and crest of the ilium as long as possible. This can best be accomplished by placing the patient partly on the side opposite to that on which the operation is to be done, and partly prone. Pads should be placed under the abdomen, and crowding up under the opposite ileo-costal space so as to make as prominent and large as possible this space on the side on which the operation is to be performed. The usual antiseptic precautions should be carefully carried out, thorough scrubbing with green soap, washing off with alcohol or ether, followed by the antiseptic or aseptic solution favored by the operator. The incision down to the adipose capsule of the kidney is made as in other operations. It may be either oblique, an inch below and parallel to the last rib, or vertical, along the outer edge of the erector spinæ muscle. The latter incision is the one I very much prefer, and is the one generally adopted in nephrorrhaphy. The oblique incision, while perhaps equally as serviceable in other operations on the kidney, is, for the purposes of this operation, inferior to the vertical. The skin incision is made from the last rib to the upper border of the crest of the ilium, along the outer border of the erector spinæ muscle. After division of the skin and cellular tissue and lower fibres of the latissimus dorsi muscle, the sheath of the erector spinæ is opened and this muscle is crowded inward by retractors toward the spinal column. The division of the middle layer of the lumbar fascia follows and the exposure of the quadratus lumborum muscle, which is easily recognized by the direction of the coarse fibres from above downward. This is also crowded inward and the anterior layer of the lumbar fascia divided and the perirenal fat (adipose capsule of the kidney) exposed. During the operation it should be remembered that the pleura extends down to the twelfth rib, and sometimes a little below it, and care should be exercised to avoid opening it. This accident happened to me in one case, where the pleural cavity was punctured at a point one-eighth inch below the last rib; no bad consequences followed. The kidney can by pressure from the abdomen be pushed into the wound, and it then remains to fasten it in place in its normal situation behind the twelfth rib.

The following different plans have been adopted: 1. The adipose capsule, opened or unopened, is united by sutures to the edges of the incision. This was Hahn's original operation, but it is now nearly abandoned. 2. After freely opening the adipose capsule the sutures are passed through the fibrous or true capsule of the kidney. This is a method which has been often successful, but is gradually being susperseded by one of the following methods, which seems to promise better results. 3. After free exposure of the kidney the sutures are passed directly through its parenchyma. They are passed through a considerable portion of the substance of the kidney, and at such a depth that they completely control its movements. Two or three such sutures are used, and they penetrate the kidney for a distance of about an inch and a half, and at a depth of one-fourth to one-half inch below its surface. 4. The fibrous capsule is divided vertically for a distance of two to three inches, and peeled off the kidney on each side till a raw surface of considerable extent is made, which is then brought into contact with the cut tissues in the loin. The sutures are then passed as in the last method, entering and emerging through the capsule just outside the raw margin. It has been found from experimentation on animals that, when the kidney, deprived of its capsule, is brought into contact with the cut muscles of the loin, the union resulting is far firmer than when the unbroken capsule is brought into apposition with the same structures. The results of operation seem to be in accord with these experiments. The division of the capsule is supposed also to serve another useful purpose in the relief of tension from the kidney itself. The last-mentioned method appears to me to be the securest.

I have operated according to the latter in four cases, and in none of them has there been any sign of relapse. The method does not seem to be attended with any special dangers. As far as we know at present the passage of sutures through the parenchyma of the kidney does not appear to cause any disturbance, either immediate or remote. It is even the exception to find red blood-corpuscles in the urine after these operations. Care should be taken, however, that the sutures are not tied too tightly, as otherwise they might cut the kidney tissue. I prefer to pass them threaded on a common round sewing-needle through the kidney itself. They can then be drawn through the muscles on each side of the incision by means of a handled needle. My own plan before tying these sutures is to unite the cut muscles carefully by means of buried sutures, thus shutting off the kidney from view, and then to tie the kidney sutures over the united muscles. In this way no tension is placed upon the kidney sutures. The skin is then united, and if deemed best a drainage-tube placed at the lower angle of the wound. In my later cases no drainage has been employed; but if there be any doubt about the absolute sterility of the wound, sponges, instruments, or dressing, then by all means a drain should be inserted. Formerly it was the custom not to close the external wound by sutures but to leave it entirely open, packed with gauze, so that it might fill up with granulation tissue. It was considered that the adhesions so formed by means of granulation tissue were firmer than those obtained by a primary union.

Various materials have been employed for sutures—silk, catgut, kangaroo tendon, silkworm-gut, and silver wire. The important point is that the material be thoroughly aseptic. Probably chromicized catgut and silk are the best materials. The former will hold for several weeks and will then disappear. The latter will become encapsulated, as a rule, and cause no disturbance, but occasionally the system will not tolerate its presence, and it will be eventually discharged through a sinus. Silkworm-gut and wire, while easily made aseptic, and while very unirritating and durable, may be apt to cut the kidney tissue. A number of operators, principally of the Italian school, consider it wise to fasten the upper end of the kidney at a higher point than can be reached by the ordinary incision. To accomplish this they have resected the twelfth rib in whole or in part, and sometimes the eleventh as well. To the periosteum of these ribs the sutures are fastened. In a few cases they have been attached to the periosteum without removal of the rib. This appears to

be an unnecessary procedure. It must certainly add to the dangers of the operation, and in one case it was to some extent responsible for a fatal result. Schachner has performed a number of experiments upon animals in the endeavor to replace the sutures "by natural stays in the shape of a pocket formed between the transversalis and internal oblique muscles." The method was successful in animals, but it remains to be proved whether or not it will be of advantage in the human subject.

The subsequent treatment of the case is of importance. Considerable neuralgic pain is felt for the first week, or longer, shooting down toward the groin. This can be quieted in the usual way by opiates. It is of great advantage to keep the patient flat on the back for two or three weeks at least after the operation, and rest in bed should be maintained for another two weeks. This will necessitate confinement to bed for about five weeks, and another two weeks should elapse before the patient can resume business of any kind. No violent exercise should be attempted for at least four months. In a few cases lumbar hernia (of the kidney through the cicatrix) has followed nephrorrhaphy, but it is an accident of very rare occurrence. *Andrew J. McCosh.*

NERVES, REGENERATION OF. A reunion by first intention of the severed ends of a nerve can no longer be doubted, although such instances are rare. This desirable result is owing largely to the adoption of the most rigid antiseptic precautions, and when obtained the return of sensation begins within about twenty-four hours, soon to be followed by a return of motility.

The most valuable contribution yet offered on this subject has recently been published by Howell and Huber (*Journal of Physiology*, xiii., No. 5, 1892). Their investigations were partly physiological and partly histological.

With a single exception dogs were used. The nerves experimented upon were the ulnar of the two sides, and in case of cross-sutures, the median and ulnar. Antiseptic precautions were observed. Carbolized catgut, or catgut in juniper, was used for sutures. The cut ends of the nerves were in almost every case brought together by one suture on each side which passed through the epineurium, wounding the nerve-fibres as little as possible. In most cases the nerve was lifted with a thread and cut with sharp scissors. After a certain time the nerve was laid bare and irritability tested in various ways, and subsequently histological examinations were made.

The chief results of this research are as follows:

In none of the experiments was there union of the cut ends by first intention. In all cases the peripheral end degenerated completely throughout its entire length. During the first four days there gradually occurred a complete loss of irritability and conductivity in both sensory and motor fibres, which lasted until regenerative changes, as shown by histological investigation, set in.

Irritability in all cases appeared first, after union was made, in the neighborhood of the wound, and from that part spread centrifugally, apparently with great slowness. The gradual increase in irritability at any one level seemed to go hand in hand with the increase in the number of newly-formed fibres, and not with a progressive regeneration in the single fibres. The return of irritability to the sensory fibres was in advance of that to the motor fibres. With the beginning of the return of irritability mechanical stimulus was more efficient than electrical stimulus. This, the authors believe, is due to the fact that the nerve-fibres in the process of regeneration are in the embryonic stage, possessing but a low degree of irritability, and that the more violent mechanical stimulation is necessary to arouse them.

Conductivity appeared before irritability. In other words, the nerve conducted impulses before it became excitable to direct stimulus.

The return of function, which began to appear at the end of three weeks, was not perfect at the end of seven weeks, although nearly so at the end of eleven weeks.

Although functional activity returns first to the fibres near the wound and spreads centrifugally, it does not follow from this that the fibres which first branch off from the trunk and have the shortest route to travel are the first to regenerate.

The possibility of the functional union of two spinal nerves is proven, but indicates that the time required for the regeneration of the nerve-fibres is longer than in the union of the two ends of the same nerve.

After complete severance from the nerve-centres of the peripheral end of the nerve, degeneration occurs throughout its entire extent.

The degenerative changes and the subsequent regeneration take place as follows: (*a*) Segmentation of the myeline and axis at the intersegmental lines; (*b*) proliferation and migration of the internodal nuclei; (*c*) secondary fragmentation and absorption of the myeline (and contained *débris* of the axis), most active in the neighborhood of the nuclei; (*d*) increase of protoplasm round the nuclei, forming finally a continuous sheath band of protoplasm lying in the old sheath; (*e*) formation of a new sheath on the periphery of this band, thus making an "embryonic fibre;" (*f*) union of the embryonic fibres of the peripheral end with those similarly formed in the central end, the union taking place in the intervening cicatricial tissue; (*g*) formation of myeline in the peripheral end as isolated drops, usually seen first near the nuclei. These afterward unite to form a continuous tube. The formation of the myeline proceeds centrifugally, starting from the wound; (*h*) the outgrowth of new axes from the old axes of the intact fibres of the central end, the outgrowth following quickly upon the development of the myeline: (*i*) in the central end, and especially when connection with the periphery is not made, several new fibres may form within the sheath of an old fibre to take the place of the portion degenerated. Each of these may develop myeline and receive a branch from the axis cylinder above. *Edward T. Reichert.*

NERVOUS SYSTEM, COMPARATIVE ANATOMY OF THE. RECENT PROGRESS.—The field is so large and the accumulated literature of the last few years so enormous, that it has seemed best to select typical or representative episodes, and to present data from various sources without attempting to edit them compactly or to assimilate them fully into a complete and orderly whole. This procedure is in harmony with the existing state of the science, which hurries from one discovery to another without intermission, and it will only be profitable to make a complete summary after the possibilities of the modern technique have been measurably exhausted. While it is not claimed that the selection has been as discriminating as could be desired, and many valuable additions to our knowledge are unwillingly passed over in silence, we trust that sufficient material has been collated to indicate the tendencies of modern research. The classes of vertebrates are taken up in succession and afterward a few special topics are discussed.

Amphioxus.—Hatschek [1] has added valuable points to our knowledge of this simplest vertebrate. The results seem to warrant the hope that the perplexing problems of cerebrogenesis may yet be solved by comparative methods.

The spinal cord of Amphioxus contains a circular canal which extends dorsad in a delicate cleft nearly to the dorsal surface of the cord. The canalis centralis is surrounded by gray matter, which extends to the dorsal surface, but on all other aspects is clothed with white fibres.

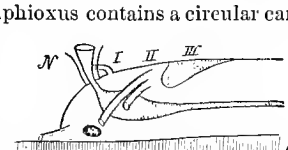

FIG. 431.—Longitudinal Section through the Brain of Amphioxus when young. *I, II, III.* vesicles; *N*, Sensory pit, which is homologous with the pituitary; *ch*, chorda.

In the young the brain consists of a cephalic enlargement of the medullary tube, which subsequently is obscured. In a later stage, three vesicles are indicated corresponding to the primary embryonic vesicles.

The first of these sections (primary prosencephalic vesicle) contains a distinct ventricle. From the cephalic

extremity of this cavity, the infundibulum is formed. It is an expansion of the brain-wall which comes into direct communication with the ciliated pit of the dorsal surface of the head. The communication is subsequently closed. The cavity of the second vesicle is a mere tube, which has been compared (with doubtful propriety) with the aqueduct. The third vesicle has a dorsally located fossa rhomboidea with membranous dorsal roof.

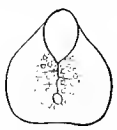

Fig. 432.—Cross Section in the Region of the Third Vesicle.

The brain in the young is in the region of the first and second segments. The ciliated frontal pit is connected by an olfactory nerve with the front of the brain. The pit is homologous with the hypophysis and nasal sac of craniates. A comparison with Ammocoetes and higher vertebrates shows that, in the latter, the infundibulum (and with it the whole brain axis) has been flexed ventrad.

The spinal nerves have the usual divisions. The dorsal root does not communicate with the ventral, but passes toward the periphery, where it divides into a dorsal and ventral ramus. The ganglion is represented by numerous cells scattered in the nerve near its point of division, and thus near their origin. This is very suggestive as to the origin of the spinal ganglion.

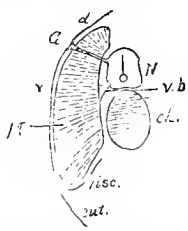

Fig. 433.—Cross Section of Body (diagrammatic). *N*, nerve tube; *ch*, chorda; *M*, muscular segment; *G*, dorsal branch, with ganglion cells passing through the muscles and dividing into a dorsal ramus (*d*) and ventral ramus (*v*), the latter again dividing into a cutaneous and a visceral branch; *v.b*, motor root.

The dorsal ramus gives off a cutaneous dorsalis and lateralis dorsalis nerve, and the ramus ventralis similarly divides into a cutaneous ventralis and lateralis ventralis. In addition to these, the ventral ramus affords a special visceral branch. There is a tendency to the formation of plexi, aud it is thought that many of the fibres may be sensory. It has been compared with the vagus, but a similar branch is found in the dorsal regions. The ventral root is the special nerve to the trunk muscles, and is purely motor. The sensory (dorsal) branch is intersegmental, the ventral segmental.

The first pair of nerves lies along the dorsal side of the cord (and the rostral muscles of the larva), and supplies the epithelium of the cephalic end of the rostrum. Some of the branches are supplied with Quatrefages' ganglion cells.

The second nerve consists of an anterior portion, distinct nearly to the root, which gives off a strong lateralis dorsalis and ventralis; these supply the remainder of the rostrum. The second portion divides into two cutanei dorsales, a cutaneous ventralis and a cutaneous visceralis, which latter innervates the buccal muscles.

The third to fifth nerves have the normal form (as above). All the viscerales unite in a plexus to which the fourth and fifth supply especially strong contingents. The separate descending branches pass to the muscles of the mouth and velum, while a strong branch, which fuses with a branch from the sixth and seventh, passes to the plexus of the branchial apparatus.

The fifth nerve gives off an especially large visceral branch which supplies a strong branch to the sensory organ of the right side (derived from the ectoderm of left side).

It is regarded as probable that the first nerve is homologous with the ophthalmicus profundus, and the ventral nerve of the rostrum with the maxillaris.

Ammocœtes.—The additions to our knowledge in the Cyclostomata have related chiefly to the homologies of the nerves. Hatschek[1] shows that there is a great similarity, in general, with the distribution prevailing in fishes and the embryological data discovered by Kupffer.[3] The cranial nerves also show the same fundamental parts as already reported in Amphioxus. The dorsal root produces (*a*) a ramus dorsalis, which divides into a cutaneous dorsalis and a lateralis dorsalis, and (*b*) a ramus ventralis, which represents a cutaneous and prætrematicus, and also gives off strong rami viscerales and the cutaneous ventralis, which together form the "post-trematicus."

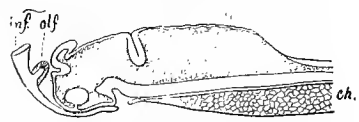

Fig. 434.—Longitudinal Perpendicular Section of the Brain of Ammocœtes, for comparison with the similar view of the brain of Amphioxus (Fig. 431). *ch*, chorda; *olf*, olfactory sac; *inf*, infundibulum.

The visceral branches carry motor fibres to supply the muscles of the mouth and gills, as well as sensory fibres to the mucous membrane.

There is a longitudinal set of connecting fibres uniting all nervi laterales dorsales, the continuation of which forms the recurrens lateralis of the vagus, extending the whole length of the animal. This longitudinal system is related with the sensory organs of the lateral line. This system embraces (dorsad and ventrad) the eye. The important morphological deduction from the above fact is that the nervus lateralis vagi is phylogenetically formed of the nervi laterales of all the spinal nerves, the direct connection with which has been subsequently lost.

Another longitudinal set of connecting fibres brings all the ganglia of the rami ventrales into communication (this arrangement is complete only in the young). The epibranchial sensory organs (organs of the ventral lateral line) are supplied by nervi laterales ventrales which branch from each of the rami prætrematici. It appears from a comparison of these types that there is essential similarity between the cranial and spinal nerves, but it is the latter and not the former which have been altered.

The trigeminus is now generally recognized as combining two nerves. Hatschek distributes the cranial nerves and head organs as indicated in the table on page 671.

In a subsequent paper[5] Hatschek announces the discovery that the dorsal roots, in all higher vertebrates, connect with the ventral root next caudad, and their branches follow the myoseptum. Thus the ventral roots are segmental, and the dorsal intersegmental. The arches are intersegmental, and the clefts are segmental. This simplifies the above scheme without invalidating the facts.

Edinger[6] describes the olfactory nerves of Ammocœtes, in which he recognizes a commissure and a chiasm which are in direct connection with the interlobular (anterior) commissure. Unfortunately no one has yet studied the olfactory in the light of our present morphological knowledge, and the existence of a radix lateralis and hippocampal rudiment is still only conjectural.

Selachii.[6]—Edinger concludes, from a study of the embryology as well as from a comparison of the adult brain, that the forebrain of sharks and rays differs from that of all other (higher) vertebrates in that no true hemispheres are formed, but the primary prosencephalic vesicle persists, and the thickened walls contain the elements which in other groups constitute the hemispheres. The sharks are somewhat in advance of the rays and have slight indications of the subdivision.

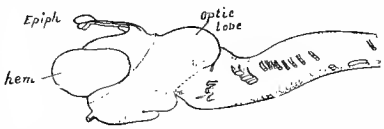

Fig. 435.—Lateral View of the Brain of Adult Petromyzon. *Epiph*, epiphysis; *hem*, hemisphere; *opt. l*, optic lobes.

The same author gives a detailed description of the diencephalon. The latter is divided into a cephalic and a caudal portion into which the pedunculi cerebri enter from the prosencephalon. The habenulæ of the two sides differ greatly in size and are connected by a commissura habenaria. The caudal or infundibular part of the diencephalon has two lateral lobes and a posterior (caudal) lobe, and bears a large hypophysis, saccus vasculosus, and

		Segment.	Myotom.	Ventral roots.	Dorsal roots.	Visceral arches. Epibranchial sense organs.
					(a) "Medullary" region.	
					Olfactory and nose (the first a "medullary" nerve related to a "neuroporus" sense organ). Optic and retina (the first an "intra-medullary" nerve related to a "medullary" sense epithelium).	
					(b) Dorsal nerve roots situated cephalad of the first myotom.	
Proötic metamers.	Fore-head.	I.	Myotom absent.	Absent	Trigeminus A*, situated cephalad of the first (reduced) myotom, later: Oculomotor, as derivative of the visceral branch of the above.	Visceral cleft absent. Anterior organ of the ventral lateral-line (?).
					(c) Normal metameric portion.	
			Myotom reduced.	Reduced	Trigeminus B,† situated caudad of first (reduced) myotom, later: Trochlearis, as derivative of the visceral branch of the above.	Mandibular visceral cleft (rudimentary). Mandibular arch. First epibranchial sense organ.
		II.	Musculus lateralis.	N. abducens	Facial, including auditory (as nerve of a dorso-lateral sense organ).	Pseudobranchial border (= hyoid cleft). Hyoid arch (behind auditory capsule). Second epibranchial sense organ.
Metaotic metamers.	Primitive hind-head region.	III.	First metaotic myotom.	Ventral root of glossopharyngeal.	Glossopharyngeal	First true visceral cleft. First visceral arch. Second epibranchial sense organ.
		IV.	Second metaotic myotom.	Ventral root of vagus.	Vagus and the dorsal ganglionic portion, including the first ventral (epibranchial) ganglionic mass with its peripheral nerves.	Second true visceral cleft. Second visceral arch. Fourth epibranchial sense organ.
	Hind gill region.	V. to IX.	Third metaotic myotom, etc.	Ventral roots of the spinal-like (spinal artigen) nerves.	Spinal-like vagus branch and the following spinal-like nerves. Second to sixth ventral (epibranchial) ganglia of vagus.	Third to seventh true visceral clefts. Visceral arches. Epibranchial sense organs.

[Segmentation of back follows.]

* Trigeminus A includes: N. frontalis primus; portio profundus of ophthalmic; N. mandibularis.
† Trigeminus B includes: N. frontalis primus; portio superficialis of ophthalmic; N. mandibularis.

recessi laterales infundibuli (mammillaria.) In adults the hypophysis consists of coiled and branching pouches. The histological structure is much as in bony fishes.

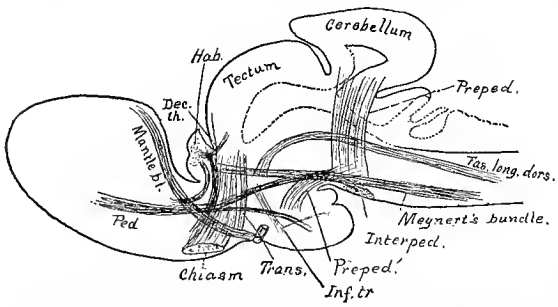

FIG. 436.—Longitudinal Section of Selachian Brain, according to Edinger. The brain is supposed to be transparent, and the various fibre systems are projected upon one plane.

Nerve-fibres are said to arise in the infundibulum, but the writer has found only gelatinous fibres in the corresponding organ of fishes.

The pedunculi divide into a dorsal and ventral tract, the latter terminates in the infundibular portion, the

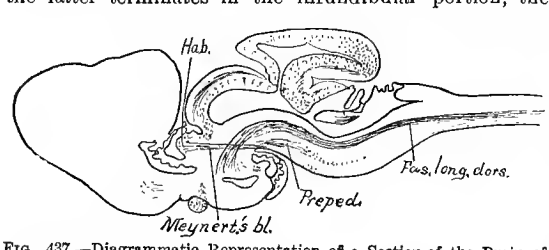

FIG. 437.—Diagrammatic Representation of a Section of the Brain of Scyllum.

former passes beyond the diencephalon. A tract which requires further study is the so-called "mantle tract," which is said to originate from the dorsal part of the prosencephalon and decussate caudad of the chiasm and ventrad of the commissura transversa. After decussation the fibres pass to the deeper layers of the tectum opticum. The commissura transversa is identified with von Gudden's commissure. A tract is described from the habenæ to the roof of the mesencephalon, also a tract to the prosencephalon comparable with the tænia thalami. The ventricular cinerea gives rise to decussating fibres. Most of the fibres of the diencephalon spring from the pars infundibularis, among them the fasciculus longitudinalis dorsalis. This bundle seems to receive a contingent from the region of the oculo-motor and passes into the ventral columns of the cord. The prepedunculi of the cerebellum arise from the region where the ventral peduncles disappear.

THE BRAIN OF DIPNOIDS.—The lung-fishes have long been recognized as of great morphological interest by reason of their primitive and intermediate position. The combination of embryonic characters in the skeleton and limbs with amphibian peculiarities of the circulatory and respiratory systems makes them very instructive in indicating the possible primitive condition of the vertebrate phylum. The neurology of the African lung-fish, *Protopterus*, has recently been carefully investigated by Dr. R. Burckhardt.* The relations of the brain of different groups of vertebrates may be expressed somewhat as in the following diagram, which, however, differs in several points from that given by Burckhardt:

Primitive vertebrate.	Lamprey.	——	Sharks. Rays.	Ganoids—Bony Fishes.
	——	——	Dipnoids.	Ichthyophis—Amphibia.
				—— Mammals.
				Reptiles——Birds.

The resemblances to lampreys (Petromyzon) is very great, in spite of certain reductions in the latter, due to retrograde metamorphosis.

Ganoid Fishes.[8]—Professor Kupffer has studied the development and discusses the morphological results. He states that at a period of forty-five hours after fertilization the brain is not yet separated fully from the epidermis. It is of great morphological importance to determine at what point the attachment is effected.

Only two vesicles are clearly distinguishable, the cephalic being the smaller. Growth is at first more rapid in the ventral part of the tube and this gives rise to a

* Das Centralnervensystem von Protopterus annectens. R. Friedlaender, Berlin, 1892.

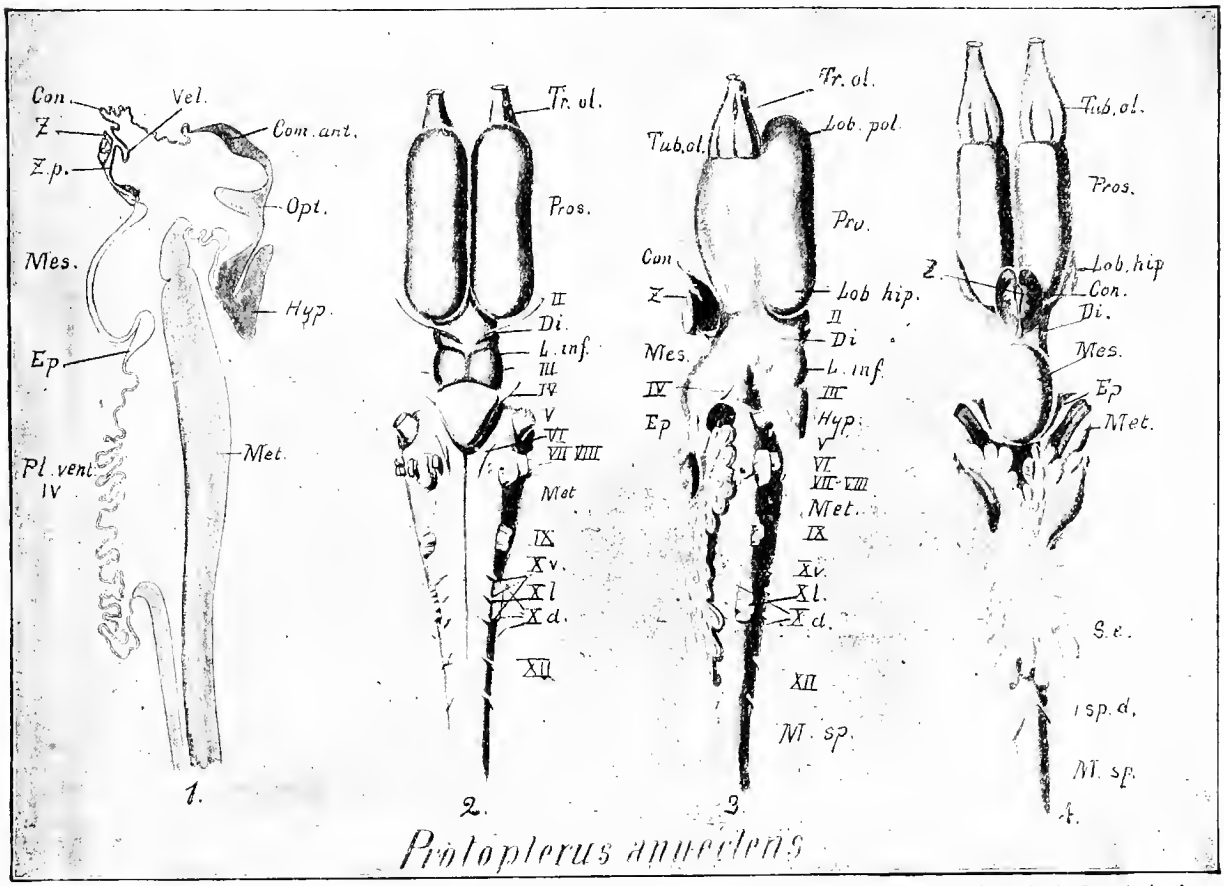

FIG. 438.—The Brain of Protopterus annectens. 1. Longitudinal median section. *Con.*, conarium or dorsal sac; *Z.*, pineal gland: *Z. p.*, "pineal pillow;" *Mes.*, mesencephalon; *Ep.*, epencephalon; *Pl. vent. iv.*, plexus of fourth ventricle; *Vel.*, velum; *Com. ant.*, precommissure; *Opt.*, optic nerve; *Hyp.*, hypophysis; *Met.*, metencephalon. 2. Ventral view of the same brain. *Tr. ol.*, olfactory tract: *Pros.*, prosencephalon; *Di.*, diencephalon; *L. inf.*, hypoaria; *Met.*, metencephalon; *II.* to *XII.*, cranial nerves. 3. Lateral view of same object. *Tub. ol.*, olfactory tuber; *Lob. hip.*, hippocampal lobe; *M. sp.*, medulla spinalis, *S. e.*, saccus endolymphaticus. 4. Dorsal view of the same brain.

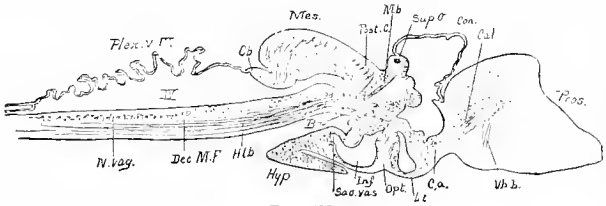

FIG. 439.

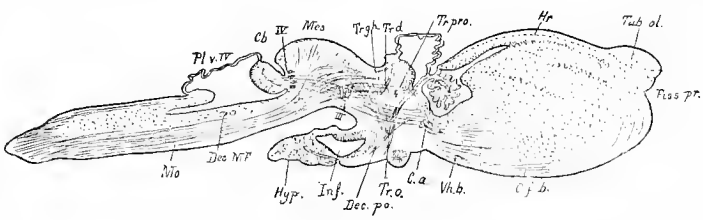

FIG. 440.

FIGS. 439 and 440.—Longitudinal Sections of the Brain of Protopterus. *Cal.*, callosum; *Vh. b.*, prosencephalic bundle; *C.a.*, precommissure; *L.t.*, lamina terminalis; *Inf.*, infundibulum; *Sac. vas.*, saccus vasculosus; *Hyp.*, hypophysis; *Tr. o.*, optic tract; *Dec. po.*, decus-atio post-optica; *Ba.*, cephalic peduncles of cerebellum; *Hl.b.*, dorsal longitudinal bundle; *Dec. M. F.*, decussation of Mauthner's fibres.; *N. vag.*, vagus nidulus; *Cb.*, cerebellum; *Mes.*, mesencephalon; *Post. C.*, postcommissure; *M. b.*, Meynert's bundle; *Sup. C.*, supracommissure; *Tub. ol.*, olfactory tuber; *Fiss. pr.*, fissura post-olfactoria; *Hr.*, cortex; *Olf. b.*, olfactory fibres; *Tr. gh.*, tract from superior commissure to cerebrum; *Tr. d.* and *Tr. pro.*, tracts from superior commissure to diencephalon and cerebrum (tænia).

"*plica encephali ventralis*" (*pl. vent.*). This is the floor of the mesencephalon and is the first indication of what in mammals is called the saddle-cleft. The roof, like the floor of the brain, consists of simple epithelium. The first indication of the pineal appears near the middle of the roof (*ep*², Fig. 443), nearly midway between mesencephalon and prosencephalon. Just caudad of the plica is the pons flexure. The slight curvature of the floor in front of the plica is constant in all vertebrates and is called by Kupffer "tuberculum posterior" in spite of the previous use of nearly the same term for the obscure corpora quadrigemina posteriora of Sauropsida, etc. The cephalo-dorsal part of the brain tube is open, and communicates by a tubular conduit with a space beneath the outer layer of the epidermis, while the brain-walls are continuous with the inner epidermal layer (at *r*, Fig. 443). Just below (ventrad of) this communication is the recessus opticus, on the caudal aspect of which the optic chiasm will develop, and on the cephalic aspect the anterior commissure. The hypophysis is at this stage of unexpected size and shape (*hy*), and it impinges on the front of the brain-tube. The organ is developed from the layer of cells where the entoderm and inner ectoderm layer meet in front of the head. It is in immediate connection with a thickened part of the inner ectoderm layer which is to

form the sucking disk (*hf*, Fig. 443), immediately above the mouth.

When the age of fifty-seven hours is reached (Fig. 444), the brain has elongated, the connection of brain and epidermis is now a solid cord of cells. The epiphysis has become more distinct.

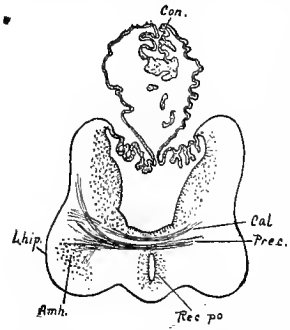

FIG. 441.—Section through the Precommissure of Brain of Protopterus. *Con.*, conarium; *L. hip.*, hippocampal lobe; *Cal.*, callosum; *Amh.*, cornu ammonis; *Rec. po.*, recessus preopticus; *Prec.*, precommissure.

From this time on the hypophysis begins to separate from the skin, with which it is for a long time connected by a stalk. The brain communication with the ectoderm is severed, and a slight protuberance at this point remains, which the author calls the tuber olfactorius impar.

The region of the future infundibulum (Fig. 446) becomes greatly expanded and several sinuses are developed. The inferior commissure system appears earlier than the chiasm fibres.

The tuber olfactorius impar, which Kupffer considers the morphological front of the head, and which was originally in juxtaposition with the hypophysis, becomes more and more widely separated from it and ceases to grow, and even becomes reduced. At the end of larval life (Fig. 446) the paraphysis *ep'* is derived from the prosencephalon in front of the dorsal sac.

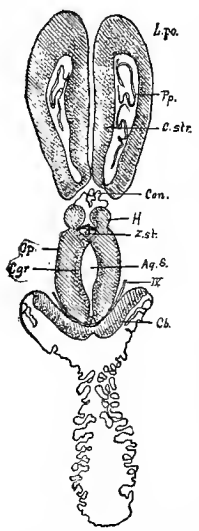

FIG. 442.—Longitudinal Horizontal Section through the Cerebral Hemispheres, etc., of Protopterus. *L. po.*, lobus post-olfactorius; *Pp.*, preplexus; *C. str.*, striatum; *H.*, habena; *Z. st.*, stipe of pineal gland; *Aq. S.*, aqueduct; *Cgr.*, axial gray matter; *Ch.*, cerebellum.

The velum transversum (*vt.*), which immediately precedes, begins to assume a plexiform appearance. The commissures are well developed. The star in Fig. 446 indicates what the author and Burckhardt regard as the caudal limit of the base of the mesencephalon. Two commissures of the infundibulum are called com. debelis (*de*) and com. terminalis (*t*), though it is hard to see what excuse can exist for these new terms. The author identifies the com. debelis with Edinger's decussatio infundibuli. The dorsal sinus of the infundibulum becomes the hypoaria, and the ventral becomes the saccus vasculosus, though also producing two lateral vesicles which are probably the homologues of the similar sacs of Teleosts which Herrick has homologized with the mammillaria.

Kupffer concludes that his researches settle the question as to the morphological front of the brain. Baer, His, and the writer have contended that the region of the infundibulum is the front, while Reichert and Kölliker locate it in the terma in front of the chiasm. Mihalkovics locates the theoretical front in the middle of the terma and denies the existence of a "hook-curvature" of the axis. Von Wijhe shows that the point of attachment of the brain with the skin is independent of the hypophysis. Kupffer completes this argument by discovering a median olfactory fundament.

The Ganoids have a much greater development of the roof of the diencephalon than is characteristic of the Teleosts and Selachii. The greatly distended base of the diencephalon Kupffer designates as hypencephalon. The most caudal part of this segment gives rise to the hypoaria, which the present writer, on embryological grounds, has been tempted to relegate to the base of the mesencephalon.

Regarding the whole cavity cephalad of the mesencephalon as a single vesicle, Kupffer arranges the secondary modifications of its walls as follows: 1. From the cephalic wall, the optic vesicles and stalks. 2. From the dorsal wall, the epencephalon (= cerebrum), the paraphysis or anterior epiphysis, the parencephalon (diencephalon), the epiphysis proper. 3. From the floor, the hypencephalon with the saccus dorsalis, hypoaria and saccus vasculosus.

The author makes much of the fact that there is in Amphibia a large postpineal part of the roof which is absent in the Ganoids.

The adult brain has been recently examined by Goronowitsch[10] in Acipenser, and by Herrick[11] in Scaphirhynchus and Lepidosteus. The following extracts from the paper of Goronowitsch will be useful:

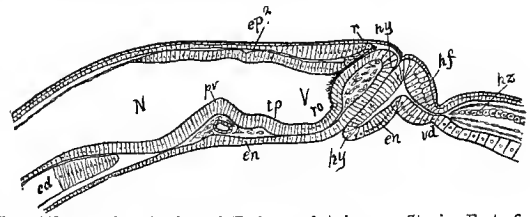

FIG. 443.—Median Section of Embryo of Acipenser Sturio, Forty-five Hours after Fertilization.

"*Cerebrum.*—The roof of the prosencephalon is membranous, and consists of a variously folded epithelial lamina. The roof of the olfactory lobes, however, consists of thick medullary walls. Between the roof of the prosencephalon and the epiphysis there is a broad membranous sac, the cavity of which is distally in wide connection with the cavity of the prosencephalon. The blind end of the sac is directed proximally (cephalad!). The sac, therefore, must be considered as a broad diverticle of the roof of the prosencephalon, springing from a point cephalad to the origin of the epiphysis. This may be called, for the sake of brevity, simply the dorsal sac.

"At the anterior margin of the left ganglion habenula (the left is much the smaller) a lateral induplication of the membranous roof of the prosencephalon enters the ventricle. This fold is somewhat complicated. The epithelial layer of which it consists forms numerous folds and sacs, into which projections of the membranes and blood-vessels enter. The structure is, in other words, that of a plexus choroideus.

"Careful study of continuous series of sections indicates that there is nowhere a discontinuity in the epithe-

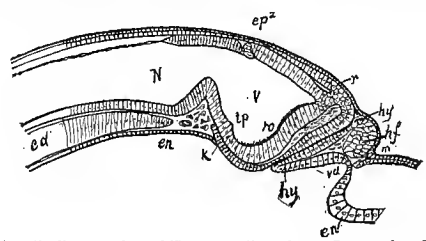

FIG. 444.—Similar Section of Embryo, Sixty-four Hours after Fertilization.

lial layer. The cavity of the prosencephalon is therefore completely closed. The dorsal lamina of the fold forms the ventral wall of the dorsal sac, and the ventral lamina forms the membranous wall of the prosencephalon. It thus appears that the opening of the dorsal sac is asymmetrical. Cephalad from this point the two chambers are separate. The ventral portion of the neural tube at this region consists of thick paired masses, the basal ganglia. The membranous roof bears a system of

folds which becomes more complicated. The middle portion projects into the ventricle and forms a sort of falx cerebri. The dorsal wall also circumscribes the dorsal sac laterad and encloses it in a plexiform structure derived from the roof the prosencephalon.

"Somewhat cephalad of the base of the olfactory lobes a groove appears upon the dorso-median aspect of the basal ganglia, which passes mesad and can be traced directly into the cavity of the olfactory lobe. The median falx of the roof dips deeply into the ventricle of the prosencephalon. The falx extends to the epithelial lamina which connects the two olfactory lobes. Cephalad of this point the membranous roof of the prosencephalon is continued to form paired sacs dorsad of the olfactory lobes.

"In this structure of the prosencephalon of A. ruthenus I detect the paired nature of the prosencephalon, which consists in the strongly developed falx as well as the membranous sacs of its cephalad portion.

"At the cephalic level of the chiasm two prominences appear upon the dorsal portion of the encephalon wall which have the structure of the basal ganglia. This structure extends soon to embrace the entire lateral walls of the prosencephalon. These ganglia consist of a very compact, finely granular stroma, with peculiarly arranged ganglion cells, and of a system of exceedingly fine, non-medullated fibres. Beneath the epithelium, in the dorsal region of the ganglia, is a layer of small cells whose fibres extend ventrad and radially. Such cells are not found in the ventral portions, but instead irregularly scattered small cells. In the midst of the ganglion are large cells with large round nuclei and pale body. The processes are also radially disposed to the ventricular surface, producing in cross-sections a very characteristic habitus. The transition in structure in passing into the olfactory lobes is gradual.

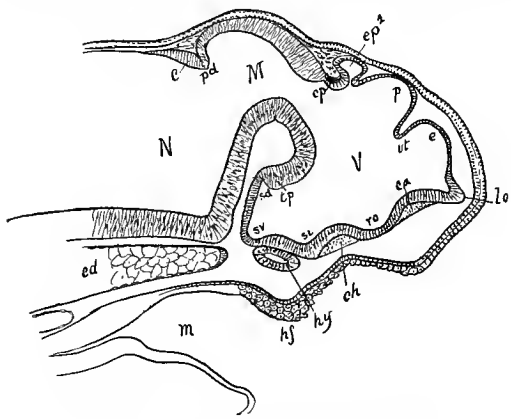

FIG. 445.—Similar Section of Larva, Three Days Old.

"The cephalic ventrally arched end of the embryonic nerve-tube, which, according to Götte, forms the primitive prosencephalon, is to be regarded as the most primitive phyletic condition of the prosencephalon which ontogony suggests. The primitive prosencephalon is homodynomous with a segment of the spinal cord. By the growth of the dorsal surface of the primitive prosencephalon arose the discrete central organ of smell, while the lobus infundibuli is the result of a protrusion from its base. The formation of the olfactory centre led to the development of the prechordal portion of the skull. The architecture of the cranium of the most primitive of the Gnathostomata, the Notidaidæ, corresponds to that of the brain. The gradual development of the organ of smell gave rise to the rhinencephalon of recent Selachii. This still indifferent organ exhibits no special homologies with the diencephalon and prosencephalon of higher vertebrates. It is closely connected with the lobus infundibuli, which is reduced in higher vertebrates.

"On one hand, the reduced form of rhinencephalon of Ganoids and Teleosts is derived from the rhinencephalon of Selachii, which, on the other hand, give rise to the structure of the prosencephalon in Dipnoii, Amphibia, and Reptilia. It is among these forms that the first indications of the origin of the prosencephalon of higher vertebrates may be sought. The first step toward the higher organization consists in the reduction of the lobus infundibuli and a transformation of the tracts connecting with the caudal parts of the nervous system. The development of the thalami and the reduction of the lobus infundibuli alters the development process of the neural tube in higher vertebrates from the earliest stages on. There appears a diencephalic and a secoudary fore-brain, the former having an entirely different significance from the posterior part of the prosencephalon of fishes, for it is the result of accelerated development of a certain dorsal portion of the neural tube which remains undeveloped in fishes. With the gradual development of the thalami and alteration of the rhinencephalon of Selachii, there gradually arise the tegmentum cruris and the pes pedunculi of higher vertebrates.

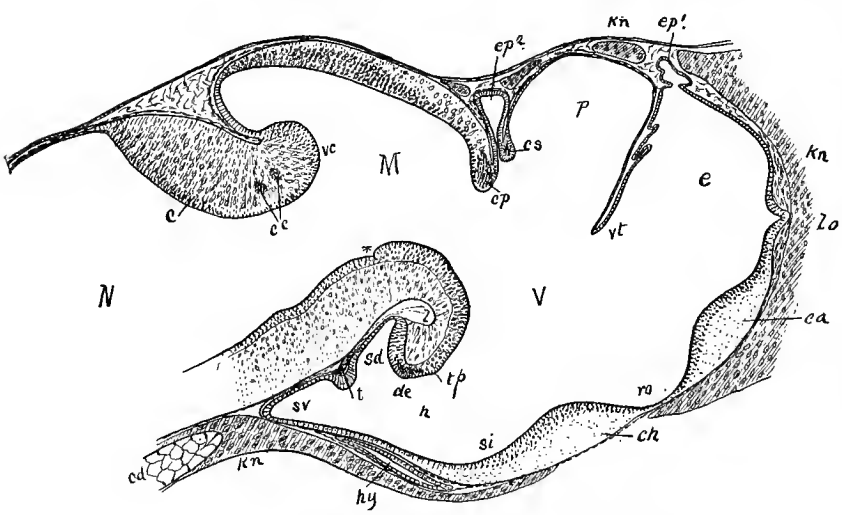

FIG. 446.—Similar Section of Larva, Four Weeks Old.

Description of Figures 445 *and* 446.—*c*, Cerebellum; *ca*, precommissura; *cc*, commissura cerebelli; *cd*, chorda dorsalis; *ch*, chiasm and commissura post-opticæ; *cp*, post-commissura; *cs*, supra-commissura; *de*, commissura debilis; *e*, cerebnm; *en*, entoderm; *ep*¹, paraphysis; *ep*², epiphysis; *h*, hypencephalon = infundibular region; *hf*, sucking disk, *hy*, hypophysis; *hz*, heart; *kn*, cartilage; *lo*, lobus olfactorius impar.; *M*, mesencephalon; *m*, mouth; *N*, metencephalon; *p*., præpineal roof of diencephalon (parencephalon); *pd*, plica dorsalis; *pv*, plica ventralis; *r*, median olfactory plate; *ro*, recessus opticus; *si*, sinus post-opticus; *t*, commissura terminalis; *tp*, tuberculum posterius; *v*, prosencephalon; *vt*, velum transversum of the fore-brain.

"*The Thalamus.*—The lateral walls of the lobus infundibuli form two round, lateral projections, the lobi inferiores, containing a considerable cavity. The posterior part of the lobe extends into a membranous sac, the so-called saccus vasculosus. Ventrad, the lobe connects with the bilobed hypophysis.

"The walls of the lobus infundibuli consist of finely granular stroma, staining pink with carmine, resembling that of the peripheral portion of the cerebellum. In the peripheral portion this stroma is compact, and it requires high powers to make out a fine fibrous structure parallel to the surface. Two fibre systems are more obvious entad. The fibres of the first run parallel to the surface, those of

the second radial to the surface. The latter spring from a layer of tissue clothing the inner surface. This layer is composed of a few series of round cells, much resembling those of the granular layer of the cerebellum. They are, however, somewhat larger than the latter, and the dark protoplasm mass surrounding the round nucleus of these cells is more highly developed. It is possible to trace the processes of these cells into the fibres of the radial system. In the fibrous zone round cells are scattered, as well as rod-like cells of the neuroglia.

"In the ventral portion of the cleft-like canal connecting the lobus infundibuli with the mesencephalic ventricle a ganglionic body composed of large cells occupies either side. Out of these ganglia springs a tract of non-medullated fibres which, passing caudad, subdivides, part of the fibres passing to the caudal part of the lobus infundibuli, and part to the dorsal portion of the sacculus vasculosus. Associated with this system is a rather large bundle of non-medullated fibres derived from a small cluster of nerve-cells lying dorsad to the above-mentioned ganglion and ventrad to Meynert's bundle, immediately beneath the epithelium. The ventral portion of the caudal wall of the lobus passes into the thin epithelial wall of the saccus vasculosus, a part of the fibrous layer entering it. The saccus itself is a broad, very vascular, folded sac, clothed within by a peculiarly modified epithelium.

"The discoidal *hypophysis* consists of two completely distinct parts. The caudal portion is composed of three or four lobes, into each of which passes a thick bundle of non-medullated fibres, which passes to the ventral portion and subdivide in the several sacculi. The saeculi of the cephalic portion are covered, like the former, with multilamellate epithelium with fusiform cells, but no nerve-fibres are present. The interstitial substance is connective tissue only. A thin layer of epithelium connects the two portions.

"*The Ganglion Habenulæ.*—Cephalad of the ganglion interpedunculare and ventrad of the transverse fibres of the commissura ansulatæ, there are two longitudinal bundles, which could be followed caudad only to the interpeduncular ganglia. These are Meynert's bundles, the right being much stronger than the left. The bundles pass cephalad and mesad of the fibres of the oculo-motor, and gradually pass dorsad, and at the point of communication of the ventricle of the lobus infundibuli with the mesencephalic ventricle they lie adjacent to the epithelium. These bundles terminate cephalad of the anterior commissure in the ganglion habenulæ."

Herrick, in speaking of Lepidosteus and Scaphirhynchus adds: "The lateral ventricles are not absent, nor are they merged in the olfactory ventricles, as stated by others. A section taken at a point in front of the foramen of Monro in the sturgeon brain shows that a cavity clothed by tela choridea (or pallium) extends cephalad along the dorso-mesal surface of each olfactory lobe. This cavity is of great morphological importance; part of its walls are modified to form a plexus, and it comes into direct communication with the aula. The surface of the lobe bordering is, like other ventricular surfaces, covered with epithelium. The cellular structure is also unlike that of the remainder of the lobe. It seems unquestionable that this space is homologous with the cavity of the lateral ventricle, which is not roofed over with nervous matter, but has merely the tela or pallium. These two ventricles become confluent cephalad to the

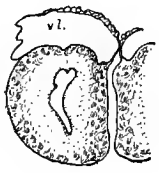

FIG. 447.

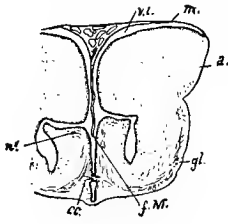

FIG. 448.

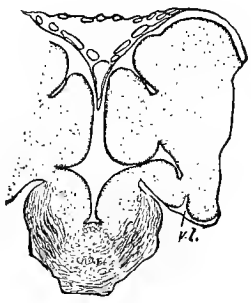

FIG. 449.

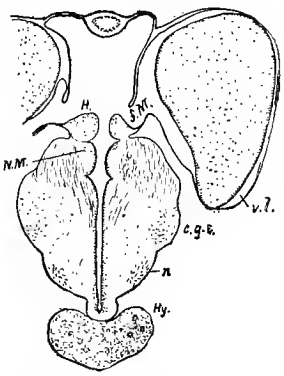

FIG. 450.

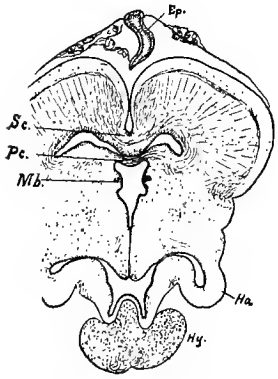

FIG. 451.

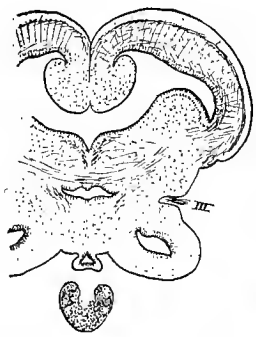

FIG. 452.

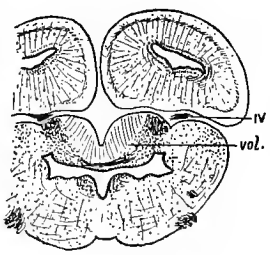

FIG. 453.

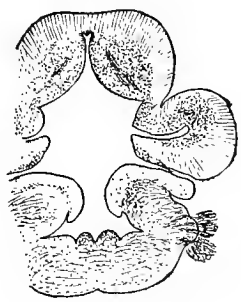
FIG. 454.

FIGS. 447–454.—Transections through the Brain of the Gar-Pike (Lepidosteus). Fig. 447.—Olfactory lobe. *v.l.*, cephalad projection of the lateral ventricle, roofed over by the velum. Fig. 448.—Transection at the callosum, *c.c.* *v.l.*, lateral ventricle; *m.*, membranous roof of the ventricle corresponding to the mantle; *a.l.*, axial lobe of the cerebrum: *f.M.*, foramen of Monro; *gl.*, remnant of the glomerular layer of the olfactory; n^1, olfactory nidulus beneath the aqueduct of the olfactory. Fig. 449.—Transection back of the chiasm. A mesad protuberance of the axial lobe corresponding to a part of the striatum is separated by projections of the ventricle. The aula is partly confluent with the ventricles. *v.l.*, spur of the posterior cornu passing cephalad. In the connecting portion uniting the thalamus and hemispheres some evidence of the tænia thalami was detected. Fig. 450.—Transection at the level of the habenæ. The lateral ventricles have completely circumscribed the axial lobe. *c.g.e.*, corpus geniculatum externum; *n*, lateral nidulus of the thalamus; *Hy.*, hypophysis; *n.M.*, nidulus Meynerti; *f.M.*, foramen of Monro. Fig. 451.—Transection through the posterior commissure. A portion of the epiphysis is seen above, *ep.* *S.c.*, commissura Sylvii; *Pc.*, post-commissura; *M.b.*, Meynert's bundle; *Ha.*, Hypoarium. Fig. 452.—Transection at the middle of the optic lobes. *III*, third nerve in a groove between the hypoaria and lateral lobe of the thalamus. The tori project medianly into the ventricle. Fig. 453.—Transection through the posterior part of the optic lobes. *IV*, fourth nerve; *vol.*, volvulus, or portion of the cerebellum thrust into the optic ventricle. Fig. 454.—Transection through the medulla and cerebellum at the opening of the recessus lateralis.

openings of the olfactory lobes, but a partial division, by a depending loop corresponding to the dorso-mesal walls of the mantle, may be traced back of that point. From the ventral extension of these median walls two arms, forming with them an irregular inverted Y, pass laterad nearly to the ectal thickened walls of the hemisphere, shutting off a median aula from the lateral ventricles, with which the former is connected by a large portæ. It is from the ventricles thus bounded, and not from the median chamber, that the olfactory aqueduct springs.

"The development of nervous matter in the cerebrum is greater relatively in the gars, therefore the membranous portion of the mantle is greater in Scaphirhynchus. In Lepidosteus the ventricle gives off two spurs in the median portion delimiting a body somewhat resembling the corpus lenticulare of the striatum. The posterior cornu sweeps back of the crura and then circumscribes the ventral and ectal portions of the cerebrum, finally meeting the dorsal extension of the ventricle, enclosing a large occipito-basal lobe much as in reptilia. The extent of the ventricle may be most easily recognized by the epithelial covering of the axial lobe where it is present.

"The cerebrum is more highly developed in Lepidosteus. Cephalad, it projects beyond the olfactory, and appears in transection as two independent bodies dorsad to the olfactory lobes. Fig. 447 illustrates a section through the olfactory and extreme cephalic part of the lateral ventricle, which is bounded only by the pallium. The relations are essentially the same in all Ganoids. Fig. 448, which passes through the callosum, shows the relation between the olfactory aqueducts and lateral ventricle. The real homologues of the foramina of Monro are considerable slits. In the sturgeon the relations are similar, but the partial eversion of the hemispheres laterally brings the openings of the aqueduct of the olfactory lobes farther laterad.

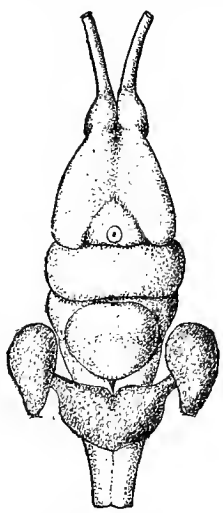

Fig. 455.

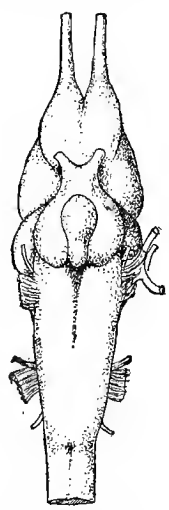

Fig. 456.

Figs. 455 and 456.—Dorsal and Ventral Views of the Entire Brain of the Gar. The bi-lobed mass lying behind the cerebellum is not of a nervous character.

"Respecting the *dorsal sac*, Lepidosteus affords much clearer information than the sturgeon, and renders necessary a considerable change in the interpretation of this structure offered by Goronowitsch. Morphologically it is a dorsal pouch of the diatela, such as may be detected in all reptiles in which the epiphysis is strongly developed. The asymmetry upon which Goronowitch lays so much stress is slight, and more apparent than real. The fact that it extends so far cephalad between the hemispheres is an incident to the cephalad projection of the epiphysis. It may be useful to first study the structure of the latter.

"The *epiphysis* springs from the most caudal portion of the recessus pinealis, which is clothed, as usual, with very large and dense epithelium, very different from that of the adjacent parts of the third ventricle. There seems to be a perforation passing obliquely dorso-caudad, forming the communication between the cavity of the epiphysis and the recessus. The epiphysis itself is tubular, and arches rapidly caudad to a point over the tectum, then curving more rapidly cephalad, between the hemispheres, is slung, as it were, in the membrane connecting them. The structure is like that of reptiles, varying much in different localities by the greater or less development of certain elements. In characteristic portions there is, first, the wall of connective tissue; seated upon this are slender cells, fibrous in character, which support small granular nuclei in several series, and centrally a larger nucleus beyond which the cell extends as a long narrow flagellum projecting into the cavity. The appearance is as though the single stalk supports nuclei of both sorts, though this may be an illusion. Nerve-fibres may be followed in the spaces between the cell-bases, extending in the direction of the axis of the organ, and passing into the larger nuclei. There can be no doubt of the nervous character of the organ.

"A blood-sinus closely invests the epiphysis, outside of which is a second investment from the dorsal sac which projects caudad to ensheath it. The walls of the dorsal sac consist of a single-layered epithelium with long cilia or flagella projecting into the lumen. Numerous plexiform diverticles also project into the cavity. The fibres from the epiphysis were traced, with apparent certainty, to the supra-commissura.

"Cephalad of the habenulæ, as well as immediately above them, the dorsal sac communicates with the third ventricle, the lateral ventricles being entirely distinct. Slightly farther cephalad the dorsal sac is shut off from a median portion which must be considered as homologous with the aula. Into this median portion the cavities of the lateral ventricles open, as usual, the only difference being that the aula is more elongated than usual, and the portæ are correspondingly enlarged. It has sufficiently appeared from the above that the dorsal sac is not a portion of the cavity of the prosencephalon, but of the diencephalon. It is not a new structure, but one found in reptilia as well, and pertains to the epiphysis."

In this connection was identified, apparently for the first time in fishes, a homologue of the hippocampus.

"The habena is imperfectly divided into two parts, a ventro-median portion, with smaller cells, giving rise to Meynert's bundle, and a cephalo-dorsal and ectal portion, of larger cells, giving rise to the tænia. The right habena is somewhat larger and is apparently chiefly associated with the fibres of the epiphysis."

The *hypoaria*, or caudo-lateral lobes of the cinereum, are less highly developed in Lepidosteus than in the sturgeon. They arise caudad of the chiasm as tuberosities of the lateral wall of the infundibulum dorsad of the ventral nidulus of large cells above mentioned. A diverticle of the infundibulum enters them, and this cavity expands to a spheroidal cavity. The cell structure is similar to that of the tuber. In Lepidosteus they extend much farther caudad, so as to reach the exit of the third nerve. A rather strong tract enters the caudo-mesad portion where it is becoming separated from the thalamus and passes toward the tract of the third nerve, passing Meynert's bundle, and apparently unites with fibres passing toward the cerebrum. If these fibres be compared with the fornix tract, they might seem to warrant the suggested homology of the diverticles of the third ventricle between the hypoaria with the mammillaria. This seems the more reasonable, inasmuch as there seems to be a homologue of the corpus geniculatum dorsad of them.

The *lobi optici* are very large and resemble those of reptiles in nearly every respect. Very large ventricles occupy their centres, and where these are confluent (Fig. 25) there is a curious pendant body on either side of the median line due to a lateral diversion of the median walls of the tecta, below their union with each other. This body, originally called fornix by Carus, may perhaps

retain the name suggested by Fritsch, *torus longitudinalis*, since it is free from the false homology involved in the other. The structure of this body is very simple, consisting of dense clusters of small cells like Deiter's corpuscles.

From the base of each optic ventricle there is a projection which has been called torus semicircularis. These lobes must be regarded as an inherent part of the mesencephalon, being provided with a slightly modified ventral accumulation of the cell-layer constituting the fourth of the above-mentioned layers of the tectum. The structures are those already familiar in reptiles, and called (rather unfortunately) by Rabl-Rückhard the *eollieuli*.

The roof of the aqueduct is thickened and thrust far forward under the optic lobes, or better, the optic lobes are thrust so far caudad that they over-arch the valve of Vieussens or *valvula eerebelli*. The presence in this body of the decussation of the fourth nerve is sufficient proof of the correctness of the homology.

In Lepidosteus the adhesion of the valve dorsally upon a forward tongue of cerebellum ventrad is considerable, but in Acipenser the ventral (cerebellar) portion is pushed forward and rolls cephalo-dorsad, fairly filling the cavity. The structure of this body, which may be called *volvula cerebelli* or *volvula*, is identical with that of the cerebellum proper.

The Cerebellum.—In the development of the cerebellum we have the most characteristic feature in the brain of the ganoid fishes and, at the same time, the peculiar modifications of the theme express the generic variations most distinctly. In the gars, where the whole brain is quite reptilian, the cerebellum is highly developed superficially, while in the sturgeon only a relatively small part is exposed, the remainder being packed in the cavity of the mesencephalon and the laterally enlarged fourth ventricle. In Lepidosteus the cerebellum may be divided into the following parts: first, a cephalic invasion of the mesencephalic cavity, more or less closely associated with the valve, constituting the *volvula* as above described; second, the median lobe or *vermiform lobe*, third, two *lateral lobes*; fourth, a posterior pouch or *bursa*.

In Scaphirhynchus the volvula is enormously developed and thrust far forward, completely obscuring the valve. Appearing first as a pentagonal projection from the inner (dorsal) surface of the (inverted) valve, it goes on increasing cephalad, till, rolling ventrad, it folds upon itself, turns caudad, carrying its median protuberance upon its (now ventral) surface, and passing somewhat dorsad to connect with the vermiform lobe. The central portion consists of white matter filled with enormous and beautiful branching Purkinje's cells, the lateral portions containing the Deiter's corpuscles. There is no bursa nor distinct cephalad diverticle, as in Lepidosteus, but the vermiform lobe remains a solid mass with its white matter mesad and dorsad and its granular layer laterad and ventrad to the end.

The Bony Fishes (*Teleostei*).—The discovery of Rabl-Rückhard[12] that the cortex cerebri is functionally absent and simply morphologically represented by a membranous pallium of fishes has opened the way for new studies in this neglected group. Great progress has been made in identifying homologies between the fish brain and that of higher vertebrates. The olfactory region is best studied in fishes because of the variability of the tuber and clues afforded by the manner in which the identical morphological relations are expressed under the varying conditions. Here, as in all other groups so far investigated, there are two distinct roots of the tuber. The radix lateralis is derived from the pero or external part of the tuber (that part composed of the glomerules and specific olfactory cells). This root passes along the ventro-lateral aspects of the cerebrum, at the line of union of the pallium with the axial lobe, and enters a special cluster of cells which has been homologized with a part of the hippocampus ("hippocampal nidulus").

The radix mesalis passes from the pes olfactorii and, even in the numerous cases where the tuber is removed by a long interval from the cerebrum, is always distinct from the preceding. It passes through the præcommissura. It has been shown that there are somewhat constant fissures upon the surface of the axial lobe and that the lobe is topographically subdivisible into subordinate lobes which differ in histological structure and fibrous connections. Thus the cephalic portion gives rise to the ventral peduncles which end in the hypoaria, while the dorsal part originates the dorsal peduncular bundles which pass to the midthalamus and there come into relations with the sensory niduli. The commissures of the cerebrum are difficult of interpretation. The great central bundle which connects the two axial lobes consists of three distinct portions, as described by Edinger and Bellonci; first, the præcommissura; second, decussation of olfactory radices; third, axial commissure (commissure of basal cerebral fasciculus, Edinger). In some cases feeble indications of a callosum have been recognized, as well as fibres from the "hippocampal nidulus," forming a "fornix" (Herrick).[14] The diencephalon is much modified in fishes and has received exceedingly divergent interpretations. The dorsal wall is frequently greatly reduced by the cephalic growth of the tectum opticum while its ventral aspect is increased by numerous expansions of a nervous or non-nervous nature. The non-nervous portions are essentially parts of the same system. The hypophysis and saccus vasculosus are both parts of a system of expansions of the ventral walls which are so thinned that only the thin, fibrous walls of the spongioblasts remain. These fibres have been described as nervous, but are undoubtedly remnants of the epithelium cells dragged out of the original position by distention of the walls. The saccus receives numerous vessels and is essentially a sort of plexus, while the axial part of the hypophysis is almost precisely similar and is in more or less direct communication with the former.

The hypophysis consists, in addition, of a mass of tubular vessels derived from the pharynx as in other groups. There are possibly nerve-fibres in the axial portion of the hypophysis, but most of the fibres which pass dorsad from it may be spongioblastic (gelatinous.) The epithelium of the saccus is ciliated. Caudad of the saccus are two small pouches which have been homologized by Herrick with the mammillaria. The great expansions back of the tuber cinereum known as the hypoaria or lobi inferiores are regarded by most authors as expansions of the base of the thalamus, but recently the view has been advanced that they represent (in part at least) the base of the mesencephalon which in other vertebrates is largely lost in the "saddle cleft."

In the base of the diencephalon of fishes the several decussations and commissures are unusually distinct. The commissura ventralis is the most ventral member of the system. The fibres arise in the tuber cinereum and form a true commissure. The commissura transversa is closely associated with the chiasm. Its fibres seem to spring from cells near the entrance of the cephalic branch of the optic tract into the tectum and may be associated with the anterior brachium opticum. A small but distinct bundle with similar course forms the commissura minor.

The commissura horizontalis, after forming a sharp loop across the median line, passes by a reverse curve through the nidulus ruber to the nidulus "corticalis" near the habena.

Meynert's bundle pursues the same course in fishes as in higher animals and serves as a valuable landmark. A possible tænia thalami connecting the diencephalon and prosencephalon was noted.

The dorsal surface of the thalamus gives rise (over the aula) to a remarkable pouch or dorsal sac which may extend far cephalad and is intimately associated with the epiphysis. It seems probable that the same structure exists in all vertebrates and forms the plexiform body, sometimes called paraphysis and in some cases mistaken for the epiphysis itself.

The habena is frequently well-developed and contains numerous small cells. It sends numerous spongioblast fibres into the tectum. The most remarkable external structure on the lateral surface of the diencephalon is

the geniculatum, which in its internal structure is peculiar. The ectal surface has numerous large cells like the peripheral cells of the hypoaria. These give rise to two fork-like processes which form a switch-station for the tracts. The interior is composed of similar cells in a great mesh-work of fibres. The ventral commissure enters it and thus suggests a connection with the brachia optica, while a contingent of fibres passes to the dorsal peduncle.

Although the optic nerves pass over the walls of the thalamus there is no connection directly with the cells of that region. The tracts divide at once into a cephalic and a caudal portion which pass severally to the cephalic and caudo-lateral portions of the tectum. The gray matter of the diencephalon will be further treated in connection with the mesencephalon.

The roof of the mesencephalon is composed of a greatly distended tectum opticum, while much of the central cinerea is crowded into the interior of the ventricle in the form of the torus. The latter is derived from the median part of the tectum and contains granules and cells. Its spongioblasts are connected with the tectum and are obviously simply the elongated walls of the displaced epithelium cells whose ventral ends have been crowded into the ventricular space. These slender remnants of the cell-walls (" gelatinous tracts ") are among the most important indices of the structural relations of the modified brain-walls. The tectum opticum is so complicated and difficult that no apology is necessary for giving in full the suggestions derived from a study of this organ in fishes.

The fibre-tracts are : 1. The optic fibres, entering from the cephalo-mesal and caudo-lateral aspects respectively. These tracts are part of the same continuous sweep of fibres from the optic nerve, which have been separated by the architectural necessities of the brain; their internal course is morphologically identical. 2. The fibres of the cephalic and caudal brachia which, after effecting cellular connections at their exit from the tectum (?), connect with a double commissural system (transverse and ventral commissures) as above described. 3. The radiation to the lemniscus derived from the ventral ganglionic series of the tectum and passing to the lateral aspects of the medulla. 4. Associated with the latter the fibres of the middle peduncles of the cerebellum (decussatio tegmenti) and probably also fibres to the third, fourth, and perhaps the sixth nerve niduli. There may also be among them commissural fibres. 5. The Sylvian commissure system whose fibres pass in a more or less complicated course from one side to the other, originating in the ectal reticulum of either side. 6. A system of fibres belonging to the category of gelatinous tracts, *i.e.*, connective fibres springing from the epithelium of the ventricular portion of the torus and passing to the ectal surface of the tectum.

The connective framework of the tectum is constructed on the same plan as that of the rest of the brain, and consists of a continuous epithelium with the base of each cell upon the ventricle and its summit at the periphery. The integrity of the series is greatly disturbed by the development of neuroblasts and their migration and the invasion of fibre-tracts, as well as by the great changes in position suffered as a consequence of the development of the cerebellum and volvula. The primitive simplicity is retained more perfectly in Amphibia (*Menopoma*, etc.). To all appearances, the nucleus of the epithelium cell divides without causing division of the cell, yet this is not certain. After passing the inner ganglion layer the walls collapse and form a thread which may enclose one or more nuclei and terminate at the periphery in a cell. These are conspicious in the young, but practically shrivel up with age. Between these cylindrical connective cells the neuroglia stroma, nerve-cells and fibres develop. The cells develop from the neuroblasts of the ventricular region and accumulate between the connective cells up to the level of the first fibre belt, forming a basal cellular zone. The upper portion becomes functional and some cells migrate toward the periphery. By the gradual thickening of the tectum the ganglionic layer is separated from the ventricular surface by an interval. It seems probable that only the outer portion of the dense zone of nerve-cells is functional, and it is only with these that a fibrous connection has been observed. The first layer of the tectum, beginning from the ventricle, therefore, consists of columnar epithelium cells whose protoplasm in the adult is more or less shrunken and whose nucleus may still remain distinct or may become imbedded in a thin layer of protoplasm adjoining the walls. The walls may collapse beneath the ganglion layer and there is frequently an intricate folding which produces a peculiar appearance in section, but Fusari has completely misinterpreted this appearance in Plate III. of his work.* The appearance of a brush-like radiation of fine processes is illusory and in perfectly prepared specimens, not too much dragged in cutting, the walls of the cylindrical epithelium cells can still be followed. Above this level the whole tectum becomes charged with a dense mass of gelatinous matter, giving it a homogeneous appearance. The (generally collapsed) walls of the connective cells pass directly toward the periphery and in some cases enclose nuclei with surrounding protoplasm. Whether these nuclei have simply retreated from the ventricular surface, or whether a single epithelium cell may have more than one nucleus is uncertain, but at the peripheral terminus there is always a small fusiform cell-like body.

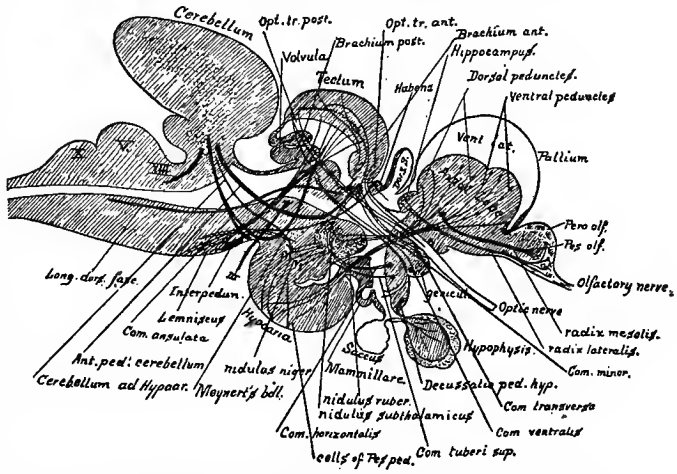

FIG. 457.—Diagrammatic Longitudinal Section of Fish-brain illustrating the Course of the Most Important Tract and Commissure. (From *Anatomischer Anzeiger*, vii., 13–14.)

These were apparently figured by Fusari as terminal expansions of ganglion-cell fibres in the plate above referred to.

It is only in well-preserved material that the distinction between the nuclei of the ventricular epithelium and the internal ganglion layer is obvious. A comparison with Amphibia shows that the same arrangement prevails there also. Each ganglion cell has its peripheral process, which passes into the ectal layer of the tectum and there divides dichotomously, mingling with the optic fibres to form a fine reticulum. This zone is perforated at intervals by the lemniscus and decussating cerebellar tracts, whose fibres collect ectad. In many cases actual communication between fibre and cell could be seen. But there is also a partial commingling of fibres of the next layer at some levels.

The fifth layer is a dense band filled with a homogeneous gelatinous substance, through which pass the fibres from the apical processes of the ental ganglion layer. It also contains sporadic cells of that layer as well as pos-

* Atti de Lincei Mem. cl. sc. fis. ecc. Ser. 4, Vol. IV. Intorna alla fina anatomia dell' Encefalo dei Teleostei.

sibly those forming the termini of the anterior branchium fibres; the sixth and seventh layers cannot be topographically distinguished with precision; the sixth is chiefly composed of transverse (sylvian commissure) fibres, while the seventh is the layer of optic fibres passing more or less obliquely caudad. Within these two layers is contained the ectal layer of ganglion cells of large size and with elongate processes. The apex process terminates in a strong fibre which divides dichotomously and gives off its ultimate branches to the reticulum. Careful study with high powers showed that these fibrils actually unite with or come into contact with the reticulum. The appearance of free termination, seen in Golgi preparations, seems to be unconvincing, especially in view of the imperfect conservation implied by that procedure. The basal processes of these cells turn cephalad and seem to enter the optic tract.

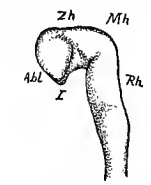

FIG. 458. — Youngest stage of Ichthyophis. *I*, infundibulum; *Abl*, optic vesicle; *Zh*, diencephalon; *Mh*, mesencephalon; *Rh*, metencephalon.

Amphibia.—The most notable recent additions to our knowledge of the amphibian brain are due to the efforts of Osborn, Burckhardt,[15] and Edinger.[6] The Gymniophona (subterranean amphibia) have been instructively compared with the salamanders, etc. Those amphibia which, like Ichthyophis, are meroblastic in development agree in the method of formation of the head with the Amniota in several aspects. We may conveniently refer to Dr. Burckhardt's figures of Ichthyophis. Fig. 458 is a lateral view of the youngest embryo. The infundibulum (*I*) is the front of the brain, which is somewhat curved ventrad. Comparing with this figure a nearly corresponding stage of the human embryo, as reconstructed from sections by Professor His, a marked similarity is obvious, Fig. 459. The greater elongation and differentiation of the human embryo is apparent and the infundibulum is less obviously the front by reason of the protrusion of the future optic recess. Fig. 460 is a later stage of Ichthyophis, in which the origin of the hypophysis is visible and the true nature of the cerebral vesicles as dorsal projections is very well exhibited. The saddle-cleft separating the metencephalon from the rest of the brain is greatly developed and still unclosed. In Fig. 461 the subsequent combinations are shown, and Figs. 462 and 463 give illustrations of the adult brain. The special development of a "temporal lobe" which may be compared with the "hippocampal rudiment" discovered by Herrick in fishes, is noticeable, though the connection of the præcommissure with the olfactory tubes described by Burckhardt must receive a new interpretation.

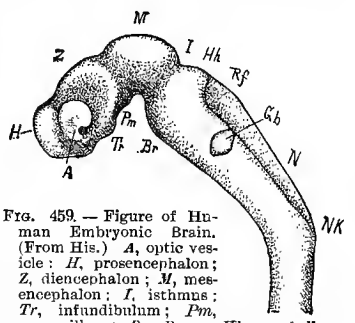

FIG. 459. — Figure of Human Embryonic Brain. (From His.) *A*, optic vesicle: *H*, prosencephalon; *Z*, diencephalon; *M*, mesencephalon; *I*, isthmus; *Tr*, infundibulum; *Pm*, mammillare; *Br*, Pons; *Hk*, cerebellum; *Rf*, roof of fourth ventricle; *Gb*, auditory vesicle; *N*, medulla; *Nk*, cervical flexure.

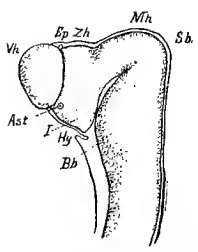

FIG. 460.—An Older Embryo of Ichthyophis. *Ep*, epiphysis; *Ast*, optic peduncle; *Sb*, mesencephalic flexure; *B b*, pons flexure.

The embryology of Ichthyophis shows that the nasal epithelium, Jacobson's organs, and other sensory patches of the roof of the mouth have a common origin, and it is but a step farther to identify them with the pituitary fundament as parts of a frontal sensory plate of the primitive vertebrate. Edinger recognized the existence of an occipital lobe in amphibia and observed the corpus callosum as described by Osborn.

Among the most stimulating papers of the last few years is Professor Osborn's[18] on the callosum. Respecting the Amphibia he says: "The cerebral commissures lie behind the foramina of Monro. They consist of an upper and a lower bundle. The former is much the larger. It passes upward and forward behind and above the foramen and gives the commissural supply to the dorso-medial portion of the hemispheres. It is the corpus callosum. The lower part is the anterior commissure. Its main division is the pars olfactoria, which supplies a part of the brain stem, the ventro-lateral portion of the hemispheres, and probably the olfactory lobes. Its lesser division, supplying the lower posterior part of the hemispheres, is the pars temporalis. The inner olfactory tracts arise near the anterior commissure, cross each other, and pass to the olfactory lobes."

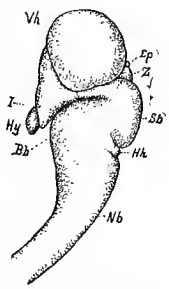

FIG. 461.—Embryo of a Still Later Stage.

The upper bundle of the callosum was found to develop at an early stage in the frog. The fibres of the anterior commissure appear somewhat later as a delicate thread beneath the callosum. A mechanical explanation of the fact that this order is the reverse of what occurs in mammals was suggested in what is called the primary and secondary positions of the callosum. In the primary position, Amphibia (and Fishes ?), this commissure lies in the floor of the primary fore-brain, a part of the brain-wall which is early developed, hence its development is as rapid as that of the anterior commissure. In the secondary position, mammalia, the callosum lies in the middle portion of the terminal plate, which is a later growth than the floor of the ventriculus communis, hence its late development. The existence of a fornix commissure was regarded as doubtful in amphibia, though certainly present in reptiles.

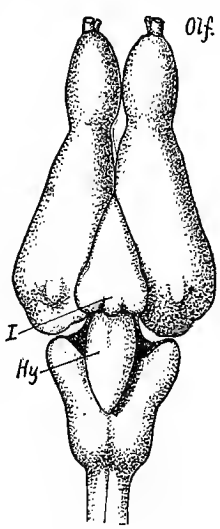

FIG. 462.

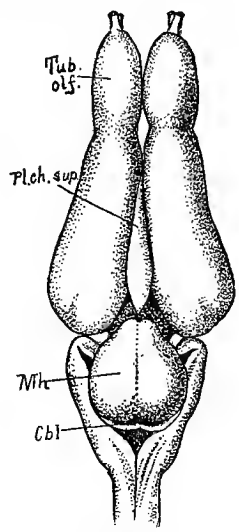

FIG. 463.

FIGS. 462 and 463.—Adult Brain of Ichthyophis.

A considerable dispute has grown up as to the propriety of applying the term callosum to the fibre-strands connecting the dorso-median portion of the mantle.

With the differentiation of a mantle from an axial portion of the cerebrum the dorsal system becomes more distinct and complicated, attention needs to be called to the fact that morphologically the precommissure, callosum, and hippocampal commissure are all parts of a

single system connecting homologous parts of segments of the dorsal part of the neuraxis. One may increase at the expense of another, or nearly supersede it, as is the case in the marsupials.

In 1888 Professor Osborn[16] devoted an extended paper to the amphibian brain. Some of his results are the following: There is a direct motor tract to the prosencephalon and diencephalon. A portion of the descending trigeminal tract passes through the cerebellum. The posterior (dorsal) longitudinal fasciculus sustains relations to the eighth, sixth, fourth, and third tracts. The nidulus of the oculomotor is connected with the post-commissure. A new sensory tract and nidulus common to the ninth, tenth, and seventh pairs of nerves was noticed. The size of the roof of the mesencephalon is in proportion to the functional perfection of the eyes. The cerebellum was regarded as intersegmental, and secondarily acquires a functional importance equivalent to that of other segments. The early constriction of the brain roof, which gives rise to the four vesicles, is for the accommodation of three nerve-fibre tracts decussating dorsally, viz., the supra- and post-commissures and the cerebellum, which in their primitive condition have a serial homology.

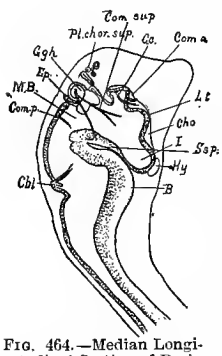

FIG. 464.—Median Longitudinal Section of Brain shown in Fig. 30. *Cc*, callosum; *Com. a.*, præcommissura; *Com. sup.*, supracommissura; *Pl. chor. sup.*, præplexus; *Ggh*, habena; *Ep.*, epiphysis; *Com. p.*, postcommissura; *Cbl*, cerebellum; *I*, infundibulum; *Cho*, chiasm; *Lt*, terma; *Hy.*, hypophysis; *Ssp*, "saddle-cleft;" *B*, pons.

In *Proteus* and *Menobranchus* the primitive epiblastic stalk of the optic vesicles is persistent.

The nerves of the third, fourth, and sixth pairs form a special system with no apparent homology or connection with the motor elements of the vagus or trigeminal systems.

The attempt to employ the cerebral commissures as landmarks of the chief morphological segments of the brain (Osborn[17]) has not been generally accepted, but has served to call out much useful discussion. Kupffer[18] attempts to show that the Amphibia have segments of the dorsal roof which are not developed in other classes, at least not to the same extent.

In Amphibia, Edinger identified the basal prosencephalic tract (ventral peduncle) which arises in the lateral and basal parts of the prosencephalon and passes to the diencephalon dorsad of the infundibulum, evidently forming anastomoses with cerebellar and other tracts. He also describes a homologue of the tænia thalami and an olfactory tract which, after crossing in the præcommissure, enters the diencephalon (?) and, doubtfully, a mantle bundle which decussates caudad of the chiasm. Two tracts (equivalent to Osborn's direct diencephalic tract) pass into the lateral aspects of the cord. The connection of the diencephalon with the cerebellum through prepeduncles is described, and it is apparent that the relations are the same as described by Herrick for Fishes.

The Brain of Reptiles.—The authors who have contributed most extensively to our knowledge of the reptilian brain are Stieda, Rabl-Rückhard, Edinger, Herrick, and Meyer. The prosencephalon was carefully described by Edinger[19] (1888), who discusses Lacerta agilis, Anguis fragilis, Emys lutaria, and Tropidonotus natrix. He divides the axial portion into a cephalic portion containing scattered cells and a caudal spheroidal portion which is called nucleus sphæricus. The origin of the peduncle tracts is in the axial lobe, and they divide in the thalamus, one to enter the nidulus of the thalamus, while the ventral portion passes on into the medulla. The figures, however, leave open the possibility that the ventral peduncle communicates in this case, as the writer has shown in Fishes, with the middle peduncle of the cerebellum.

The dorsal cortex of the median wall of the hemisphere is considered homologous with the cortex of the cornu ammonis, and a portion of the median wall devoid of cortex is said to represent the fornix ridge. Edinger says explicitly that the cortex first appears in Reptilia, though we now know that it is represented in Dipnoi and Amphibia.

A callosum and fornix bundle are recognized much as they were by the writer. Aside from the fornix region an occipital region and a dorsal region are distinguished, which latter is supposed to communicate with the olfactory. An intermediate cell layer is also mentioned.

The writer[20] published one year later a brief account of the alligator, in which many of the above points were independently observed. The mistake of Wiedersheim and Rückhard in supposing the olfactory bulb to be absent is corrected by reference to the young brain, in which the tuber still adheres to the brain.

Distinct callosum, fornix, and tænia thalami were observed, and also a bundle corresponding to that called by Edinger "*Bündel der sagittalen Scheidewand.*" The several commissures are found to occupy the same relative position as in other Vertebrates. The remarkable olfactory fossa, a depression found in all Reptiles and in the Opossum, is noticed for the first time.

"Three distinct kinds of cells can be detected in the mantle, one characteristic of the superior and anterior regions, a second of the occipital, median, and posterior-lateral regions, and a third about the ventro-basal region or hippocampus.

"The natural division of the cerebrum into an axillary and mantle portion is very convenient for the purpose of description of the nervous elements. Attention is again called to the reason for regarding these two regions more closely related than either is with the diencephalon. The corpus striatum, as such, does not exist in the alligator, but the major part of the cerebrum consists of what Rabl-Rückhard called axillary lobes (*Stammlappen*). The axillary lobes consist of a rather homogeneous mass of cells, and has a contour similar to that of the entire hemispheres, but is covered by a mantle which embraces it on all sides except behind, and is separated from it on all sides except antero-inferiorly by the ventricle, which is exceedingly narrow. The axillary lobes are, therefore, the immediate cellular envelopes of the direct extension of the peduncles. The mantle portion is exceed-

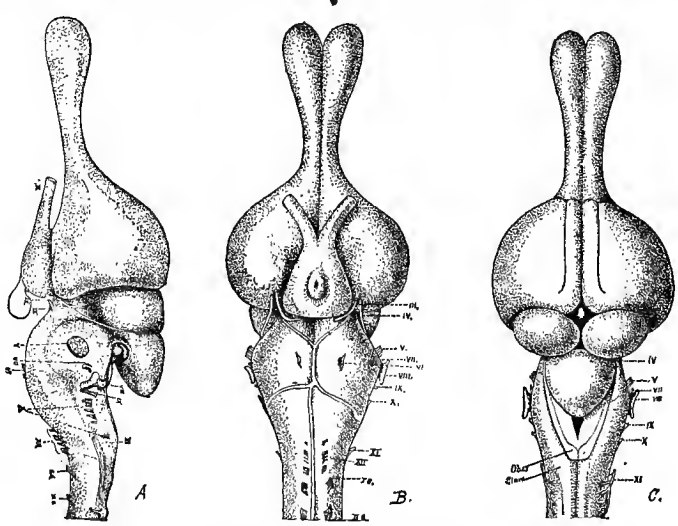

FIG. 465.—*A*, *B*, *C*, Three Views of the Brain of a Young Alligator.

ingly thin, and presents little opportunity for variety in structure. There is, however, a marked diversity in the cellular elements entering it.

"From analogy these varieties of cells may be assigned to motor, psycho-sensory, and special olfactory functions respectively. The axial lobes likewise have two sorts.

"The pyramidal cells which were first above mentioned stain deeply, have small nuclei, and have a long apex-process, generally directed obliquely toward the periphery, and several basi-lateral processes. No central basal process such as described by Meynert was seen. These motor-cells can be traced into connection with the basal prosencephalic tract (continuations of the peduncles). Indeed, similar cells can be followed to the diencephalon. The second variety of cells is flask-shaped or balloon-shaped, and has a slight power of precipitating stains; and is further characterized by the large, clear nucleus, or perinuclear space. Such cells are distinctive elements over the posterior and median parts of the cortex. Especially constant are they in the median wall.

"The great bulk of the axial lobes—that portion which protrudes into the ventricle—is filled with similar flask cells, but these are curiously clustered in groups of two or multiples of two. The evidence that these cells are undergoing rapid increase by fission in this young animal is very conclusive. All stages of the process may be ob-

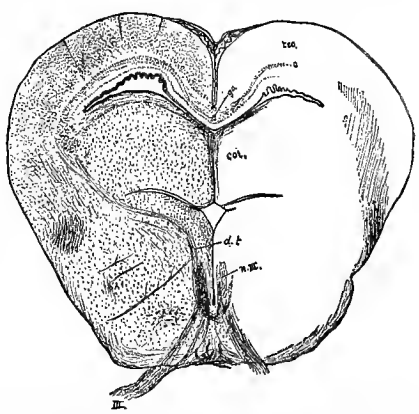

Fig. 466.—Cross-section of Optic Lobes of Alligator at Exit of Third Nerves. *col.*, Colliculus; *tec.*, tectum; *g.c.*, large cells of mesencephalic root of the fifth nerve; *n. III.*, nidulus of the oculo-motor; *d.t.*, tract from tectum passing adjacent to the nidulus.

served. It may be suggested that, if in the case of young animals this part of the brain is most actively multiplying cells, it is possible that the growth of the mantle (in which there is little material for rapid growth) may be in some way associated with this proliferation of cells, resulting in the increase of the mantle from its margins, as though the material were pushed up around the margins of the ventricle by rapid growth within.

"The connection of this portion of the axial lobes of the cerebrum seems to be with the superior or sensory longitudinal tracts of the peduncles. In addition to the tracts above mentioned, the tænia thalami, springing from the basal region and passing to the habenulæ, form a sensory link between the thalamus and the cortex. It is noticeable that the cells associated with this tract, even in the thalamus, are of the flask variety."

Four areas of the mantle were distinguished, and the variety of cells contained in each seemed to substantiate the theory that the pyramidal cells are motor and the flask cells sensory. "One cell-cluster, which occupies a relatively small area anteriorly, but increases caudad, occupies the lower median portion of the mantle. It consists of flask-like or sensory cells with fibres, which can be traced to the tract leading directly ventrad to the ventral median portion of the posterior part of the brain, *i.e.*, the hippocampal region, and seems to embrace the continuation of the olfactory tract."

The above indicates that the writer identifies the homologue of the hippocampus differently from Edinger, and relies on the course of the olfactory fibres as a guide, as Burckhardt has since done.

The existence of communicating tracts between the tectum opticum and the oculo-motor roots was noted. See Fig. 466.

In 1881[21] the writer published several contributions to the neurology of Reptiles. The free caudo-ventral portion of the cortex is definitely homologized with the hippocampus and two distinct portions are distinguished. The axial lobe is divided into two portions. The caudal one (n. sphæricus of Edinger) is coiled upon itself by the backward revolution of the hemisphere and is called the occipito-basal lobe, while the cephalic portion, receiving the peduncular tracts and probably representing the striatum, is known as the central lobe.

The cortex is aggregated in specialized regions, called the frontal, parietal, fronto-median, and intra-ventricular respectively.

The pre-commissure consists of three parts, one of which passes to the pes of the olfactory, another to the lateral regions of the hemisphere, and the third to the occipito-basal lobe. The callosum and tænia thalami are also described.

The existence of two commissures in the region of the epiphysis is noted, one being the pre-commissure, the other the commissure of the habena. Attention is called to the fact that the projecting plexus (conarium of European authors) has been frequently mistaken for the epiphysis (Zirbel).

Meyer[23] devotes an extended paper to the reptilian brain, but finds it necessary to rename many of the organs. He describes the radix lateralis as extending from the olfactory pero to the occipito-basal lobe (his "nucleus sphericus"). Much difficulty in construing the olfactory region would be removed if the pes olfactorii were recognized as a part of the hemisphere. The subdivision of the mantle into a number of distinct cell-groups is recognized. The median wall is called septum pellucidum, but the author finds no commissural fibres connecting the pallium of the two sides.

If it were present it could not represent the callosum, which, he claims, must arise in a late stage of development and form a secondary connection between the hemispheres. The writer has abundantly demonstrated the existence of a callosum in the sense employed by Osborn in other reptiles, and sees no reason why the period at which the fibres appear should influence the homology, especially as we know almost nothing of the period when they appear in Reptiles. Nothing is more probable than that a strongly developed mass of commissural fibres should create a place for themselves apparently outside the septum in which they originate.

The Brain of Birds.—The most important contribution which has yet appeared in this department is that prepared by Mr. C. H. Turner,[22] under the direction of the writer, in 1891.

Compared with other Sauropsida the avian brain is quite large and is remarkably compact. The large prosencephalon entirely covers the diencephalon, and may cover rhinencephalon and mesencephalon. Although the compactness of the brain, the highly developed cerebellum and ventrally and laterally revolved optic lobes give to the bird-brain a habitus peculiarly its own, yet it is, after all, but a modified reptilian organ. Mr. Turner shows that a careful use of brain measurements and proportions offers valuable aid in classification.

The avian prosencephalon is large, but unconvoluted. The epencephalon is well developed and transversely convoluted. From the introduction of the class Aves until now there has been a gradual retrograde evolution of the avian rhinencephalon. In the lowest type of birds the rhinencephalon is double, and projects beyond the cephalic extremity of the prosencephalon; in the highest type it is single and does not project. In the lower types of bird-brains the optic lobes are only partially covered by the prosencephalon. During the evolution of the class Aves and the differentiation of the

families in it the dorsal and lateral portions of the avian prosencephalon have grown caudad much more rapidly than the ventral and mesal portions. This has caused the caudal portion of each cerebral hemisphere to revolve toward the meson, and, at the same time, to cover the optic lobes. The avian brain has great toxonomic importance. So far, at least, as major groups are concerned, a classification based upon it agrees in all essentials with those based upon a careful study of all the structural elements. There is a distinct callosum in addition to the precommissure. There is a fibre-tract connecting the mesal division of the mantle with the optic lobe of the same side. There is a correspondence throughout the class in the distribution of cell-types. The mesal division of the mantle contains fusiform cells only. The lateral division contains pyramidal cells only. The striatum contains cells of both types. There is a proliferating area in the axial lobe where small cells are produced. There is an involution of cortex in the occipital region of which there is no external indication. Birds are pre-eminently seeing animals, and all parts that appertain to vision are developed to a great degree. The optic nerve is the largest of the cranial nerves, and the optic lobes are complexly differentiated bodies. Even the third, fourth, and sixth nerves are relatively larger than the corresponding nerves of the mammalian brain.

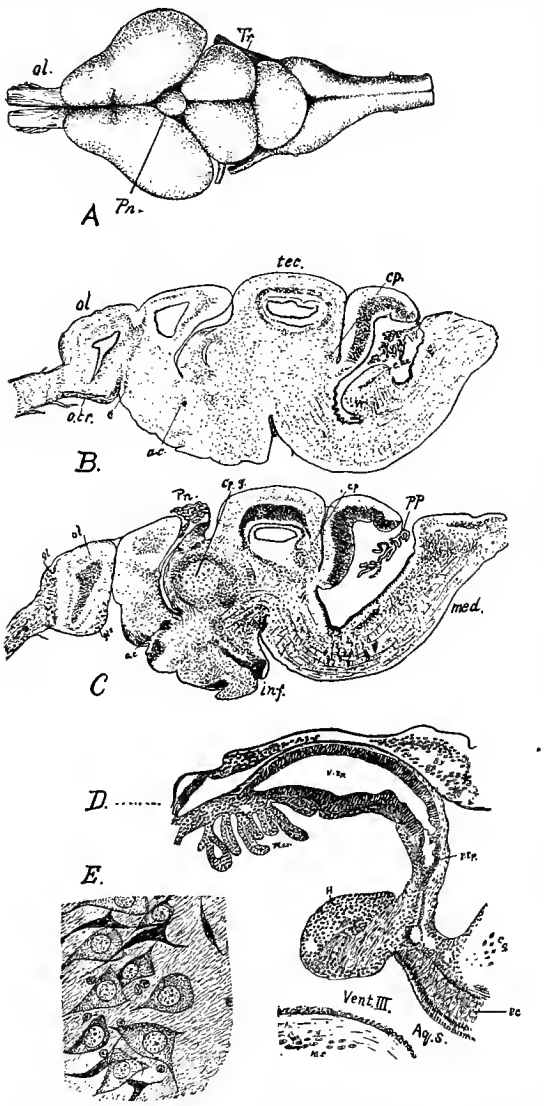

FIG. 467.—Brain of a Young Turtle (*Aspidonectes spinifer*). *A*, Entire brain from above. *ol.*, Olfactory nerves; *Pn.*, epiphysis with dorsal sac; *Tr*, fifth nerve. *B*, Longitudinal section of the same brain. *o.t.r.*, Radix lateralis olfactorius; *ac.*, precommissure; *tec.*, tectum opticum; *cp.*, corpus posterior or testes. *C*, Similar section, nearly median. *Cp.g.*, corpus geniculatum; *gl.*, *gl.*², glomerular layer of olfactory lobe; *inf.*, infundibulum; *PP*, post-plexus; *med.*, medulla; *Pn.*, epiphysis. *D*, the epiphysis. *V. Ep.*, ventricle of epiphysis; *P. ep.*, peduncle of epiphysis; *Plex.*, plexiform part of dorsal sac; *pc.*, post-commissure; *Aq. S*, Sylvian aqueduct; *s.v.*, venous sinus above epiphysis. *E*, Cells of the two sorts in mixed cortical area of the cortex. (All the figures from *Journal Comp. Neurology*, March, 1891.)

Mammalia. Minute Anatomy of the Spinal Cord.—Professor Golgi, of Pavia, by means of the method which bears his name, made out the following points, upon which recent investigations have been founded:

1. All the nervous cells of the cord have but one nervous process. (That is, only one process which gives origin directly to a nerve-fibre. Opinion differs greatly as to whether the other (protoplasmic) processes convey or receive nervous stimuli or act simply as nutrient roots.)

2. The protoplasmic (shorter, branching) processes do not give rise to nerves but are distributed to blood-vessels and glia-cells.

3. Nerve-cells differ greatly in size and form and method of branching of the protoplasmic processes, but these variations are not especially significant.

4. More essential characters are furnished by the behavior of the nervous branch, in accordance with which we may distinguish two types of nerve-cells: (*a*) Such as have an axis-cylinder which soon subdivides and produces a reticulum; (*b*) such cells as send out an axis-cylinder which maintains its integrity in spite of producing a few lateral branches. Cells (*a*) are found in the dorsal cornua and substantia gelatinosa, cells (*b*) in the region of the motor-root (ventral cornua).

5. In the cinerea of the cord there is a diffuse reticulum of fibres which is continued into the medulla and forms a communication between all parts of the gray matter. In the cord this reticulum is formed of the fibres of the dorsal roots and nervous processes of the sensory cells, as well as of branches of fibres from the motor-cells, and similar cells of the dorsal cornu and from small branches from the fibres of the various tracts.

6. In the cord nerve-cells of very different value are promiscuously scattered.

7. The second type of cells (sensory), with divided axis-cylinders, is found in the cells of the substantia gelatinosa, a considerable number of the cells of the dorsal cornu proper, a few irregularly arranged cells of the marginal layer between the two cornua, and a few which are scattered in the ventral cornu.

The motor type of cells is found represented by the majority of the cells of the ventral cornu, a few cells of the dorsal cornu, and cells of the intermediary zone, especially those adjacent to the lateral bundles.

The majority of the cells of the ventral cornu send their axis-cylinders into the ventral column or the ventral root, while a considerable number pass through the ventral commissure into the white bundles of the opposite side. A few cells send their processes into the lateral and ventro-lateral columns.

In the ventral commissure three kinds of fibres cross to the opposite side: those of the cells of the dorsal cornua, those from cells in the ventral cornua, those from the zone between the central canal and the lateral columns. There seems to be a doubt in the mind of Golgi whether the cells actually pass into the columns of the opposite side or simply divide to form a reticulum. The fibres of the sensory nerves, after entering the spinal cord, subdivide like the axis-cylinders of cells of the second type.

To these important statements the following were added by Ramón y Cajal, who used the same methods and came to similar conclusions as Golgi, quite independently of the latter:

(1) The nerve-fibres of the sensory roots divide after entering the cord into an ascending and descending branch, associated with the fibres of the dorsal cornua.

(2) Cajal believes that the free tips of the nerve-fibres

and their branches end free instead of forming a reticulum.

(3) In accordance with the above, nervous influence is transmitted by contiguity or contact and not by continuity of the paths.

Professor Kölliker, in an admirable monograph published in 1891, reports the following results:

(1) The sensory root-fibres divide, as described by Cajal, the branches lying in the dorsal columns are superficially in the substantia gelatinosa in the marginal zone. Some of these branches may be followed four to six centimetres, while others turn entad and end in free tips.

(2) No instance of direct connection between the fibres of the dorsal roots and the cells of the cord has been observed.

(3) All sensory longitudinal fibres of the columns give off collaterals, which subdivide and end free in the gray matter. These are particularly numerous in Clark's column and the marginal region of the gelatinosa.

(4) The motor root-fibres spring from large and small

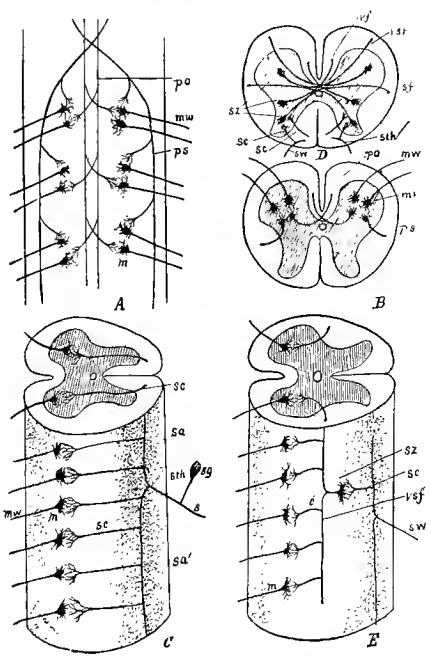

FIG. 468.—Diagrams of the Tracts and Centres in the Cord. *A*, Longitudinal section. *po*, Ventral pyramidal tract; *ps*, lateral pyramidal tract; *m*, motor cells; *mw*, motor roots. *B*, Cross-section to show the same elements. *C*, Diagram of the elements concerned in reflex action. *s*, Sensory root-fibre; *sa*, ascending, *sa'*, descending branch; *sc*, sensory collaterals. *D*, Diagrams of the decussating fibres in the ventral commissure. *sz*, Cells of the fasciculi; *vf*, fibre of lateral bundle; *vsf*, fibre of ventral bundle; *sc*, sensory collateral; *sw*, sensory root; *sth*, point of bifurcation. *E*, Diagram of short tracts.

cells of all parts of the ventral cornua in the form of a simple axis-cylinder. (There may be small branches.)

(5) The ventral and lateral columns of the cord are composed in part of fibres which arise in all regions of the cord. These cells frequently give off from their fibres more or fewer lateral branches, which end free in the gray matter.

(6) All, or nearly all, the conducting fibres of the ventral and lateral columns give off collaterals which enter the gray matter of the ventral cornu and the ventral part of the dorsal cornu and terminate free, and many of the fibres themselves bend at a right angle and end in the same way.

(7) The ventral commissure consists of (*a*) nervous processes from cells of the cinerea of all regions, which, after crossing, are continued as longitudinal fibres of the ventral and ventro-lateral columns, (*b*) crossed collaterals of the ventral and lateral columns, and (*c*) crossed protoplasmic processes of a part of the cells of the ventral cornua.

(8) The dorsal commissure is composed of (*a*) crossing collaterals of sensory root-fibres, (*b*) possibly the crossing of collaterals of the dorsal part of the lateral columns.

(9) Nerve-cells of three sorts, (*a*) motor, (*b*) cells of the columns, and (*c*) other cells whose nervous processes do not extend beyond the gray matter but simply subdivide within it (dorsal cornu).

(10) Protoplasmic processes subdivide minutely and ramify in various parts of the gray and white matter, but do not give rise to nerve-fibres or anastomoses.

(11) The glia-cells are formed from the elements of the medullary plate, and are either primary or secondary, the former remaining as the ventricular epithelium.

Professor Kölliker, accordingly, agrees with Golgi that the protoplasmic processes are solely nutritive, never exerting a nervous influence over adjacent structures. The influence exerted by one neuron upon another is purely by contact, not by continuity. Voluntary motion is produced by the effect produced by pyramidal fibres upon the motor cells of the ventral cornua, a process which is facilitated by the collaterals and terminal brushes of the former forming a net-work around the latter and thus coming in contact with the cell.

Sensory impressions are conveyed through the dorsal root-fibres, which ascend to the medulla and thence by undiscovered paths to the brain. Reflex reactions are explained by the passage of collaterals of the dorsal root-fibres to the cells of the ventral cornu.

MINUTE ANATOMY OF THE CEREBELLUM.—The most important recent additions to our knowledge of the histology of the cerebellum are derived from applications of the Golgi method to embryos of various groups of Vertebrates. The most significant papers are those of Golgi, Cajal, and Kölliker. It will be remembered that the cerebellum contains four layers, which, beginning at the periphery are (1) the molecular layer, containing superficial fibres; (2) the layer of Purkinje cells; (3) the granular layer; (4) the white matter or axis-cylinder layer.

(1) Golgi was the first to clearly prove the existence in the molecular layer of small ganglion cells. These cells are of variable form and give off "axis-cylinder" processes, which lie chiefly transverse to the convolutions, and which, in the deeper cells, give off perpendicular fibres which, according to Cajal, form a basket-like envelope for the Purkinje cells. The peripheral cells are smaller, and are similar to other bipolar cells. Gierke had observed what he called neuroglia envelopes of the Purkinje cells, and it is not impossible that these "basket cells" may be of this nature, but the unanimous opinion of those who have studied them by the new methods is that they are nervous, and that the processes which envelop the Purkinje cells do not actually unite with the latter but simply are contiguous to them.

(2) Purkinje's cells are shown by this method to have an extraordinarily abundant supply of processes similar in structure to the protoplasmic processes. These processes ramify in the molecular layer, and, although they may reach the surface, do not anastomose or connect with the pia, the blood-vessels, or other fibres. These fibres are chiefly confined to one plane, *i.e.*, transverse to the convolutions. The axis-cylinder process may give off a few lateral processes, but continues into the white zone.

(3) The granular layer contains two kinds of cells: (*a*) The small nerve-cells are scattered throughout the layer and give rise to a number of short, much-branched protoplasmic processes and to one long-axis cylinder. The latter passes between the Purkinje cells, and, after penetrating the molecular layer, divides into two branches, which extend parallel to the surface and in the plane of the gyri for some distance. It would seem that these cells are the ones which migrate from the surface at a late period of embryonic life, as described by Herrick (see next article). (*b*) The larger cells of the granular layer are not numerous and are irregularly distributed. The "axis cylinder" branches very profusely.

The medullated fibres form a dense layer beneath the Purkinje cells, while others pass into the molecular layer

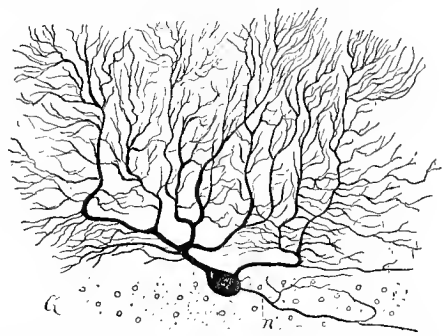

FIG. 469.—A Single Purkinje Cell (by Golgi's Method). *n*, Axis-cylinder process passing into the granular layer (*G*).

and subdivide. Such fibres also occur in various parts of the molecular layer. The connections are as yet obscure.

TYPES OF CORTICAL CELLS.—Various observers substantiate Golgi's statements that sensory and motor (psycho-motor and psycho-sensory) cells differ in the nature of their axis-cylinder or nervous process. Martinotti especially claims that the ganglion cells communicate by a single nervous process with the axis-cylinder, while the protoplasmic processes do not connect directly or indirectly with the nervous fibres but tend to pass to the blood-vessels and surfaces. Two sorts of ganglion-cells are recognized: one in which the nervous process divides and forms a network or neuropilem, the other in which there is direct connection with a corona radiata fibre. Herrick has attempted to distinguish sensory and motor cells by other methods. In those regions ventrad of the rhinalis fissure the cortex is composed of cells whose processes subdivide to form a dense neuropilem or nerve-felting in the so-called neuroglia layer entad of olfactory fibres from the radix lateralis. This type of cell corresponds with the second type of Golgi (Fig. 472, *s*).

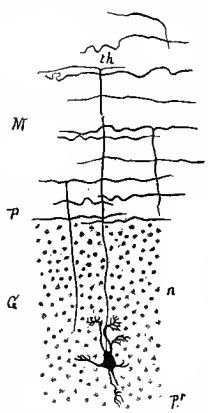

FIG. 470. — One of the Smaller Cells of the Granular Layer. *th*, Bifurcation of axis cylinder (*n*); *pr*, protoplasmic process; *M*, molecular layer; *P*, layer of Purkinje cells; *G*, granule layer.

The motor cells are pyramidal with a peripherad process much more conspicuous than the remainder. Regions known to be sensory in function contain a large number of cells of a different type; the form is rather flask-shaped than pyramidal, and the nucleus is clear and spherical. The delimitation of areas is very incomplete, and both types of cell are to be found in nearly all parts of the dorsal cortex, though the second (æsthesodic) variety is most abundant over the occipital region. The same writer has shown that in reptiles and other vertebrates lower than mammals the distinctions between the two types of cells is very clearly seen.

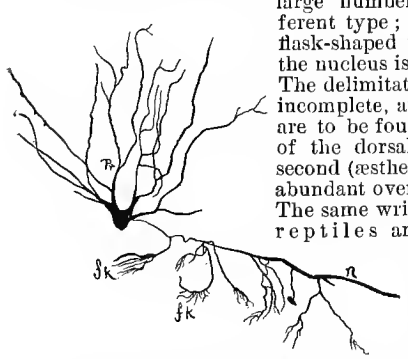

FIG. 471.—Basket Cell from Molecular Layer. *Pr*, Protoplasmic processes; *n*, axis cylinder; *fk*, basket-like envelope of the Purkinje cells.

FISSURES OF THE CEREBRUM. Dr. J. D. Cunningham,* in the "Memoirs of the Irish Academy of Science" bearing his name, gives an extended account of the comparative development of the surface anatomy of the cerebral hemispheres. We condense from this work the following statements:

Complete Fissures ("Total Falten").—The transitory fissures which appear in an early period of the development of the hemispheres are distinguished by the fact that they are a result of a series of deep infoldings of the thin cerebral wall and form shelf-like projections into the ventricles.

Under normal conditions none of the fissures which appear on the lateral aspects of the hemispheres persist in the adult, though in the ape two at least are persistent. Upon the mesal aspect, on the contrary, the choroid, a portion of the arcuate, and sometimes the parieto-occipital with part of the calcarine fissures persist. The choroid and arcuate appear as early as the fifth week. The choroid fissure occupies the lowest limit of the mesal wall, reaching the porta, cephalad, and extending caudad nearly to the extremity of the temporal lobe. Though not at first occupied by blood-vessels, and therefore not formed by them, its walls do not develop into nervous tissue but remain epithelial and are occupied by this preplexus. The fissura arcuata (*Ammonsfurche* of Mihalkovics) makes its appearance on the mesal face of the hemisphere at a higher level than the choroid fissure, and while it extends, like the preceding, into the temporal lobe, it also passes cephalad into the frontal region. That portion of the hemisphere lying between the two fissures mentioned is termed the *arcus marginalis*, in connection with which are formed the callosum, the gyrus dentatus, and the fornix.

The caudal part of the fissura arcuata is retained in adults as the hippocampal fissure, and gives rise to the elevation in the floor of the descending cornu known as the hippocampus major.

Dr. Cunningham does not agree with Mihalkovics and other writers that the cephalic part of this fissure produces the callosal fissure, but regards this portion as transitory.

The remainder of the complete fissures are transitory. The mesal wall of the hemispheres being thicker than the outer the transitory fissures there first appear. They may appear as early as the eighth week, and reach a high degree of development only after

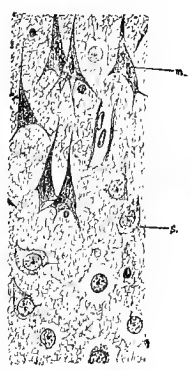

FIG. 472.

FIG. 473.

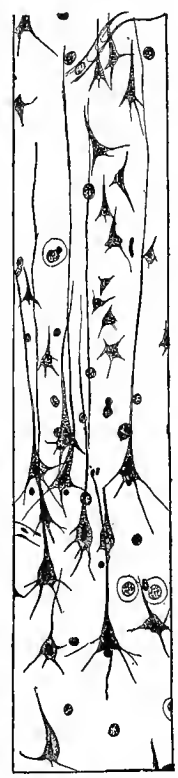

FIG. 474.

FIGS. 472, 473, and 474.—Types of Cortical Cells (all from the Opossum). Fig. 472, *m*, motor (above), and *s*, sensory (?) cells (below). Fig. 473, sensory (?) cells. Fig. 474, pure motor cells.

* Contribution to the Surface Anatomy of the Cerebral Hemispheres, J. D. Cunningham, Cunningham Memoirs of Royal Irish Academy, vii.

the tenth week. Their maximum development is reached between the periods when the fornix and callosum appear, *i.e.*, near the beginning of the fifth month.

On the mesal aspect of the hemispheres the transitory fissures, which vary in number, radiate from the arcuate fissure toward the free border of the hemisphere, and others, lying between them, but not connecting with the arcuate fissure, appear near the margin. The usual number on each hemisphere appears to be eight.

The primitive fissures which bound the cuneus are the precursors of the calcarine and parieto-occipital fissures. As the wall of the cerebral vesicle thickens, and the hemisphere elongates, the stellate fissures become detached from the arcuate fissure and gradually disappear.

Upon the outer aspect the arrangement of the fissures is also radial, with the Sylvian fossa as the centre, but these fissures usually do not reach the fossa. There is frequently an additional fissure occupying the place of the future Sylvian. In some cases the precursor of the calcarine is carried horizontally around the occipital pole, appearing on the lateral surface as an external calcarine fissure.

It is regarded probable that under abnormal conditions, as when the callosum fails to develop, the transitory fissures may persist to a certain extent. The fact emphasized by Sir William Turner, that in *Macropus*, where the callosum is rudimentary, the radiating fissures resemble those of an immature human brain, is at least suggestive that the development of the callosum has some effect on the disappearance of these fissures.

Dr. Cunningham fully agrees with His and Kölliker that the occipital lobe is due to a general growth and not a local out-pouching of the hemisphere; its peculiar form is due to the transformations produced by axial flexures —especially the pons flexure. This backward thrusting of the posterior part of the hemisphere is chiefly responsible for the preservation of the precursory calcarine and parieto-occipital fissures. The temporary fissures are in all probability peculiar to primates, and appear prior to the appearance of a distinct occipital lobe.

The parieto-occipital and calcarine fissures form upon the mesal aspect of a posterior part of the adult hemisphere a >— shaped figure. The stem is directed obliquely ventrad and intersects the gyrus fornicatus. The parieto-occipital fissure forms the more direct continuation of the stem, and continues on the ectal surface as the external parieto-occipital fissure. The calcarine branch passes toward the occipital pole. The stem is called the anterior calcarine fissure. The apex of the cuneus gives off two deep annectant gyri—the gyrus cunei and anterior cuneo-lingual gyrus. The gyrus cunei forms a barrier between the parieto-occipital fissure and the stem, while the gyrus cuneo-lingualis anterior separates the stem and the posterior part of the calcarine fissure.

The calcar (hippocampus minor) is formed wholly by the stem or anterior calcarine fissure.

In apes the calcarine fissure is deep and much more stable than the parieto-occipital. In the chimpanzee the gyrus cuneus is on the surface (a condition found in 3.9 per cent. of human brains), while in the orang and gibbon the cunei may be on the surface or at the bottom of the fissure. The gyrus cunei is never absent. Cunningham believes that the whole calcarine fissure of anthropoids corresponds to the "stem" of the human calcarine, or rather, the whole length of the precursor of the human calcarine is the equivalent of the ape calcarine. The posterior calcarine of man is of later origin and takes the place of an abolished portion of the original fissure. The cuneus of the ape does not have the same morphological value as that of man. Only the cephalic part is present in the ape, the caudal part is absent or blended with the gyrus lingualis. In the ape the entire length of the calcarine fissure is on the tentorial face of the hemisphere.

The posterior calcarine fissure is distinct from the "stem" in origin, the latter being a "complete fissure" and having unbroken continuity of existence with the fore-part precursor.

The occipital and parietal indices are the distances along the mesal margin of the hemisphere intercepted by the intersection of the external parieto-occipital fissure and the fissure of Rolando respectively, in the first case measuring from the occipital pole, in the second from the parieto-occipital intersection, both these distances in terms of hundredths of the entire length along the dorsal margin of the hemisphere.

For the human brain the following averages are given:

5½ to 6½ months..	O. index,	18.8;	P. index,	28.5.
6½ to 7½ months..	"	18.6;	"	24.7.
7½ to 8½ months..	"	20.7;	"	24.1.
Full time fœtuses,	"	20.8;	"	25.7.
First 12 months..	"	22.3;	"	25.6.
4 to 5 years.....	"	23.2;	"	24.2.
11 to 15 years....	"	20.8;	"	27.4.
Adults.....	"	21.2;	"	25.5.

For apes the following table is given:

Orang.....O.	index,	23.2;	P. index,	21.3.
Chimpanzee.....	"	24.2;	"	19.9.
Hamadryas.....	"	29.5;	"	20.5.
Cynocephalus....	"	29.7;	"	22.6.
Mangaby.....	"	30.5;	"	24.1.
Macaque.....	"	31.0;	"	19.0.
Cercopithecus....	"	32.9;	"	19.0.
Cebus:.....	"	33.1;	"	20.6.

The low parietal index and high occipital index are instructive features. In low apes there is an enormous increase in the occipital portion of the border; whereas, in the high apes, the amount of increase is smaller. The relative shortness of the parietal border in high apes is due to the relative increase of the occipital and frontal borders. In low apes the reduction of the parietal portion is entirely due to the great size of the occipital lobe.

The following summary is reproduced verbatim:

1. At an early period in the development of the cerebral hemisphere a series of deep infoldings of its thin walls make their appearance. On the exterior of each hemisphere these show in the form of sharply cut linear fissures.

2. Certain of these fissures are permanent; the great majority are transitory.

3. The transitory fissures, with two exceptions, have disappeared by the time the corpus callosum is fully formed.

4. A deficiency of the corpus callosum is associated with a persistence of the temporary fissures.

5. The temporary fissures indicate an important stage in the growth of the cerebrum, and are apparently associated with the mapping out of the occipital lobe.

6. A quadrupedal pause in the growth of the cerebrum brings the skull capsule into antagonism with the growth of the hemispheres, and, in consequence, the wall of the cerebrum is thrown into folds. These folds disappear as the occipital lobe assumes shape, owing to the expansion of the cranial cavity, and a restoration of growth harmony between skull and brain.

7. Consequently it is only in Primates, which alone possess well-developed occipital lobes, that transitory infoldings of the cerebral walls in all probability exist.

8. The two transitory fissures which do not disappear before the full development of the corpus callosum are: —(*a*) the external calcarine, and (*b*) the external perpendicular fissure of Bischoff. In point of fact the latter fissure does not appear until after the full development of the corpus callosum.

9. The external calcarine fissure produces an infolding of the outer wall of the posterior horn of the lateral ventricle, which presents the same direction, and lies immediately opposite to the true calcarine infolding, or the calcar avis.

10. The fissure corresponding to this in ape is, as a rule, permanent, and in some species its anterior end forms in the adult a bulging on the outer wall of the ventricle.

11. The external calcarine fissure disappears before the sixth month of fœtal life in man.

12. The external calcarine fissure is present on the outer surface of the fœtal cerebrum from the beginning of the fifth month to the end of the sixth month.

13. It is a complete fissure and corresponds to the "Affenspalte" on the ape's brain.

14. The "Affenspalte" on the ape's brain is also a complete fissure, and presents a well-marked bulging on the outer wall of the posterior horn of the ventricle; but, unlike the external perpendicular fissure of the human fœtus, it is permanent.

15. Certain fissures, therefore, which are complete and temporary in the human brain, are complete and permanent in the ape's brain.

16. The complete permanent fissures in the human are:—(a) the fore part of the calcarine; (b) the hinder part of the fissura arcuata; (c) in many cases the parieto-occipital; and (d) in some cases the mid-collateral. The Sylvian fissure is not a complete fissure.

17. Of the fissura arcuata the hinder part alone is preserved as the fissura hippocampi. The fore part, which is generally supposed to be retained as the callosal fissure, is in reality obliterated.

18. Synchronous with the appearance of the radial transitory fissures on the mesal face of the hemisphere two fissures appear, which lie in series with the former and occupy the ground afterward held by the parieto-occipital and calcarine fissures. These may be termed the precursors of these fissures.

19. The precursor of the parieto-occipital fissure sometimes shows an unbroken continuity of existence with the parieto-occipital fissure of the adult brain. In other cases it is obliterated, and its place is afterward taken by a secondary sulcus, which attains, however, a very great depth.

20. In the adult brain the parieto-occipital fissure, even in its complete form, does not form any eminence on the inner wall of the posterior horn of the ventricle, because it does not extend downward as far as the cavity. Above its lower end the hemisphere is solid.

21. The posterior end of the calcarine precursor is in every case obliterated, and the anterior part retained. The extent of the part obliterated varies considerably in different brains.

22. The anterior preserved portion of the calcarine fissure forms the "stem" of the >— shaped fissural arrangement on this part of the hemisphere, and its hinder part corresponds to the calcar avis.

23. In the place of the hinder portion of the calcarine precursor, which is obliterated, a secondary furrow appears. This may be termed the posterior calcarine sulcus.

24. The posterior calcarine sulcus is formed in two pieces which run together and also form the "stem." In this way the entire length of what, in anatomical language, is called the calcarine fissure is formed.

25. The posterior calcarine sulcus is not a complete fissure.

26. In the ape the entire length of the calcarine fissure is represented by that portion of the fissure which in man is termed the "stem," and by that alone. The posterior calcarine sulcus does not exist in any form in the apes.

27. The cuneus, therefore, has a different morphological value in the apes and in man. In connection with this compare the abnormal human hemispheres. These exhibit certain conditions which approximate to those present in the apes.

The Fossa and Fissura Sylrii.—The sign of the Sylvian depression appears at the end of the second month of development. Dr. Cunningham summarizes his investigations as follows:

"1. As growth proceeds the outline of the Sylvian fossa changes considerably. At first nearly circular, it elongates in a vertical direction and then backward on itself, and assumes a triangular outline.

"2. The high prominent mantle-border or rim which surrounds the depression is divided by intervening angles into four sections, viz.: The *temporal*, or lower; the *fronto-parietal*, or upper; the *frontal*, which is formed by an opening out and flattening of the primitive single anterior angle; and an *orbital*, or front portion.

"3. Each of these portions of the bounding rim acts as an independent line of growth, and consequently, in course of time, four opercula grow over the Sylvian area so as to enclose it. The temporal and fronto-parietal opercula appear first; the frontal and orbital do not develop until a much later period.

"4. The so-called three limbs of the fissure of Sylvius are formed by the meeting over the Sylvian area of the contiguous lips of the four opercula; the posterior horizontal limb intervenes between the frontal-parietal and the temporal operenla; the anterior ascending limb between the frontal and fronto-parietal operenla; the anterior horizontal limb between the frontal and the orbital operenla.

"5. The frontal operculum is therefore the same as the 'cap de Broca,' and it shows great variations in its length. It may be absent altogether, and then the two anterior limbs of the Sylvian fissure are fused into one. When the frontal operculum is reduced in length we have the Y-condition of the two anterior Sylvian rami.

"6. The Sylvian fossa once mapped out on the surface of the hemisphere, it extends very rapidly. The growth is not proportionate with that of the hemisphere, it is much more rapid.

"7. During intra-uterine life the anterior end of the insula maintains a very nearly fixed position with reference to the anterior end of the cerebrum, while the posterior end of the cerebrum moves rapidly toward the occipital pole. After birth the posterior end of the insula is fixed, while the anterior end, as growth advances, oscillates slightly—at first approaching and then retreating from the anterior end of the cerebrum.

"8. An anterior limb of the Sylvian fissures can only be determined by the following tests: (*a*) It must cut right through the entire thickness of the operculum and reach the furrow surrounding the island of Reil. (*b*) It must lie in front of the præcentral sulcus.

"9. A single anterior limb of the Sylvian was present in 30 per cent. of the hemispheres examined; the two anterior limbs, quite distinct and separate, were present in 37.5 per cent.; the Y-shaped condition of the two limbs was present in 31.5 per cent.

"10. The two orbital limbs of the Sylvian fissure cannot be regarded as belonging to the same category of the true anterior limbs. They are not developed as primitive deficiencies in the orbital operculum.

"11. The posterior insula is not connected with the extremity of the temporal lobe, as Erbstaller has asserted, but with the limbic lobe.

"12. On the surface of the fœtal insula there appear three radial furrows which correspond in every respect with the three "Primärfurchen" on the outer surface of the mantle (viz., the fissure of Rolando, the inferior præcentral sulcus, and the vertical limb of the intra-parietal sulcus). The radial furrows on the insula clearly belong to the same fissural system and intermediate links between the three radial fissures on the outer surface of the hemisphere, and the three radial fissures on the insula may exist in the form of secondary sulci, cutting the margin of the fronto-parietal operculum.

"13. The fissure of Rolando is clearly the proper boundary of the frontal lobe. Above, it is only separated from the calloso-marginal fissure, which bounds the lobe internally, by a narrow but superficial gyrus; below, the inferior transverse furrow of Erbstaller acts as an intermediate link between it and the sulcus centralis insulæ. The sulcus centralis insulæ and the calloso-marginal sulcus are brought into close relationship at the anterior perforated spot on the base of the brain. An almost continuous fissural system, therefore, marks out the limits of the frontal portion of the cerebrum.

"14. The temporal pole is formed entirely by the forward growth of the fore part of the temporal operculum.

"15. In the adult brain the insula is proportionately longer in the male than in the female. At all periods of growth it would seem that the insula is relatively longer on the left side than on the right side. In the negro

brain it would appear that the insula is relatively shorter than in the European brain.

"16. In the anthropoid ape the so-called anterior limb of the Sylvian fissure is not homologous with either of the anterior limbs in man.

"17. In the chimpanzee and orang there are only two opercula, viz., the fronto-parietal and the temporal. The frontal and orbital opercula of the human brain are entirely absent in the anthropoid cerebrum.

"18. Restricting the term insula to that part of the hemisphere surface which is concealed from view by opercula, the extent of this area in the ape is very much less than in man. The central index is 18.2 in the chimpanzee and 21.5 in the orang; in man the central index is 29.6. In the lower apes the central index is higher than in the anthropoids.

"19. In man the field of the insula shows marked changes with reference to the cranial wall during intra-uterine life. More and more of its area comes to lie under cover of the parietal bone, and relatively less under cover of the frontal bone, as development proceeds. In the adult the coronal line cuts the insula in such a manner that thirteen per cent. of its length lies in front of it, and eighty-seven per cent. behind it.

"20. In the chimpanzee and the low apes no part of the insula lies in front of the coronal line; in the orang the upper and anterior corner of the insula projects slightly in front of this line.

"21. In the human infant and young child, as well as in the ape, the point at which the stem of the Sylvian fissure reaches the outer surface of the hemisphere is situated relatively further back than in the human adult.

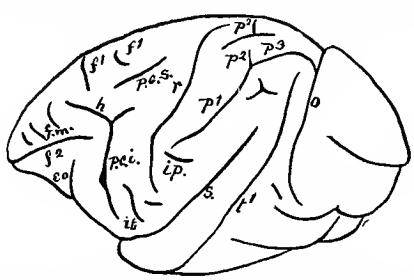

FIG. 475.—Left Cerebral Hemisphere of a Chacma Baboon. *p*, Various parts of the intra-parietal system of furrows; p^1, sulcus post-centralis inferior; p^2, two parts of the sulcus post-centralis superior; p^3, ramus horizontalis; *i.p.*, sulcus post-centralis transversus; *o*, occipital operculum.

"22. The Sylvian fissure is relatively longer in the left hemisphere than in the right, and in the ape than in man. . . .

"28. In the cebus the Sylvian fissure lies above the level of the squamous suture; in the macaque, homadryas, and orang, it lies immediately subjacent to the fore-part of the suture: in *Cynocephalus anubis* and the chimpanzee the fissure is situated in its fore-part below the level of the front part of the suture.

"29. The relative depth of the parietal and temporal lobes in the lower apes resembles that in the human child; in the anthropoid ape the relative parietal depth of the hemisphere exceeds that in the human adult."

The Fissure of Rolando.—Cunningham found that in sixty per cent. of the brains examined the upper end of the fissure of Rolando turned over the mesal border of the hemisphere; in nineteen per cent. its ventral end was connected by a shallow transverse sulcus with the Sylvian fissure. The fissure of Rolando appears in two parts, the lower two-thirds appears before, and independent of, the upper third. The relative position of the fissure of Rolando is remarkably constant. The upper fronto-Rolandic index is 53.3, the lower 43.3. In anthropoid the upper end of the fissure of Rolando is placed relatively further back than in man. The average Rolandic angle in the human brain is 71.7. The average relative length of the fissure of Rolando is 39.3.

The Intra-parietal Sulcus.—"1. The entire sulcus, single and continuous in some of the lower apes (*e.g.*, Cebus), becomes broken up in the human brain into a group of furrows which present different relations to each other in different cases.

"2. Three of the elements of the sulcus in the human brain, viz., the sulcus post-centralis inferior, the ramus horizontalis, and the ramus occipitalis, are disrupted portions of the original fissure; one, the sulcus post-centralis superior, is a superadded element. (Fig. 482.)

"3. In the development of the sulcus in the human fœtal brain, all the four segments of the sulcus have, as a rule, an independent origin, although, as Pausch has shown, the sulcus post-centralis inferior and the sulcus horizontalis very frequently appear as one continuous furrow.

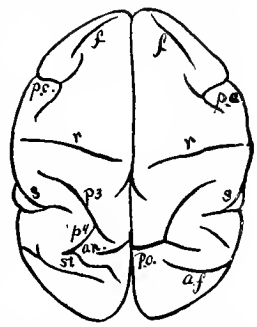

FIG. 476.—Cerebrum of Cebus Albifrons. *f*, Sulcus frontalis inferior; *p.c.*, sulcus post-centralis inferior; *r*, fissure of Rolando; *s*, Sylvian fissure; *p*, intra-parietal sulcus; p^3, ramus horizontalis; p^4, ramus occipitalis; *st*, furrow corresponding to sulcus transversus occipitalis of Ecker; *p.o.*, parieto-occipital fissure; *an.*, first annectant gyrus; *a.f.*, ape cleft.

"4. The sulcus post-centralis inferior usually appears first; then the ramus horizontalis and ramus occipitalis; and last of all the sulcus post-centralis superior.

"5. In Cebus there is no sulcus post-centralis superior, it is present, however, in most of the old world apes, *e. g.*, the baboon, macaque, gibbon, chimpanzee, orang, and gorilla. (Fig. 476.)

"6. In the chimpanzee and orang there is reason to believe that this segment of the post-central sulcus consists of two elements, one placed above the other. (Figs. 479 and 480.)

"7. Eberstaller's third and lower segment of the post-central sulcus (viz., the sulcus post-centralis transversus) is not only present in man, but also in the majority of the old-world apes.

"8. In the apes the intra-parietal sulcus is deeper than the fissure of Rolando, the opposite is the case in man. This would seem to indicate that the morphological value of the sulci is different in man and the apes. The phylogeny and ontogeny of these furrows are in apparent variance with each other. The fissure of Rolando appears first on the developing cerebrum of the human fœtus, yet it is the intra-parietal sulcus which first makes its appearance in the evolution of the primate cerebrum. . . .

"11. In man there appears to be a general tendency toward a union of the two originally distinct post-central elements of the sulcus, and a divorce from the lower of those of the ramus horizontalis. . . .

"13. The ramus occipitalis was connected with the ramus horizontalis in 63.7 per cent. of the adult human hemispheres examined.

"14. The union between these two elements of the sulcus, as Ecker and Wilder have shown, is much more common on the left side than on the right.

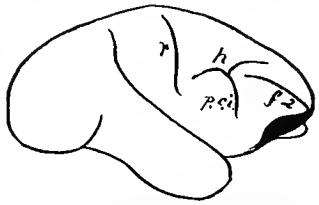

FIG. 477.—The Outer Surface of the Cerebrum of Cebus Albifrons. *r*, Fissure of Rolando; *p.c.i.*, sulcus præcentralis inferior; *h*, ramus horizontalis; f^2, inferior frontal sulcus.

"The sulcus transversus of Ecker is not the homologue of the Affenspalter in the apes, but merely a terminal bifurcation of the ramus occipitalis."

The Sulcus Præcentralis.—"1. The sulcus præcentralis inferior in the human brain is composed of a vertical and

a horizontal limb. The latter is carried forward into the middle of the frontal convolution.

"2. This furrow is the earliest to appear on the outer surface of the frontal lobe of the fœtal brain. In some cases it is seen in the fifth-month cerebrum in the form of a long, deep, vertical sulcus, which subsequently undergoes a retrograde development before its adult condition is reached. In many cases, in its early condition, it presents a form in every respect comparable with that observed in the cerebrum of the low ape (Cebus). Frequently it is developed in several pieces.

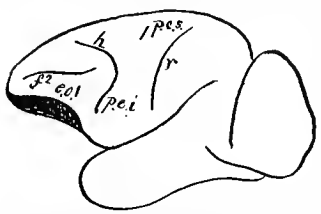

FIG. 478.—Another view of the same: *p.c.s.*, Sulcus præcentralis inferior (?); *e.o.*, a slight trace of the sulcus fronto-orbitalis. Other letters as in Fig. 477.

"3. The sulcus præcentralis superior is closely connected with the basal part of the first frontal furrow. It is usually developed along with it. It consists of two pieces—an upper and a lower—which may be partially or completely separated from each other, as well as from the basal part of the first frontal furrow by an annectant gyrus.

"4. Two additional furrows belonging to the præcentral system are occasionally present, viz., the sulcus præcentralis medius and the sulcus præcentralis marginalis.

"5. The sulcus præcentralis medius may arise in two different ways: (*a*) It may be formed by the ramus horizontalis of the inferior præcentral sulcus divorced from the vertical stem and assuming a very oblique or an almost vertical position; (*b*) it may consist of a new element placed between the superior and inferior præcentral furrows, but showing a closer connection with the former. . . .

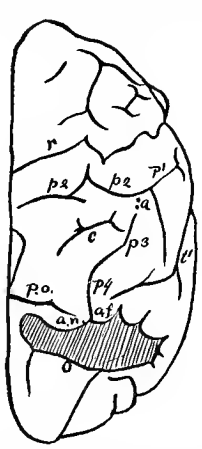

FIG. 479.—Cerebral Hemisphere of Young Female Chimpanzee, as seen from above. The operculum on each side has been removed. *r*, Fissure of Rolando; p^1, sulcus post-centralis inferior; p^2, two portions of sulcus post-centralis superior; p^3, ramus horizontalis; p^4, ramus occipitalis; *b*, terminal bifurcation of the intra-parietal sulcus: *p.o.*, parieto-occipital fissure; *a.n.*, first parieto-occipital annectant gyrus; *a*, deep annectant gyrus in the course of the intra-parietal sulcus; *c*, secondary sulcus in the superior parietal lobule; *a.f.*, bottom of the "ape-cleft;" *o*, cut surface of occipital operculum; t^1, parallel sulcus.

"12. The superior frontal gyrus and the middle frontal gyrus are each partially subdivided into two tiers or subdivisions by furrows which may be respectively termed the sulcus frontalis mesialis and the sulcus frontalis medius.

"13. Both of these furrows have secured a firm footing in the human brain, but only one (viz., the frontalis medius) has established itself upon the brain of the chimpanzee." . . .

"17. The sulcus frontalis mesialis is absent or poorly developed in the brain of the negro. . . .

"20. The sulcus præcentralis inferior and the inferior frontal sulcus are the furrows which are most firmly impressed upon the brain of the apes. In Cebus they alone are present; in Calithrix there are also traces of the sulcus præcentralis superior and sulcus fronto-orbitalis; in the baboon there are, in addition, a rudimentary sulcus frontalis superior, and perhaps (?) traces of a sulcus frontalis medius. (Figs. 475 and 476.)

"21. In the chimpanzee and the gorilla the sulcus frontalis medius is often present in a form precisely similar to that seen in the human brain; in the orang the condition of this sulcus is doubtful; in the gibbon the sulcus frontalis medius is absent.

"22. In the chimpanzee, therefore, the same convolution tiers may be seen as in man, with this exception: the superior frontalis is never split into two by a sulcus frontalis mesialis.

"23. The inferior frontal convolution of apes is very different from that in man.

"24. The frontal and orbital Sylvian opercula are completely absent in the apes.

"25. Consequently, a portion of the island of Reil is uncovered and exposed on the surface of the cerebrum.

"26. The sulcus fronto-orbitalis of apes corresponds to the anterior limiting sulcus of the island of Reil in man.

"27. There are no anterior limbs of the Sylvian fissure in the anthropoid apes. The so-called anterior limb of the Sylvian fissure corresponds to the anterior free border of the fronto-parietal operculum.

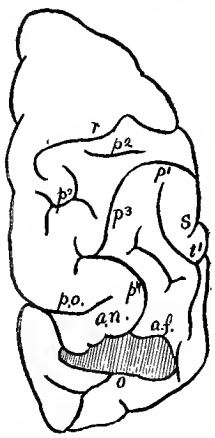

FIG. 480.—Right Hemisphere of a Male Orang, Six Years Old. *r*, Fissure of Rolando; p^1, sulcus post-centralis inferior; p^2, two parts of sulcus post-centralis superior; p^3, ramus horizontalis; p^4, ramus occipitalis; *a.n.*, first parieto-occipital annectant gyrus; *p.o.*, parieto-occipital fissure; *a.f.*, bottom of "ape-cleft;" *o*, cut surface of occipital operculum; *s*, fissure of Sylvius; t^1, parallel sulcus.

"28. About the seventh month of fœtal life the inferior præcentral sulcus of the human brain attains a position which it retains unaltered throughout all the subsequent changes of growth; previous to this it is placed relatively further back on the surface of the hemisphere.

"29. At first it is placed in front of the coronal suture. The sutural line, however, moves forward so that the sulcus ultimately comes to lie behind it.

"30. In the ape cerebrum the inferior præcentral sulcus lies relatively much further forward than in the cerebrum of man. It may be placed subjacent to, or in front of, the coronal line."

Morphology of the Primitive Brain Tube.—Embryology and comparative anatomy are continually throwing new light on the problem of the archetypal structure of the neuraxis.

The most obscure point and one of fundamental im-

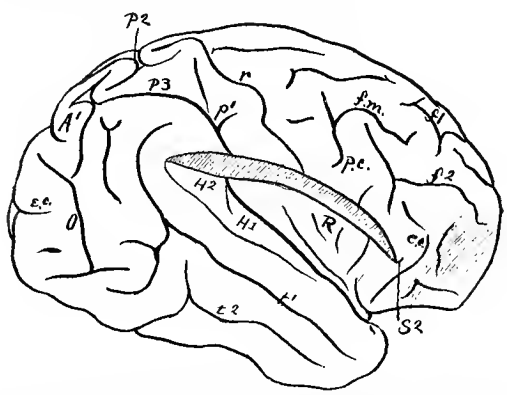

FIG. 481.—Right Cerebral Hemisphere of a Male Orang-outang, Six Years Old. f^1, Sulcus frontalis superior; f^2, sulcus frontalis inferior; *f.m.*, sulcus frontalis medius; *e.o.*, sulcus fronto-orbitalis; *p.c.*, sulcus præcentralis inferior; *p.c.s.*, sulcus præcentralis superior; *p.c.i.*, sulcus præcentralis inferior; *r*, fissure of Rolando; p^1, sulcus post-centralis inferior; p^2, sulcus post-centralis superior; p^3, sulcus horizontalis intra-parietalis; *e.c.*, external calcarine fissure; t^1, parallel sulcus; t^2, second temporal sulcus; H^1, H^2, H^3, transverse temporal gyri of Heschl; *R*, insula; A^1, first annectant gyrus; S^2, anterior free border of the fronto-parietal operculum; *O*, anterior edge of the occipital operculum.

portance in the morphogenesis of the brain is the primitive cephalic end of the neuraxis. The two prevailing schools are represented by Professor His and Professor Kupffer, respectively. It is quite possible that many of the contradictions grow out of the fact that the various authors have been employing different axes.

Professor His uses an imaginary line lying in the base of the tube, and finds that its cephalic extremity coin-

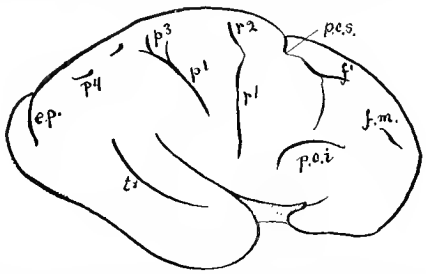

FIG. 482.—Outer Surface of a Cerebral Hemisphere in the Early Part of the Seventh Month: t^1, Parallel sulcus; *p.c.i.*, inferior frontal; f^1, sulcus frontalis primus; *p.c.s.*, sulcus præcentralis superior; *r*, fissure of Rolando; *p*, intra parietal sulcus; p^1, sulcus post-centralis inferior; p^3, ramus horizontalis of the intra-parietal sulcus; p^4, ramus occipitalis; *e.p.*, fissura perpendicularis externa.

cides with the basilary ridge immediately above the recess of Sessel. Others employ a median axis which would terminate in front of the chiasm (Kiebel). Others seem to employ a dorsal axis which, according to His, would terminate in the upper extremity of the terma. To us it seems that the first of these is the most satisfactory reference line, since the diameter of the tube varies greatly, and the length from the termination of the ventral to that of the dorsal axis is by no means constant, while the point of the infundibulum is relatively constant. This selection has another advantage in mak-

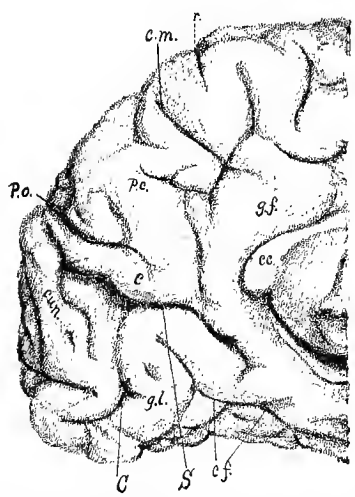

FIG. 483.—Hinder Portion of Cerebral Hemisphere of Full-term Fœtus, showing Conditions Approximating to those of Anthropoid Apes. *r*, Upper end of fissure of Rolando; *c.m.*, calloso-marginal sulcus; *p.o.*, parieto-occipital fissure; *cun.*, cuneus; *c*, gyrus cunei; *p.c.*, præcuneus; *g.f.*, gyrus fornicatus; *c.c.*, callosum; *c.f.*, collateral fissure; *C*, posterior secondary calcarine fissure; *S*, "stem" of calcarine fissure.

ing the chorda coextensive with the neural axis, and obviating the necessity for a distinction between chordal and prechordal brain segments.

When the medullary tube closes it has three lines of union or sutures; the ventral suture marks the line where the chorda was separated, the dorsal suture is the line where the medullary tube has separated from the ectoderm, the frontal suture is the line where the front of the tube closes, though it often remains open for a time, forming the neuropore. At the point where the frontal suture unites with the ventral is a transverse ridge—the basilary ridge—which marks the front of the brain base. Professor His distinguishes a basal plate and lateral alæ, the former giving rise to the motor centres, including the bridge, peduncles, pars subthalamica, and at the cephalic extremity it gives rise to the optic vesicles.

The tendency of the brain to fold sharply in the mesencephalic region is common to all vertebrates. This fold, which gives rise to the saddle cleft, thrusts a part of the base into the cavity of the mesencephalon, producing the tegmental tuberosity, behind which is the recess of the isthmus, and in front of which is the mammillary fossa. The former has been identified by Bürckhardt as a constant element, and the latter has been shown by Herrick to be represented by distinct paired vesicles even in fishes.

The recess of Rathke penetrates more or less caudad of the basilary ridge, and the caudal wall of the recessus infundibuli gives rise to the infundibulum and the upper fundament of the hypophysis. The saccus vasculosus lies between the mammillary recess and the infundibulum. The formation of the hypoaria is due, in the opinion of the writer, to a reduction of the mesencephalic fold. In this case, instead of the formation of the tegmental tuberosity, the excess of the base is thrust cephalolaterad and appears to occupy the walls of the diencephalon.

Respecting the roof of the diencephalon, Professor His[24] has given a summary which is so useful that it is given somewhat at length:

"With regard to the structures called epiphyses, recent times have begun to make sharper distinctions, since Goette has shown that the roof of the diencephalon in amphibia forms two projections, a cephalic ('adergeflechtknoten') and a caudal or true pineal. Since then, the presence of several rudiments has been repeatedly noticed, most recently by Bürckhardt in Protopterus, and Eydeshymer in Amblystoma. The latter author calls only the cephalic projection epiphysis, the caudal paraphysis, and very justly lays emphasis on the fact that the caudal structure appears later than the other. An examination of the profiles of various embryonic brains shows that epiphyses may arise at more than two places.

"The choroidal node found by Goette at the cephalic margin of the diencephalon in amphibia, belongs to the category of cephalic epiphyses. Here it is easy to distinguish them, as the distance between the two is very great. The epiphysis of Selachii also arises from the cephalic part of the roof of the diencephalon. Later, however, almost the whole diencephalic roof is elevated, and there results the familiar projection included between fore-brain and mid-brain, and whose base extends caudad nearly to the post-commissure. Similar conditions prevail in teleosts. An epiphysis of the cephalic roof of the diencephalon was encountered by me in a human embryo 10.5 mm. in length.

"The roof-plate forms at this stage a small median longitudinal ridge with two lateral angles. Cephalad this ridge is triangular, and the median angle separates for a short distance as an independent appendage.

"When I first discovered this structure, some years since, I fancied I had solved the history of the pineal, and only a careful profile reconstruction revealed the fact that this body belongs to the very front of the roof of the diencephalon. The body seems later to disappear in the folds of the plexus.

"The true epiphysis develops much later, after the post-commissure is already formed, by protrusion of the most caudal part of the diencephalic roof. In the bird brain, as even Remak noticed, the epiphysis arises from the middle of the diencephalic roof, and the same is true for the epiphysis of reptiles.

"Thus we distinguish epiphyses of the front, middle, and posterior of the diencephalon roof. For the latter name pineal may be usefully retained.

"Besides these special forms of outgrowth, we en-

counter an elevation of the whole roof, as in Selachii and Teleostei. Goette's "Adergeflechtknoten" certainly pertains exclusively to the group of anterior projections, while the so-called parietal eye of reptiles belong to the middle group." [Later investigations proved it to belong to the posterior group.]

Bürckhardt gives the following arrangement of the parts of the diencephalic roof: 1, Præplexus; 2, velum; 3, "Zirbelpolster" (paraphysis); 4, supra-commissura; 5, pineal; 6, intercalary segment; 7, post-commissura. This seems to be a satisfactory arrangement, except that it fails to take into account the development of the projections from the region of the præplexus which are mentioned by His. There is a remarkable constancy in arrangement of these parts. The writer has shown that the current opinion that the pineal is absent in reptiles rests on a mistake. In serpents the pineal is greatly modified, being a very large lymphoidal body occupying a sling of membrane above the supra-commissure, and is connected either with it or the "Polster," or roof in front of the commissure. The structure of the body is very like that of the glandular part of the pituitary. In turtles there is a large and well-developed tubular pineal as well as a strong flexiform outgrowth cephalad. It is easy to discover that the tube is connected directly with the third ventricle just caudad of the supra-commissure. In ganoid fishes the tubular pineal is well developed and is closely associated with the dorsal sac or expanded roof of the thalamus and aula. There is an enormous plexiform development of the pallium taking the place of the præplexus. In all essentials teleosts agree with the ganoids.

Among the most remarkable structures are the hypoaria of fishes (Fig. 484) which are not externally obvious in other groups.

The hypoaria have usually been considered appendages of the thalamus, but Herrick insists that they are morphologically caudad of the mammillaria, and contain elements of the pes pedunculi or the cephalic part of the floor of the mesencephalon. In this connection he identifies the peculiar cells with which the motor peduncles unite with similar cells in the reptilian mesencephalon and that of mammals. The corpus rotundus is identified with the nidulus ruber, and the latter is shown to be the centre of sensory redistribution, as the before-mentioned cells are of motor connection (especially with the cerebellum).

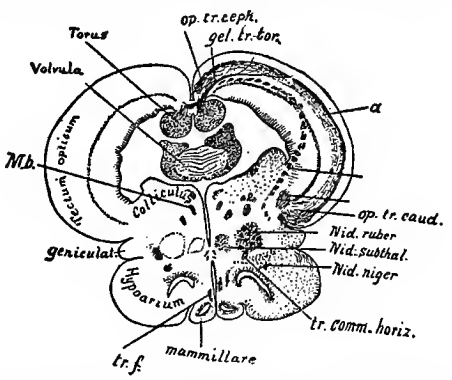

FIG. 484.—Transection of the Brain of a Small Bass. Diagrammatic. Especially designed to show the position of the mammillaria and fornix tract (*tr. f.*) as well as the general relations; *gel. tr. tor.*, gelatinous tract from the torus to periphery of the tectum.

The great consolidation in this region in mammals, and higher vertebrates generally, is largely effected by what Professor His terms the saddle cleft, *i.e.*, the fold of the floor of the mesencephalon, which fills the cavity of the mesencephalon. In embryonic reptilia the mesencephalon is obviously double, and this seems to be universally true at some stage. The cephalic diverticle is pushed cephalad and participates in the curvature of the first embryonic vesicle, while the second is lost in formation of the saddle cleft. The isthmus, or cephalic neuromere of the medulla, is obscured by the development of cerebellum and pons and has no corresponding nerve-roots. The trigeminus springs from two neuromeres, the facial and auditory from a single neuromere, as does the glosso-pharyngeal. It is not yet clear what relation is sustained by the tenth and twelfth nerves to the neuromeres from which they spring. The relation of the chorda to the neural tube, from a morphological point of view, is greatly illuminated by the discovery of Selenka,[25]

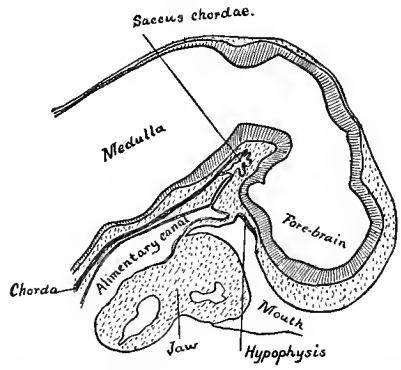

FIG. 485.—Illustration showing the Relation between Chordal Sac, Alimentary Canal, and Brain Flexure in Opossum. (From Selenka.)

that in the opossum there is a curious tortuous tube, apparently related to the cephalic end of the entoderm, but which is really a hollowed and contorted modification of the chorda. Selenka reminds us of the origin of the chorda as an originally hollow diverticle from the entoderm.

The contorted modification must be ascribed to the head-fold which interferes with the normal forward growth of this body, and coils it within the space behind the infundibulum.

This tubular body is quite distinct from the hypophysis, which develops as usual from the ectoderm. This fact, taken in connection with Professor His's statement that the neuropore is coextensive with the whole area from infundibulum to terma, strongly enforces the view that the infundibulum (or at least the basilary ridge) is at the morphological front of the neuraxis.

C. L. Herrick.

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NERVOUS SYSTEM: HISTOGENESIS OF ITS ELEMENTS. To Professor William His, Sr., of Leipzig, science is chiefly indebted for the generalizations formulating the laws of development of the nervous elements.

Three sources may be recognized for the various elements included in the central nervous system. First, the materials directly or indirectly derived from the primitive epithelium of the neural plate and tube; second, cellular or other products (exudates) from the circulatory vessels; third, migrant (connective) cells and cell-products from the adjacent tissues. Inasmuch as the first class is, strictly speaking, the primitive and essential group, we restrict our notice to it. Even in the medullary plate the columnar epithelium suffers modifications, but these modifications are precisely like those changes which may be observed in sensory epithelium generally. The nuclei, which originally nearly filled the cell, are left near the centre, while an outer and ental space is developed by the growth of the cell (Fig. 486). The ectal portion undergoes a rapid change. A fluid substance accumulates in the granular protoplasm, at first in the form of small vesicles, which subsequently fuse with each other and leave only an irregular reticulum of the more indurated substance. (Fig. 487).

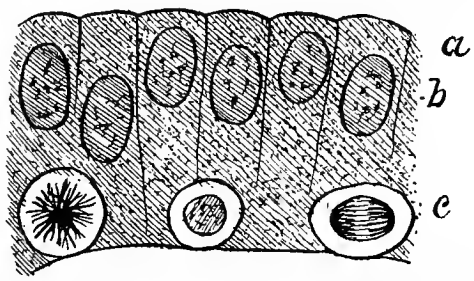

FIG. 486 (After His).—Neuro-epithelium with Ectal Zone (*a*); Ental Zone (*c*), containing neuroblasts with karyokinctic figures; and a Median Zone (*b*) containing the nuclei.

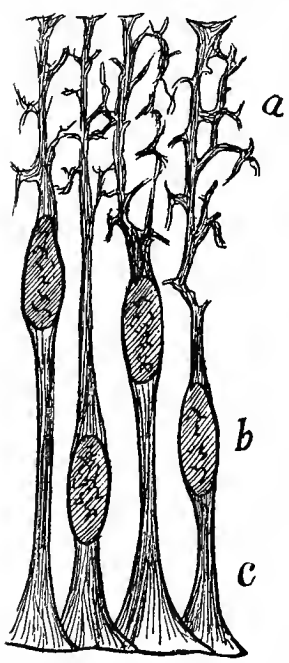

FIG. 487 (After His). — A Later Stage. The ectal layer has been reduced to a reticulum, while the ental portion acquires columnar structure and the nuclei are scattered at various positions in the columnar portion.

The process just described results in the production of a *neurospongium, i.e.*, a sort of framework, in the interstices of which the genuine nervous elements are formed. The primitive cells which are thus modified are spongioblasts, and are the non-nervous elements in the neuro-epithelium. The spongioblast, then, consists of an inner columnar portion, a middle nucleated zone, and a peripheral marginal or "veil" portion. The columnar inner portion never loses its individuality, and forms the so-called lining epithelium of the ventricles and other cavities of the central nervous system.

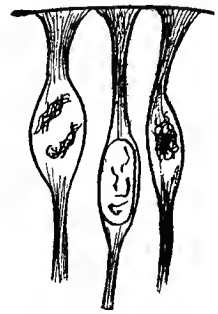
FIG. 488 (After His). — Spongioblasts, with Mitosis of Nuclei.

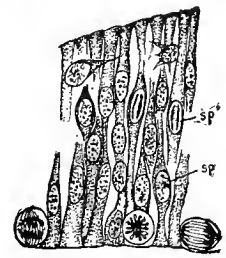

FIG. 489 (From Herrick). — Part of the Mesencephalon of a Garter-snake Embryo, showing numerous neuroblasts, with karyokinetic figures and two spongioblasts (*sp'*) in the same process.

In reality this endyma is not a true epithelium, but is composed of the persisting bases of cells which, morphologically, and generally structurally, retain a connection with the ectal part of the brain-tube. The so-called connective or supporting elements of the retina, organ of Corti, and even of the olfactory epithelium, have essentially similar structure. The spongioblasts multiply to supply the exigencies of the growth of the organ, and mitosis may occasionally be detected in the nuclei. (Figs. 488 and 489.)

Professor His considers that the spaces in the marginal portion of the neurospongium are all produced from vacuoles in the cells, *i.e.*, are intra-cellular. The present writer is convinced that in lower vertebrates, at least, these spaces are intercellular, and the peripheral portion of the cells simply collapses, leaving the interspaces to be filled by an exudate soft and nutritive enough to facilitate the growth of the neurons. (Figs. 489, 490, 491.)

That the entire thickness of the brain-walls is penetrated by the thread-like rudiments of the spongioblasts is well proven.

The Neuroblasts.—It remains an open question whether the rudiments out of which the nervous elements are formed are from the first distinct, or whether the former may be continuously produced up to a certain period by the subdivision of an indifferent epithelium. In any event, at a very early stage there are scattered among the bases of the spongioblasts ovoid or spherical cells, with large dark nuclei, which are in all stages of cell-division. After subdivision these neuroblasts withdraw from the ventricle, adjacent to which they are always formed, and either assemble in various portions of the marginal zone to undergo immediate transformation into

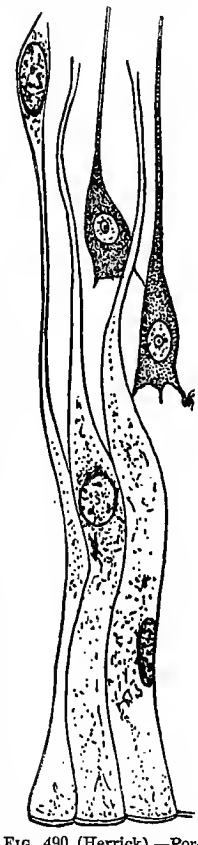
FIG. 490 (Herrick).—Portion of the Tectum (of the optic lobe) in the Trout, showing the neuroblasts in the interspaces between the spongioblasts.

functional neurons, or accumulate in the nucleary zone in the form of reserves. It seems proper to conclude that all the genuine nerve-cells and fibres in the central system are thus formed from epithelial proliferation or indirect derivation from the same source. In those regions of the tube in which neurons are not formed (as over the roof of the fourth ventricle) the resulting structure is a plexus-former, velum, or some other secondary structure. The rate at which neuroblasts are formed varies greatly in different parts of the brain and in different animals. In fishes, the whole cortex (pallium) fails to develop neuroblasts, and it, therefore, has the character of a velum. In human embryos the formation of neuroblasts ceases at the end of the second month, at least in the medulla, and the period of greatest activity is during the development of the nerve-roots. After the birth of the neuroblasts they migrate peripherad and seek their definitive positions. Professor His claims that the neuroblasts of the dorsal part of the tube behave differently from those of the ventral part. The former emerge from their original sites obliquely, so that they turn parallel to the surface and send their processes ventrad and even to the median line. The ventral neuroblasts strike the surface perpendicularly, and the axis-cylinder given off passes out to become a motor nerve.

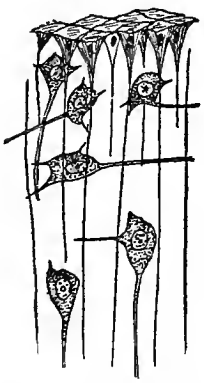

Fig. 491 (Herrick). — A Portion of the Dorsal Ventricular Surface of the Axial Cerebral Lobe of Amiurus, showing the connection of the epithelium cells with the fibrous framework, and also the oblique position of the ventricular cells, while the deeper cells connect directly with the axis-cylinders of the peduncles.

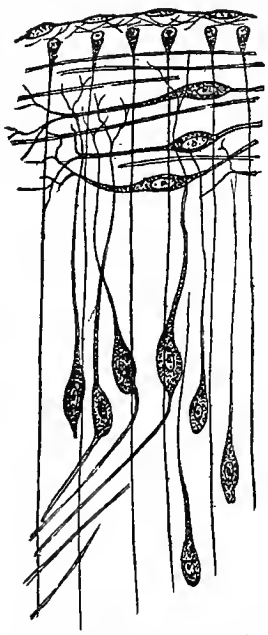

Fig. 492 (Herrick). — A Portion of a Longitudinal Section of the Tectum of Trutta Fario, Nine Days Old, showing the horizontally placed optic tract cells and the connection of the inner cell layer with the lemniscus fibres. The spongioblasts are reduced to mere fibres, terminating in small knobs ectad. [These figures are from the *Anatomischer Anzeiger*, vii., 13 to 14.]

Such migrations are especially remarkable in the medulla. Although similar to the spinal cord at first, it soon becomes divided on either side by a longitudinal fissure into an axial portion and lateral alæ. The motor niduli of the hypoglossus, accessory, vagus, and glosso-pharyngeal are accumulated from the neuroblasts formed in the axial part. The tractus solitarius is formed out of fibres from the glosso-pharyngeus and vagus, and lies along the boundary between the axial and ala portion.

According to Professor His, the alæ fold upon themselves, and from the neuroblasts formed out of these pockets spring the olives, accessory olives, and other clusters of cells isolated from their fellows.

In the case of the cerebellum there is some evidence of a more or less extensive dorsad and cephalad folding of the lateral walls, by means of which the proliferating epithelium is brought into immediate relations with the parts to be supplied. The cells of Purkinje, as well as those of the dentate nidulus, are derived from proliferating epithelium of the ventricles. Throughout the higher regions of the brain there are entirely analogous processes. The striata are centres of rapid proliferation. There are formed great masses of cells, some of which seem to suffer suspension of development until demands are made. The exact nature of the intermediate stages, and the factors which determine the length of time during which proliferation may continue, are obscure. The "granules," such as are so abundant in the cerebellum and olfactory tuber, are undoubtedly mostly developed from the same process of epithelial proliferation.

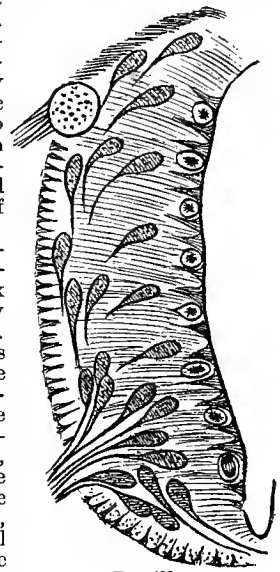

Fig. 493.

The processes just described are somewhat modified in the cerebral cortex (Figs. 494 and 495). They are similar in all animals. The rapidly dividing cells accumulate to form a dense zone near the ventricle, leaving only the marginal zone free. Into this the neuroblasts begin to pass, and, from being radial, become parallel to the surface. The axis-cylinder grows rapidly, while, from the opposite end of the cell, the protoplasmic processes emerge and ramify intimately in the mass. A comparison of Figs. 494 and 495 shows that in the embryo snake and the embryo dog similar conditions prevail.

The early proeesses are comparatively well understood, but toward the close of the embryonic development a phenomenon is encountered, which is variously interpreted. The ectal portion of the massive organs, especially the cerebrum and cerebellum, become somewhat rapidly clothed with a dense mass of granules which subsequently disappear (Fig. 496). Professor His suggests that these are white blood-corpuscles which, after wandering from the sinuses surrounding the organ, make

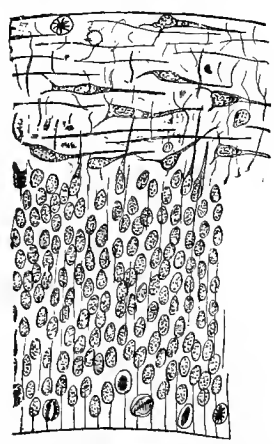

Fig. 494 (Herrick).—Portion of the Base of the Thalamus Vesicle in Young Snake Embryo. *K*, karyokinetic figures in the young neuroblasts near the ventricle. The spongioblasts (*op*) are elongating; *gr*, granules formed from the neuroblasts; *nb*, neuroblasts transforming into neurons, of which the axis cylinder (*a.c.*) processes are directed parallel to the surface.

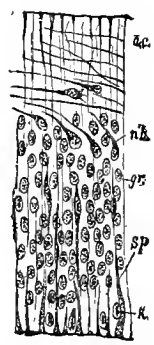

Fig. 495 (Herrick). — Similar Section from Dog Embryo. The section is from the frontal region of the right hemisphere. The relations are as described under Fig. 494, except that the neurons have begun to develop protoplasmic processes as well as the axis-cylinder.

a temporary halt near the surface before passing throughout the substance of both gray and white matter. The period at which they appear in the human embryo is about the end of the second month. While not doubting the existence of amœboid cells as above described, the writer has suggested other sources for part of these cells. It will be noted that the peripheral zone of cells arises only after direct communication with the ventricles has been cut off by interpolated white matter. Subsequently the number of granules (*e.g.*, beneath the Purkinje layer in the cerebellum) rapidly increases. Their source can only be the peripheral collection of granules. Fig. 496 shows that, at this stage, there is often rapid multiplication going on within that layer. Careful study has not revealed any other source for these proliferating granules than diverticles of the epithelium, from which migration in this more round-about way is kept up. It is a familiar fact that the earlier granules are derived from the proliferating neuroblasts of the ventricular surface; it is inherently improbable that the subsequent ones should spring from as distinct a source as the pia or its vessels. The peripheral proliferating layer soon disappears by the migration of its elements toward the ventricle.

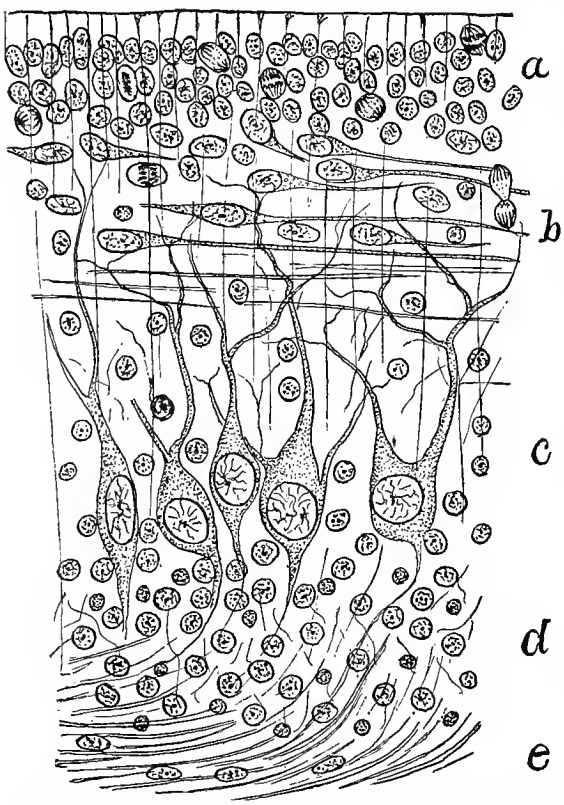

FIG. 496.—A Section of the Cerebellum from Embryonic Opossum. *a*, Superficial proliferating zone; *b*, tracts and cells of the molecular layer; c, Purkinje's cell layer; *d*, granular layer; *e*, fibre zone.

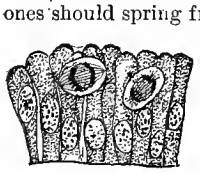

FIG. 497.

There can be no doubt that the study of the conditions determining the proliferation of neuroblasts are of the highest importance in construing the causes of precocity, senility, and decline.

The Organs of Special Sense.—The essential similarity of the sensory and nervous epithelium has already been pointed out, and may be a warrant for deriving the latter from the former phylogenetically. In the case of the retina we have the very remarkable instance of a diverticle of the brain, which is mechanically invaginated, resulting in the conversion of the invaginated portion into a highly modified form of brain tissue (retina), and the uninvaginated portion into a pigmented velum (pigment layer). Accompanying and co-operating with this process is the conversion of a portion of the superficial sensory epithelium, first into a ciliated sac, and then into a solid and transparent mass (the lens and capsule) without the formation of permanent neuroblasts.

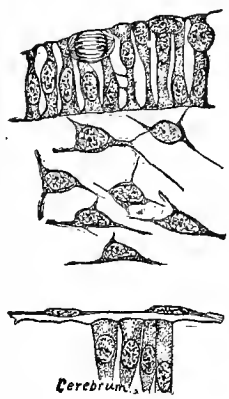

FIG. 498.

Preliminary to the development of the sensory organs, the existence of an undifferentiated sensory epithelium, or *cephalic sensory plate*, must be recognized. This plate, whose morphological cephalic end is at the infundibulum, extends over the convexity of the head and arches laterad, including the prerudiments (anlags) of the lens and arches, caudad to include auditory sac (anlag) and lateral (bronchial) sensory apparatus. The epithelium is essentially uniform over the entire area in an early period (Fig. 497). It consists of columnar epithelium (spongioblast) cells with scattered neuroblasts near the ectal surface.

The subsequent modifications are very like those of other nervous lamina. The neuroblasts migrate toward the ental surface and there accumulate along the distended ental portions of the spongioblasts. The process may be easily traced in the case of the olfactory. It will be recalled that phylogenetically the olfactory is a dorsal organ, and is connected by the pituitary (hypophysis) with the infundibulum or morphological front of the brain. By the development of the projecting walls of the head the olfactory anlag is carried forward, the growth being from the angle of the mouth cephalad, as can be shown by observing the direction of invagination of the olfactory sac. Jacobson's organs are intermediate between the olfactory and the hypophysis. Fig. 498 illustrates the first changes in the future olfactory epithelium. The ental portion of the spongioblasts is becoming disassociated and the formation of a reticulum is begun. In Fig. 499 the migration of the neuroblasts toward the inner surface and the incipient invagination is shown, while Fig. 500 illustrates the origin of the olfactory nerve by migrating neuroblasts. In the way indicated the olfactory nerve impinges upon the cephaloventral or lateral aspects of the hemispheres, and there proliferates and calls out the development of the peculiar structure of the olfactory pero. The subsequent connection of the pero with the hippocampal region by means of the radix lateralis is especially well shown in fishes and in other classes of lower vertebrates. That a portion of the same fibres enter the walls of the thalamus is suggested by a study of mammalian embryos.

FIG. 499.

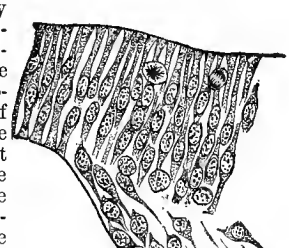

FIG. 500.

The fact that the lens is essentially a sensory depression, homologous with the nasal sac, is one of the well-established generalizations of the last few years. In this

case, however, neuroblasts are not developed, and the spongioblasts undergo very remarkable gelatinous transformation, though the nuclei may always be demonstrated by sufficient preparation.

The internal ear is the next organ of this lateral series, and its formation beautifully illustrates the uniformity in diversity characteristic of all morphological processes. The auditory sense organ, like the preceding, is an invagination of specialized sensory epithelium continuous with that which, in lower vertebrates, forms the "organs of the lateral line." It first appears as a saucer-like depression (Fig. 501), from which is formed the capsule from the various transformations of which the "membranous labyrinth" with its sensory patches is formed.

The primitive sac divides into a cephalic and caudal portions. Comparison of the methods of development of the lateral line-organs in the dogfish, for example (Ayers), shows great similarity with the early morphological changes in the ear by which the semicircular

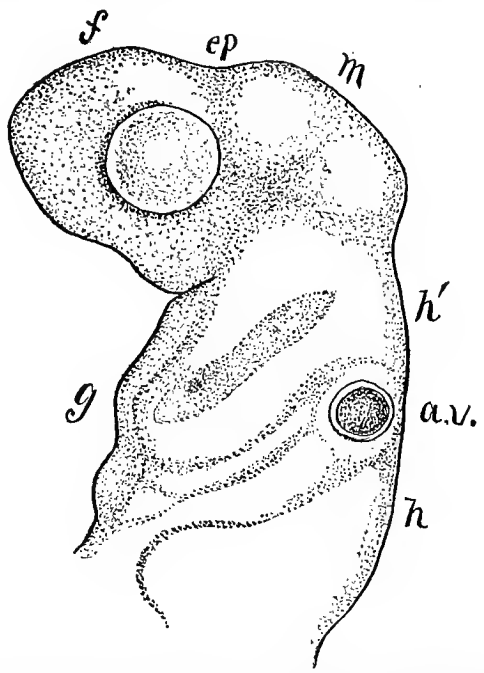

FIG. 501 (After Ayers). — Head of Embryonic Shark, *Acanthias vulgaris*, showing the saucer-like depression, showing the insinking sense-organ which is to be converted into the auditory sense-organs of the shark. *a.v.*, Auditory vesicle; *ep*, position of epiphysis; *m*, mesencephalon; *f*, fore-brain; *g*, gill-region; *h*, medulla.

canals are formed. "Within the two chambers formed four canal sense-organs develop. The two external organs are soon enclosed within the ampulla of the two complete and relatively large canals which are now formed about them." "Up to this time the organs have retained the primitive relations to each other, a serial arrangement along a line running in an antero-posterior direction. Now there begins a distortion of the structure as a whole, which continues ever after and reaches its greatest development in the mammals, viz., a process of sinking and drawing out ventrally of the posterior chamber of the ear, so that hereafter we might speak of a superior and an inferior portion or chamber" (Ayers). By progressive subdivisions the four patches give rise to the eight definitive auditory sensory organs of mammals. Meanwhile, the neuroblasts have migrated to the ectal surface and give rise to the two ganglia (vestibuli and cochleæ) from which the two branches of the auditory nerve are produced.

The transformations of the epithelium in the formation of the organ of Corti are out of place here, but obey laws easily intelligible from our knowledge of the history of the spongioblasts elsewhere.

The retina is essentially a modification of a portion of the primitive neural tube. The pigment layer undergoes a change directly comparable with that which produces the velum cerebelli or the introductory stages of plexus formation. The original limits of the tube are represented in the retina by the membranæ limitantes.

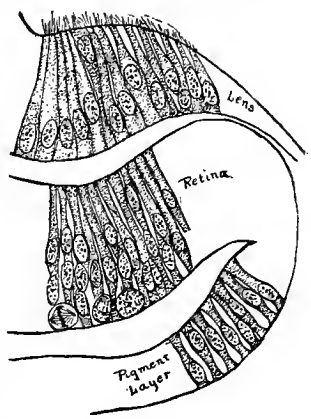

FIG. 502.

The relations are at first exactly as in the brain proper (Figs. 502, 503). The neuroblasts are formed adjacent to the ventricular surface and migrate to the ectal surface. A portion remains in the nucleary (granular) layers and corresponds to the granules which lie adjacent to the ventricles in the brain. The method of formation of the rods and cones is still a matter of dispute. Professor His thinks they are formed by protrusion of backward-growing processes of the neuroblasts. It is, perhaps, doubtful if we have not to do with the nuclei of the spongioblasts and the greatly modified homologues of the cilia characteristic of ventricular epithelium. In any case the true neurons collect in a single or double series on the vitreous surface of the retina, and give rise to an axis-cylinder process which passes through the chiasm to the tectum opticum, and to protoplasmic processes which subdivide in the "inner molecular layer" (equivalent to the marginal reticular zone of the brain). The direct connection between the ganglion cells and the rods and cones has not been observed, and probably the connection is through a reticulum or neuropilem as in all other cases. The nerve-fibres develop in the human retina at about the fifth week. It is obvious, from the results of recent investigation, that fibres arising in the teetum opticum pass toward the retina as well as vice versa.

The spinal ganglia, which originate near the margin where the medullar tube separates from the ectoderm, appear in the form of a band on either side the tube. The aggregation into separate ganglia may be ascribed in part, at least, to the mechanical effect of the myomers or primitive vertebrate. The neuroblasts of the ganglion put forth a process which penetrates the medullary tube and at once divides into an ascending and descending ramus. From these rami short branches are formed which engage processes of the motor cells of the ventral cornua and form reflex channels, while other communicating tracts are related to the columns of the cord. The opposite extremity of the neuroblast passes to the peripheral end organ. During early stages the neuroblasts are motile, and, either as a result of a common impulse or by the results of the growth of the tube, they come to lie upon the lateral aspects of the cord. Connection is effected in a secondary way between the motor and sensory roots, and experiments have even shown that motor fibres may find exit via the sensory ganglion; for many of the purely motor nerves temporary embryonic ganglia have been reported, but it is to be feared that such reports rest on false conceptions of the method of proliferation of the nerve itself. (Figs. 504, 505, 506.)

FIG. 503.

Respecting the development of nerve-fibres, our opinions have been very largely moulded by the great work of Flechsig, who describes, somewhat in detail, the origin

of the sheaths from special amœboid cells. Only quite recently, in the case of the olfactory, it has been shown that the nerve is composed of moniliform series of neu-

Fig. 504. (From His)—Illustrates the origin of the Spinal Ganglia from the Connection between the Neural Tube and the Ectoderm. It is stated by some observers that the ganglion anlags temporarily fuse and again separate.

rons. Kölliker says: "In my studies upon the development of the organs of smell in human embryos I discovered that the olfactory, unlike all other nerves, in the

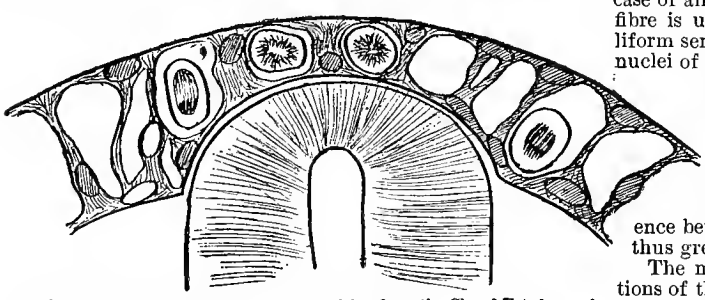

Fig. 505.—Stage in which Neuroblasts are arising from the Closed Ectoderm after Separation of the Neural Tube.

earliest stages consist throughout their entire extent of nucleated bundles of the finest parallel fibrils, which bundles I compared with the axis-cylinders of other nerves. From this circumstance I concluded that these nuclei correspond to the nuclei of nerve-cells, and that a nucleated sheath of Schwann, accordingly, is not present, although it has been assumed by all authors since Max Schultze. If this were correct, then the olfactory fibres consist of bipolar nerve-cells, which either each sends a process peripherad, or, as seemed to me probable, are united in moniliform series, as must be assumed in the sympathetic; in this case the nerve grows by successive subdivision of the nucleated portions without complete separation of the resulting segments.

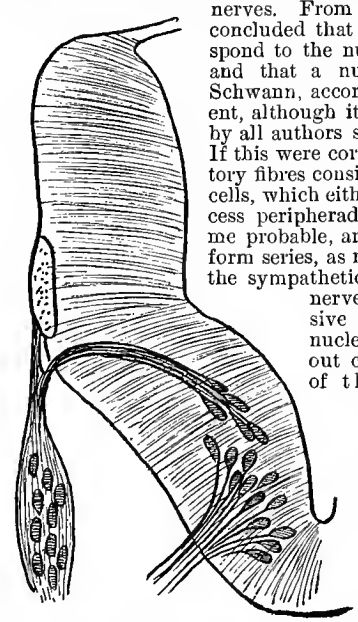

Fig. 506.—Diagram Illustrating the Origin of a Medullary Nerve, with the Sensory Portion derived from the Tractus Solitarius, which is at the demarkation between basal plate and ala.

"In any case the development of such a nerve from the central nervous system is difficult to explain from any existing analogy, and it afforded a very desirable solution of the matter when His, a short time since, announced that the olfactory does not develop from the olfactory lobe, but rather takes its origin from the epithelium of the olfactory pits, and grows in the centripetal direction, like the cells of the spinal ganglion. This investigation of His I have recently verified with the following results:

"In the earliest stages the olfactory pits have no nerves, and are not connected with the olfactory lobe. In an embryo chick of four days there is a slight proliferation of the epithelium of the olfactory at the end nearest the brain only, forming a bundle .030–.054 mm. thick, which can be followed to the outer margin of the hemisphere without entering into any connection therewith. The bundle is finely fibrous and nucleated, and exhibits on its surface fusiform cells."

Professor His regards the nerves themselves as the olfactory ganglion. These cells, inasmuch as they were originally epithelium of the nasal pit, have undergone a considerable migration, so that the question naturally arises whether all the nerve-cells of the olfactory ganglion have not gradually entered the bulbus. Professor Kölliker does not believe that the cells grow into the bulbus, while His supposes that they do thus enter and proliferate.

The present writer is tempted to believe that, in the case of all sensory, if not motor nerves, the definitive fibre is usually the result of the fusion of a moniliform series of neurons whose nuclei remain as the nuclei of the sheath of Schwann. The well-known fact that during degeneration the nuclei of Schwann's sheath begin to proliferate, seems to point in the same direction. Huber has shown that the theory that these nuclei are latent and preformed in the sheath, and the other that the nuclei migrate from node to node, are equally untenable. The difference between the sympathetic and spinal nerves is thus greatly diminished.

The modifications going on in the several portions of the brain itself as it approaches maturity are too numerous to be followed in detail. Among the most important of these are the formation of what may be termed switch stations in the brain. Such stations are the nidulus ruber (sensory) and the cells of the isthmus region (pes pedunculi) where the connections are effected with the cerebellum. These relations are most beautifully shown in reptiles and fishes (Fig. 507).

The structure of the ruber is peculiar in the dense

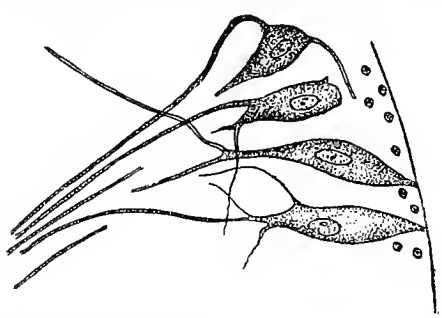

Fig. 507.—Switch-cells from the Hypoaria (Lobi inferiores) of Fishes. These cells connect directly with the motor-tracts from the cerebrum, and indirectly with the cerebellum. (Herrick.)

structure of the neuroglia, the great abundance of blood-vessels, and the tendency, in some groups, to suffusion with proteid matters. In the fishes the body which has been identified with the ruber has a peculiar spotted appearance which has been resolved into dense clusters of cells in a suffused investing stroma, as illustrated by Fig. 509. The olives, whose origin has already been described, are similar to the above-mentioned, both probably being derived from invaginated portions of the original ventricular epithelium.

In conclusion, it must be admitted that the most im-

portant factor in the preparation for a rational interpretation of the perplexities of the nervous mechanism is the

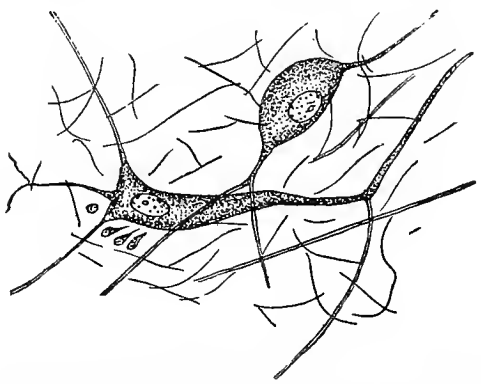

FIG. 508.—Cells from the Peripheral Portion of the Ruber. These cells communicate with the dorsal sensory tracts from the cerebrum. (Herrick.)

recognition of the essential unity of the process of nervous development, and of the existence of a single typical nervous element—the neuron—through the endless com-

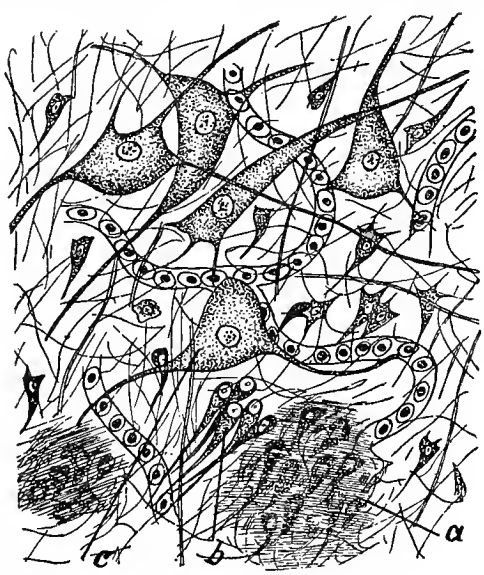

FIG. 509.—Portion of the nidulus ruber (rotundatus) of a fish. *a*, gelatinous glomerule; *b*, clustered cells; *c*, ganglion cell.

binations and modifications of which the entire central system has been produced. *C. L. Herrick.*

NEYRAC. A small watering-place in Ardèche, France.

LOCATION.—Neyrac is prettily situated on the right bank of the river Ardèche, about two miles from Vals. The place has a number of alkaline-calcareous springs. The *Source les Bains* is the only spring now in active use. The temperature of the water is 80° F.

INDICATIONS.—The waters of Neyrac have the reputation of being tonic, slightly aperient, and solvent. They are made use of in certain skin diseases, rheumatism, scrofula, chlorosis, gastralgia, and female disorders. In olden times they enjoyed a great reputation in the treatment of leprosy.

ACCOMMODATION.—There is a small thermal establishment and several clean lodging-houses. Nothing approaching the requirements of modern scientific bath treatment has yet been established at this resort.

Edmund C. Wendt.

NICE. This city, which continues to be the most popular resort on the Riviera, has already been described in its main features in Vol. VIII. of the HANDBOOK, under the article "Riviera." The writer having recently spent a winter there, it may be well to briefly indicate the results of some of his personal observations. For a more detailed account the reader is referred to the writer's report, which was published in the *Medical Record*, March 12, 1892. So far as its claims go to be considered as a first-class health-resort, the town of Nice has received from different authors both exaggerated praise and undue condemnation. There is no doubt that the rapid growth of this city, accompanied by deficient sanitary arrangements, has vitiated the old title of Nice to rank as the best natural winter sanitarium on the north shore of the Mediterranean. But despite its undeniable imperfections, the town still attracts large numbers of invalids and pleasure-seekers, who often loudly complain but yet return to its hospitable shores winter after winter. This, in itself, is an argument in favor of Nice.

In regard to the important matter of drinking-water, it appears that the source mentioned as impure in the writer's report has now been suppressed by the authorities. The water supplied by the Nice Company is carried from distant hills in a completely closed aqueduct. It has the following composition:

ANALYSIS OF THE NICE DRINKING-WATER (made by M. Durand-Clay, de l'École des Ponts et Chaussées):

Ingredients of one litre, evaporated to dryness.	St. Theole.		
	Crevice in rock.	Source of Prê.	Peillon source.
	Gr.	Gr.	Gr.
Insoluble residue	0.010	0.004	Traces
Alumina and peroxide of iron	0.001	0.001	Traces
Chalk	.....	0.085	0.050
Magnesia	0.016	0.009	0.040
Alkalies (various)	0.016	0.008	0.030
Chlorides	0.013	Traces	0.020
Sulphates	0.005	0.011	0.010
Organic matters	0.016	0.003	0.030
Carbonic acid and unclassified substances	0.054	0.059	0.060
Total residue of evaporation of one litre	0.212	0.180	0.240

The water is thus seen to be a mixed one. It is hard, chalky, and very slightly acidulous to the taste. Filtration is not necessary, but boiling would of course destroy the traces of organic admixture that it undeniably contains.

Most of the dangerous old wells of Nice have been closed up, and a foreigner need not fear the Company's water at the present time.

As regards drainage difficulties, some notable improvements are already well under way. The writer's report mentions this subject as follows:

Fully recognizing the shortcomings of their present system of sewage disposal, the authorities are now considering two new plans for perfecting the same. The first of these is M. Bérard's plan. It is quite simple, and would be comparatively inexpensive. After rectifying, repairing, or newly constructing a comprehensive system of street sewers, a large collecting conduit is to be built parallel with the shore line. This will carry the sewage down to the river Magnan by a natural incline. Thence either an iron conduit will convey it nearly five hundred feet out to sea, or it will be used in fertilizing country fields. The advantages of this plan are that it is cheap, feasible, and measurably effective.

The other plan is a more extensive and expensive one, but having been abandoned need not be described. The writer has quite recently learned that several objectionable open sewers and contaminated streams have already been canalized, and that the municipal authorities are evidently hard at work to perfect their drainage system. There is little doubt that the diminished prestige of Nice will in some measure return as soon as the most urgent sanitary reforms shall have been carried out.

In regard to the healthfulness of Nice, it may be said

that the city's death-rate will bear favorable comparison with that of most French towns. Moreover, it appears to be diminishing rather than increasing. In justice to this much-abused city, it should also be borne in mind that, in calculating percentages, the permanent population is used as a basis. The census of 1891 gives Nice 97,720 inhabitants. But as there is a large floating population, estimated to reach 30,000 or 40,000 during the season, and as many invalids go to Nice to die, it follows that the actual death-rate, chargeable to the town proper, must be even lower than the official returns make it. These figures are given by the Board of Health :

In 1883.....	30.75	deaths	per 1,000.
" 1884.....	29.55	"	"
" 1885.....	28.82	"	"
" 1886.....	24.60	"	"
" 1887.....	25.21	"	"
" 1888.....	20.62	"	"
" 1889.....	21.78	"	"
" 1890.....	21.63	"	"

In the experience of the writer the climatic peculiarities of the Riviera invite sudden chills and colds, certain throat troubles, and an exacerbation of some nervous symptoms. But beyond that, all the evil that has been laid at the door of Nice, on the score of its dangerous climate, has been dictated by ignorance, envy, or malevolence. It must stand to reason that a place highly prized by the Romans for its sunshine and dry air, and which for centuries has maintained an excellent reputation as a winter health-resort for all classes of patients, cannot be totally devoid of substantial and permanent advantages. Volumes have been written on the climate of the Riviera. Nice enjoys nothing more nor less than a fair average of Riviera climate. This means that it is not devoid of drawbacks, and that ideal winters are not found there. Nice is more sheltered than some places, but it is nevertheless exposed to the *mistral*, which blows at Nice just as it blows at most other Riviera spots.

It should be borne in mind by invalids and tourists that Nice and the Riviera in general really possess two distinct and different climates, viz., a sea-shore or marine climate, and an inland or mountain climate. It is quite well known that immediate proximity to the sea may induce sleeplessness and other symptoms, denoting too exciting an action on the nervous system. The dry, sunny, inland air is tonic and sedative ; the air in immediate proximity to the shores of the sea is bracing and exciting. The air of the city and its suburbs is often a mixture of the two.

It is thus apparent that a number of local climates are found at Nice, concerning which the resident physicians will inform invalids.

The class of patients likely to derive some benefit from a winter season spent at Nice comprises those in need of sunshine, warmth, dry air, and creature comforts.

Anæmia, chlorosis, scrofula, gout, rheumatism, chronic bronchitis, asthma, catarrhal conditions of the upper air-passages, the early stage of phthisis, chronic Bright's disease, and diabetes may all be more or less favorably influenced by the climate of Nice. The feebleness of old age and exhaustion from over-work or over-indulgence are also among the indications for a season on the Riviera.

In conclusion, it may be borne in mind by the physician that the city of Nice has so many superior attractions and offers so much in the way of amusements and distraction, that it is more largely visited by wealthy semi-invalids (and particularly by Americans) than any other resort on the Riviera. And thus it happens often enough that patients sent elsewhere gravitate toward this gay capital of the Mediterranean littoral without repenting their choice. *Edmund C. Wendt.*

NOTIFICATION OF INFECTIOUS DISEASES.

Among the different measures employed by sanitary authorities for the prevention of the spread of infectious diseases, the notification of the occurrence of such diseases now occupies a prominent place. Municipal authorities especially should have the requisite power everywhere to require immediate notice to be given them of every fresh outbreak of diseases dangerous to the public health in order that such authority may take proper measures for the protection of the community.

The chief advantages of a system of notification lie in the possibility which is thus given to a local board of health to determine the extent of prevalence of an epidemic or a localized outbreak, and to inquire into the local causes which have operated to produce it. The board can then act intelligently in applying the proper remedies for preventing its further spread.

Laws enacted with this object in view have been in force in the older States for many years, but not until within the past ten or twenty years have pains been taken to execute such statutes with such degree of efficiency as to make them really protective. The law requiring the householder to report each case of dangerous disease to the local authority was enacted in Massachusetts in 1792, and that which requires the same duty on the part of the attending physician was enacted in 1827.

Various attempts have been made in England to enact a similar statute, but these efforts were unsuccessful until 1889. By the terms of the law then enacted the notification of infectious diseases to the sanitary authority was made compulsory throughout London, while the principle of local option was applied to all other districts.

During the year in which this bill was under consideration by Parliament, intense opposition had been manifested by many of the members of the medical profession throughout England. Objections were offered not only by the people but also by the medical profession, but the bill passed and finally became a law.

The fallacy of the objections has been abundantly proven by the three years' experience of the towns of England where the Notification Act has been adopted. The notification of each case is made by a certificate furnished by the attending physician, for which a fee of two shillings and sixpence is paid, except in a case where the person giving the certificate is the medical officer of a public institution, when the fee is one shilling.

The diseases to which this act applies are small-pox, cholera, diphtheria, membranous croup, erysipelas, scarlet fever, typhus, typhoid and puerperal fever, and any other infectious disease which may be added to this list by the sanitary authority of a district.

Up to the present year (1892), the act had been adopted in 1,051 districts, having an aggregate population of nearly sixteen millions, to which should be added the population of London and fifty towns in which local acts made it compulsory, making in all a population of 24,012,399 over which the act was in force, out of a total of 29,001,018. In a few towns the sanitary authorities had availed themselves of the power to require notification in the case of measles, Rötheln, chicken-pox, and hydrophobia.

In Massachusetts there can be no doubt that the law relative to notification has been productive of excellent results in the prevention of disease, especially in the cities and large towns. It has furnished the local boards of health with the necessary information relative to the origin of outbreaks of infectious disease, and in many instances enabled them to take timely steps for preventing its further spread. The recent law requiring local boards to keep records upon this important matter, has furnished information as to the prevalence of certain diseases in the principal cities and towns of the State. In the smaller towns it is probable that instances of failure to comply with the provisions of the statute are much more frequent than they are in cities.

In the Twenty-third Report of the State Board of Health of Massachusetts, a table is presented for the first time, giving a summary of the records of such local boards of health as could be obtained in this direction.

From this table it appears that the number of reported

cases and deaths, and the percentages of deaths to reported cases, were as follows:

Reported cases of diphtheria	2,444
Reported deaths from diphtheria	575
Percentage of deaths to reported cases	23.5
Reported cases of scarlet fever	4,517
Reported deaths from scarlet fever	151
Percentage of deaths to reported cases	3.34
Reported cases of typhoid fever	2,414
Reported deaths from typhoid fever	460
Percentage of deaths to reported cases	19.05
Reported cases of measles	5,861
Reported deaths from measles	84
Percentage of deaths to reported cases	1.4

The foregoing percentages may be considered as somewhat larger than the actual percentages of fatalities from these diseases during the year, for the reason that the number of deaths is known, while the number of reported cases is probably less than the actual number.

Similar tables and percentages have also been prepared from the English returns for the same year, in which the ratio of deaths to reported cases was slightly greater in the case of each disease than those of Massachusetts for the same year.

The records of these cases, preserved in the offices of the local boards of health, have proved very serviceable in recent years as an aid in the tracing of the causes and conditions prevailing in local epidemics of typhoid fever, especially where water and milk supplies were involved.

Samuel W. Abbott.

OLD AGE, RECUPERATIVE POWERS OF. The life of man may be broadly divided into three periods, namely, of growth, of maturity, and of decline. These three stages are characterized by sharply defined differences, both physical and mental, which are patent to the most unobserving. Youth is a period of restless growth. The stature is increasing; the bones, the muscles, the blood-vessels, and nerves, all are lengthening and expanding, regularly and evenly; the vital organs are being strengthened and adapted to the work they have to perform in the economy; the reproductive organs and those of special sense are developing; the nervous system is maturing and acquiring, by slow degrees, a more perfect and regulated control over all the functions of animal life; while at the same time the intellectual faculties are slowly unfolding and gaining, step by step, the mastery over the purely physical impulses or unreasoning instinct. In a word, the final scenes of evolution are being again enacted—the animal is becoming human. This period is one of great danger, since the imperfectly formed tissues are extremely vulnerable and sensitive, and are prone to take on excessive reaction in response to comparatively slight insults. Disease kills quickly at this age, for the faculty of sustained resistance is as yet undeveloped. On the other hand, the recuperative forces are very efficient, as we might suppose they would be at a time when the constructive changes are at their period of greatest activity; and when, therefore, acute disease does not kill, recovery from its effects is usually rapid and complete.

The adult is the physically grown man. The process of accretion is at an end, metabolism is in equilibrium, and the anabolic or constructive changes equal, but no longer exceed, the katabolic or destructive. The skeleton is fully formed, epiphyses and apophyses are united; the frame is strongly knit, the muscles are firm; all the organs are in a state of greatest potential activity, and the whole physical complex is most wonderfully controlled and regulated by the matured and perfected nervous apparatus. Although, in the strict sense of the term, growth has ceased, there still remains the potentiality of a modified form of growth which we call repair. By means of this power losses of tissue are made good, worn-out parts are renewed, and a healthy equilibrium is maintained. Ordinarily this recuperative force is sufficient to restore only the losses of normal every-day waste, but it is capable of great extension under certain circumstances and to meet certain emergencies. Overwork or disease often causes an excessive destruction of tissue which would speedily put an end to the individual were anabolism limited strictly to these every-day needs of the economy. But we know that such losses are not irreparable, and that there is a recreative force which quickly restores the normal equilibrium when once the destructive agencies have ceased to act. This reparation, when it occurs from the effects of wasting disease, we call convalescence—growing strong; when the muscles or nervous system are wasted by over-action, we rest them in order to permit of their restoration by anabolic processes, and this rest we call re-creation.

In old age the period of stability is at an end. This stage has been well characterized by Canstatt as the period of involution or of retrograde formation. The metabolic equilibrium has been lost, anabolism no longer keeps pace with katabolism, and so the tissues waste; all the organs, with the exception of the heart and kidneys, diminish in size and perform their functions feebly, if at all; the special senses are dulled; the stature grows less; fatty and calcareous degenerations involve the anatomical elements; the bones become loose in texture and brittle, the muscles waste and lose their power, the skin shrivels, the hair bleaches and falls out—in a word, the characteristic change of old age is one of atrophy. The vital forces are less elastic, are more quickly depressed, and when once seriously lowered seldom return fully to the point where they were before. The recuperative powers, so active in adult life, are impaired, though, as we shall see, less seriously impaired than is commonly supposed. The aged are less exposed to attacks of acute disease than the young or those in middle life, but they are also less able to resist such attacks, at least at their outset; they are more liable to succumb to shock, and their reactive powers are depressed.

There is, therefore, some ground for the apprehension that most physicians feel when called to minister to an old person suffering from disease or injury, and their gloomy forebodings are, it must be confessed, frequently justified by the results. Yet the case is oftentimes less desperate than we are wont to assume, and not uncommonly the patient runs greater danger from the utter lack of hope with which his medical attendant and friends regard his condition than he does from the disease itself. The physician who looks upon an old and enfeebled man, suffering from pneumonia or from a fracture of the neck of the femur, as one doomed to speedy dissolution may be led thereby to neglect measures which he would institute in the case of a younger person. He is more or less influenced in his management of the case by the feeling that all that he can do is to relieve pain and to smooth, as far as possible, the sufferer's path to the grave. That this fear is not always justified by the results, however, must have occurred to many, for there can be few practitioners of long experience who have not seen cases which have been practically abandoned as hopeless recover, and recover not merely by chance but as the result apparently of carefully instituted treatment. It may be said that these are the exceptions that occur to every rule, that the old people would have recovered in any event, and that the treatment had nothing to do with the result. Even so; but the fact that they did recover, whether in consequence, or in spite, of treatment, proves that all old patients do not necessarily die when a serious disease attacks them, and it should serve to impress upon us the wisdom of taking into consideration the chances of recovery in every case, no matter how seemingly hopeless, and of doing what we can to favor them. The writer meets frequently an old man of nearly ninety years, who is going about to-day a cripple in consequence of a badly united fracture of the thigh. He fell on the ice and broke his femur some three years ago, and because he was so old and decrepit his medical attendant contented himself with simply retaining the leg in a com-

fortable position, making no attempt to secure perfect coaptation of the ends of the bone, thinking that it would be cruel to torture a dying man. In spite of the non-apposition of the fragments, union occurred as rapidly as if the patient had been forty-three instead of eighty-three years old, and now the poor old body is condemned to drag along the few remaining years of his none too joyous life in still greater discomfort, simply because his surgeon thought him too old to mend his broken frame.

The attention of the writer was drawn to this facility of repair, in old people, several years ago, at the time when he first took up the study of senile pathology and therapeutics, upon assuming medical supervision of a home for the aged in this city. He then shared the pessimistic views of most people, medical as well as lay, concerning the outcome of pneumonia in the aged, and felt that when once a diagnosis of the case had been established, about all had been done for the patient that the most conscientious physician could do. But when several of the inmates of the institution, whose ages ranged from seventy to eighty-five years, and who were incontestably suffering from pneumonia, falsified my prognosis by recovering instead of dying, my views began to change. I then commenced to treat the old people a little more carefully because more hopefully, and was soon as gratified as I was astonished to find that death was not the rule by any means. During the following two years there were forty-four cases of croupous pneumonia in the home, and of this number no less than twenty-seven recovered. There were seven cases of sudden death, for which no cause was evident, and which were very probably examples of that insidious and undiagnosable form of pneumonia sometimes found at autopsies on the aged; but even after adding these to the number given above, we find that there were twenty-seven recoveries out of fifty-one cases, or over fifty per cent., a great improvement over the seventy-five or eighty per cent. given by some writers on old age as the mortality from pneumonia in persons over seventy years old. These cases were not at all mild, some of them being of most disheartening gravity, and no claim is made for any specially efficacious form of treatment; the result was attributable simply to the kind nursing of the Sisters and to the recuperative powers inherent in the tissues of the aged patients.

But instances of this recuperative power were not confined to those suffering from pneumonia, and my surprise was continually excited by the repeated observation of recoveries from other grave diseases, and after injuries that would have been serious even in the young. Fractures, when not intracapsular, healed rapidly, ulcers needed only to be encouraged by gentle stimulation and cleanliness, carbuncles were not always fatal, and the wounds left by them cicatrized kindly; bronchitis and diarrhœa were hardly more serious maladies than if they had occurred in the middle-aged, and even cerebral hemorrhage did not always kill, nor did it invariably leave behind a permanently incapacitating paralysis.

About this time Professor George M. Humphrey, of Cambridge, began to publish a series of articles on Old Age in the *British Medical Journal*. His papers were based on the results of a collective investigation on "the present condition, habits, circumstances, etc., of aged persons," undertaken by the British Medical Association. Perhaps the most interesting fact concerning old people brought out by this investigation was that of the astonishing power which they possessed of recuperation after injury or disease, and this was made the subject of several of Professor Humphrey's articles. He found many cases recorded of fractures and other injuries in persons advanced in years, in which repair took place as quickly as it normally does in the middle-aged, and he also met with many instances evincing the possession by old people of astonishingly great recuperative powers after severe attacks of bronchitis, pneumonia, apoplexy, and other grave illnesses. The most remarkable were perhaps the recoveries from brain affections. There were reports of twenty-five cases "in which brain attacks associated with paralysis, in most instances hemiplegia, and in some with convulsions and unconsciousness, were in greater or less degree recovered from. In some the recovery was complete. One man had three attacks of paralysis at eighty-two, eighty-five, and eighty-six; and one woman, in addition to several attacks of unconsciousness, had left hemiplegia and convulsions at seventy-eight, paralysis of the left hand at eighty-two, and severe apoplexy at eighty-nine, after which she was able to get about again, though with weakened mind and a liability to epilepsy."

Since that time, namely, during the past ten years, there seems to have been quite a general awakening to the fact that the power of repair is not lost in proportion as senile atrophy progresses, and the literature on the subject is now becoming fairly voluminous. The titles and authors of a number of journal articles on the recuperative powers of old age will be found below in the bibliographical list appended to this essay; but the reports of individual instances of recovery from disease or injury are too numerous even to be mentioned here, and it will suffice to refer very briefly to a few only of the cases which I have found recorded in medical literature.

Among the diseases belonging to the department of internal medicine by far the most frequently noted is croupous pneumonia, a fact which need occasion no surprise when we consider that this is one of the most common causes of death in old people in our northern climate. I have already referred to my own unpublished cases to the number of fifty-one, among which there were twenty-seven recoveries. Seven of these latter were over eighty years of age, thirteen were between seventy and eighty, and the remaining seven were between sixty-five and seventy. In six cases there was consolidation in both lungs. One patient, an old woman, eighty-nine years of age, had an attack in each of two successive years, the second one involving a good portion of both lungs, yet she lived to die from the effects of falling out of bed three years later. Several of them were extremely feeble, seeming scarcely to have vitality enough to keep alive before contracting the disease, yet convalescence, when once the crisis was passed, appeared to progress as steadily and as favorably as one would expect it to do in a robust youth.

Dr. Giuseppe Lapponi reported, in the *Raccoglitore Medico* for January 10, 1887, a case of recovery from pneumonia in a woman, seventy-four years of age, who was the subject of chronic renal disease, the uræmic condition being the occasion of an apyretic state which served to mask for a time the existence of the pneumonia. The physical signs, however, left no room for doubt as to the diagnosis. Despite the very grave complication furnished by the kidney lesion, resolution of the pneumonic process was complete.

In an article in the *British Medical Journal* for June 12, 1886, Dr. George M. Humphrey relates at some length the case of Miss Hastings, aged one hundred and four years, the sister of Sir Charles Hastings, the founder of the British Medical Association. She had facial erysipelas and pneumonia, from which she recovered perfectly, when she was between ninety-nine and one hundred years of age. When within six weeks of her one hundred and fifth birthday, she had a severe attack of pneumonia, involving the bases of both lungs, but she recovered completely, the lung clearing up well and leaving only a chronic bronchitis from which she had suffered for many years.

Dr. W. Washburn, in an article in the *Medical Record* for February 18, 1893, on the value of opium in the treatment of shock and pneumonia, mentions a case of recovery from the latter in the person of a patient seventy-four years old. In this instance the patient had at first two carbuncles, then erysipelas, and finally pneumonia. The details of treatment of the case are not given, beyond the statement that small repeated doses of opium were exhibited.

Sir Andrew Clark reported, at a meeting of the Medical Society of London (*British Medical Journal*, December 20, 1884), a remarkable case of intermitting or relapsing pneumonia in a man, eighty-two years old, who

had passed through a similar attack at the age of seventy-five. The patient was ill for seven weeks, during which period he passed through nine or ten severe rigors and had six successive attacks of pneumonic exudation, finally making a perfect recovery.

My notes, personal and gleaned from periodical literature, contain the histories of a large number of cases of recovery from attacks of other severe illnesses, chiefly bronchitis, gastritis, diarrhœa, and intestinal obstruction, the reports of which would, however, extend this article beyond due limits and must therefore be omitted. Many of them are, nevertheless, of striking interest, and all furnish indubitable proof of the fact that old age offers in itself no bar to recovery from acute disease, and they show the unwisdom of abandoning hope in even seemingly desperate cases among the aged.

The most convincing evidence of the powers of repair inherent in the tissues of old people is furnished by the histories of injuries and of surgical operations. Hospital records are full of cases of recovery after operation for hernia, vesical calculus, or enlarged prostate, occurring in persons over seventy years of age, and almost every surgeon can recall many such instances in his own practice. Nearly thirty years ago, Dr. Daniel Donovan, of Skiberbeen, sought to draw the attention of the profession to the remarkable tolerance and recuperative powers possessed by the aged, and urged upon his colleagues the necessity for greater boldness in operating in such cases, reporting several successful instances from his own experience in support of his position. Since that time, Humphrey, Graham, Blum, and others have written in the same strain, but their teachings are so opposed to the general impression among surgeons that it is doubtful whether they have as yet had much influence in modifying the prevailing opinion. As Humphrey remarks: "These inferences (of the reparative powers of the aged after fractures, wounds, etc.) are so contrary to preconceived notions, indeed, to probabilities, that it takes some time and effort and frequent repetition to obtain for them a fair measure of acceptance." The fact did not escape the keen observation of the late Professor Gross, who asserted, in his "System of Surgery," that age is no barrier to union after fracture; but most other surgical authorities still incline to the contrary view. For example, in one of the latest works on surgery ("An American Text-book of Surgery," 1892), we find it stated that "old age is likewise a factor for evil. After forty, patients bear operations increasingly less and less well as their age advances," and several other writers of equal authority express themselves in much the same fashion. They are, to a certain extent, right in this discouraging view, for it is undeniable that the aged are more prone to suffer from shock after severe injuries and surgical operations, and also that their wounds are more liable to slough; there is, too, greater danger of cardiac and respiratory disturbances during the administration of a general anæsthetic, whether it be ether or chloroform. But, these dangers aside, the results of operations are almost as favorable in the old as in the young and middle-aged, and repair proceeds in them with at times amazing rapidity. The following cases, selected from a number scattered throughout periodical literature, bear testimony to this fact. Reports of operations upon old men for enlarged prostate or for the removal of vesical calculi, as also cases of operation for incarcerated hernia, have been omitted, partly because they are operations of necessity and must be performed whatever the risk, and partly because they are of such frequent occurrence that instances of recovery subsequent to them are within the knowledge of everyone. Indeed, it is strange that the frequently successful outcome of these cases seems to have had little or no influence in modifying the surgical distrust of old people in general, the fact that they often recover rapidly after the release of an incarcerated loop of intestine, notwithstanding the shock, appearing to have seldom suggested the thought that they may recover equally well after the removal of a cancer of the breast or other capital operation. No attempt has been made to arrange the following cases chronologically or in the order of their importance, the only classification being according to the nature of the operation or injury.

Amputation of the Breast.—Dr. Prégaldino (*Annales de la Société de Médecine de Gand*, October, 1886). Woman, ninety-three years of age; chloroform anæsthesia; union by first intention, except at two points where the drainage-tubes were inserted.

John A. Macdougall (*British Medical Journal*, October 11, 1884). Woman, eighty-six years of age; wound became septic, but the patient made an excellent recovery.

Daniel Donovan (*Dublin Medical Press*, August 24, 1864). Woman, eighty-four years of age; wound healed rapidly.

Thomas Annandale (*Edinburgh Medical Journal*, March, 1872). Amputation of the breast and removal of the axillary glands for cancer in a woman seventy years of age.

N. F. Graham (*Medical News*, February 7, 1891). Removal of the right breast for cancer in a woman seventy-one years of age; recovery rapid.

Amputation of the Arm or Leg.—N. F. Graham (*loc. cit.*). Amputation of the leg for senile gangrene in a man ninety-two years of age.

Daniel Donovan (*Dublin Medical Press*, September, 1855). Man, seventy-one years of age; amputation of the leg for senile gangrene.

The same (*Dublin Medical Press*, August 24, 1864). Amputation of the hand for cancer in a woman one hundred and one years of age; union by first intention nearly throughout.

Thomas Annandale (*loc. cit.*). Amputation through the condyles of the humerus for a cartilaginous tumor of the forearm in the case of a woman seventy-four years of age.

John A. Heatly (*New York Medical Journal*, June 28, 1890). A case of pyæmia in a man seventy-one years of age, requiring amputation of the forearm; healing by first intention.

John Ewens (*Lancet*, July 21, 1877). Amputation of the finger for cancer in a woman, a confirmed tippler, eighty-seven years of age; union by first intention.

Richard Jarrot (*Charleston Medical Journal and Review*, May, 1849). Amputation of the leg for gangrene in a man one hundred and two years of age.

George Owen Willis (*British Medical Journal*, November 27, 1886). Amputation of the forearm for epithelioma in a woman eighty-six years of age.

James Cantlie (*British Medical Journal*, October 30, 1886). Amputation of the leg for gangrene in a woman eighty-two years of age.

Harrison Cripps (*British Medical Journal*, May 9, 1885). Amputation of the leg for gangrene in a patient sixty-five years of age.

Dr. Atherton (*Canadian Practitioner*, September, 1887). Amputation through the junction of the middle and lower thirds of the thigh for gangrene in a man sixty-eight years of age.

F. Faulder White (*British Medical Journal*, February 8, 1890). Amputation of the arm for disease following injury to the elbow-joint in a woman eighty years of age.

Bone Operations.—Thomas Annandale (*loc. cit.*). Primary excision of the elbow-joint for compound comminuted fracture in a woman seventy-four years of age.

The same. Excision of the upper jaw for removal of a medullary tumor in a man seventy years of age.

The same. Excision of the lower jaw and of the submaxillary gland for cancer in a man seventy-four years of age.

V. Hutchinson (*Lancet*, August 4, 1877). Resection of the forearm for gangrene in a man nearly ninety years of age.

Dr. Eustache (*Journal des Sciences Médicales de Lille*, July 29, 1887). Excision of the lower jaw for sarcoma in a man seventy-five years of age.

Removal of Tumors from Soft Parts.—Henry A. Lediard (*Lancet*, November 23, 1889). Lympho-sarcoma in a man sixty-two years of age; recurrence in the cervical glands; excision, and finally complete recovery.

N. F. Graham (*loc. cit.*). Two cases of wedge-shaped excision of the lower lip for epithelioma, in men respectively seventy-four and eighty years of age; union by first intention.

John Evans (*Lancet*, August 1, 1868). Wedge-shaped excision of the lower lip for epithelioma in a man seventy-five years of age.

The same (*Lancet*, February 22, 1873). A similar operation in a man sixty-five years of age.

Thomas Annandale (*loc. cit.*). Excision of one-half of the tongue for epithelioma in a woman seventy-one years of age.

The same. Removal of a large portion of the cheek, lip, and nose for epithelial cancer in a patient seventy-two years of age.

The same. Removal of a large fatty tumor from the back of the neck in a man seventy-three years of age.

The same. Removal of a large fatty tumor from the inner aspect of the thigh in a woman seventy-one years of age.

John Ewens (*Lancet*, July 21, 1877). Removal of a cancer of the left cheek in a man seventy-eight years of age.

G. B. Ferguson (*Lancet*, March 11, 1876). Removal of a melanotic sarcoma originating in the sheath of the sartorius muscle in a man seventy-five years of age; after an attack of erysipelas, perfect recovery followed.

Ovariotomy.—Fancourt Barnes (*Provincial Medical Journal*, April 2, 1888). Three cases in women, aged respectively sixty-five, sixty-seven, and seventy years of age.

Thomas Legaré (*Journal of the American Medical Association*, August 31, 1889). A case with extensive adhesions in a woman eighty years of age.

John Homans (*Medical Record*, May 5, 1888). Case in a woman eighty-two years and four months of age.

Haywood Smith (*Lancet*, December 24, 1892). Case in a woman, seventy-eight years of age.

Joseph Tabor Johnson (*Virginia Medical Monthly*, December, 1888). Case in a woman sixty-four years of age.

The same (*Virginia Medical Monthly*, December, 1892). Three cases at sixty-seven, sixty-eight, and sixty-seven years respectively. In the same article the author gives a table of thirty-eight cases, collected from current literature, of ovariotomy in women between sixty-seven and eighty-two years of age, with but two deaths.

J. Rutherford Morrison (*Lancet*, January 21, 1893). Five cases of cœliotomy (four ovariotomy) in women, aged respectively seventy, seventy-four, seventy-two, seventy-seven, and seventy years; all recovered from the operation; one died nearly two months after the operation from the results of appendicitis; one had extensive malignant disease, but recovered from the exploratory incision, dying over two months later from the cancer; the three uncomplicated cases of ovariotomy recovered perfectly, returning to their homes within a fortnight.

Wounds and Fractures.—John A. Macdougall (*British Medical Journal*, October 11, 1884). Fracture of the left forearm, with an extensive bruise of the face, resulting from a fall, in a woman between seventy and eighty years of age.

T. Sydney Short (*British Medical Journal*, August 3, 1889). Fracture of the sternum, with double pleuropneumonia, in a man sixty-four years of age.

Hoadly Gabb (*British Medical Journal*). Fracture of the coracoid process in a man seventy-four years of age.

Thomas F. Raven (*Lancet*, August 6, 1887). Intracapsular fracture of the neck of the femur in a woman, sixty-nine years of age; osseous union.

N. Senn (*Journal of the American Medical Association*, August 3, 1889). Eight cases of intra-capsular fracture of the neck of the femur in persons from fifty to sixty-eight years of age; recovery of the use of the limb with, in some cases, hardly a limp.

A. M. Powell (*St. Louis Medical and Surgical Journal*, June, 1889). Fracture of the arch of the seventh cervical vertebra in a man sixty-eight years of age.

N. F. Graham (*loc. cit.*). Fracture of the forearm in a woman, ninety-one years of age; union complete in six weeks.

The same. Fracture of the neck of the femur in a woman, eighty-one years of age; recovery in ten weeks with a useful limb, and only one and one-half inch shortening.

The same. Fracture of the radius in a woman, seventy-six years of age; good union in six weeks.

The same. Axe-wound of the face, cutting through the bridge of the nose deep into the maxilla and opening into the mouth, in a man, eighty-seven years of age; much loss of blood; the detached portion of the nose and face was turned up and united by sutures; union was perfect, and the man was out of bed in four days.

J. Fayrer (*Medical Times and Gazette*, December 7, 1867). Fracture of the bones of the leg in a man ninety-six years of age; rapid union without any constitutional disturbance.

There are many other cases among my notes of removal of foreign bodies from the œsophagus and from the bladder, spontaneous amputation in senile gangrene, cure of popliteal aneurism, recovery from carbuncle and from the effects of serious injuries of the soft parts, etc., occurring in persons aged from sixty-five to ninety-five years. These all bear testimony to the remarkable tolerance to traumatism of the tissues of old people, and to the power of repair inherent in them; but it would be wearisome to record every instance of the sort, and those above given are sufficient to demonstrate that the aged possess a facility for repair much greater than we are accustomed to credit them with.

Various theories have been offered by the writers above mentioned in explanation of this recuperative power in the aged. Thus it has been attributed to the fact of a lessened nerve-susceptibility, or to a sort of disconnection between the different organs in consequence of which disease in one part affects more remote regions but little and causes therefore slight constitutional disturbance; this leaves the vis medicatrix free to exert all its reparative force on the affected organ or member. Graham says that the cellular elements, though diminished in size, still retain their physiological characteristics, and that they will return as certainly in the aged to the embryonic state, when a part is inflamed, as they will in the young or middle-aged; and it is in this fact of the retention by the cellular elements of their normal physiological condition that is to be found the explanation of the quick recovery of old people from serious injury or disease.

But after all, it ought not to be so surprising that aged people often recover from the effects of injury or disease. They must have been endowed at birth with considerable resisting power against the onslaughts of disease, otherwise they would have been cut off earlier. It is, as a rule, the fittest physically who survive, and it is therefore only reasonable to expect that this resisting power should continue to the end, until the long sleep comes naturally as the normal physiological termination to a well-lived life. *Thomas Lathrop Stedman.*

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OPHTHALMOMETER.*—An instrument for measuring the curvature of the refracting surfaces of the eye.

* The writer desires particularly to acknowledge his indebtedness to Dr. John Green, of St. Louis, for assistance most kindly rendered in revising articles "Ophthalmometer" and "Shadow-Test" for the press. In the course of this revision many infelicities of diction, due to the writer's brief acquaintance with the English language, have been eliminated, and some additions have been suggested and adopted with a view to a clearer and fuller presentation of the subject.—Carl Koller.

Thomas Young (1801)[1] was the first investigator to attempt accurate measurements of the curvature of the cornea in the living eye. By measuring the diameter and the prominence of the cornea, he found the chord and versed-sine of an arc of a corneal meridian; from these data he calculated the radius of curvature. Young's estimate of the curvature of the cornea agrees very closely with the results which have since been obtained by more refined methods.

Kohlrausch (1840)[2] measured the image of a distant object viewed by reflection at the anterior surface of the cornea, as in a convex mirror, and thus laid the foundation of ophthalmometry in the modern sense. The object used by Kohlrausch was a pair of candle flames placed behind small openings in an opaque screen. The images of the two bright points were viewed through a small astronomical telescope, constructed for observing at a distance of from two to three feet, and their positions marked by two adjustable spider-lines in the eye-piece. The length of the image (distance separating the images of the two points of light) was then read, through the telescope, on a finely divided scale placed as nearly as possible at the distance at which the image had been observed.

Now the object and the image lie at conjugate foci of the cornea, considered as a convex mirror, and the relations of the two focal distances is expressed by the equation

$$\frac{1}{f'} - \frac{1}{f} = \frac{2}{r};$$

or

$$r = 2f \cdot \frac{f'}{f - f'}; \qquad (1)$$

in which

r = the radius of curvature of the cornea.

f = the distance of the object from the surface of the cornea.

f' = the distance of the image from the surface of the cornea.

As the observing distance is taken at between two and three feet, and the object is stationed at as great or at a greater distance, f is quite large in comparison with f'; it is admissible, therefore, without sensibly affecting the accuracy of the equation, to disregard f' in the denominator of (1) and to write the equation in the simplified form

$$r = 2f \cdot \frac{f'}{f} = 2f'.* \qquad (2)$$

Again, the length of the object is to the length of the image in the ratio of their respective distances from the centre of curvature of the convex mirror (cornea).

Designating these distances by g and g' respectively, we have

$$\frac{g'}{g} = \frac{\text{length of image}}{\text{length of object}}.$$

But

$$g' = r - f$$

and

$$g = r + f$$

whence

$$\frac{r - f}{r + f} = \frac{\text{length of image}}{\text{length of object}};$$

or

$$r - f = (r + f) \cdot \frac{\text{length of image}}{\text{length of object}}. \qquad (3)$$

* To test the error involved in the use of this simplified equation, compare the values of r derived from (1) and (2) in a special case. For example:

Let $f = .8$ metre $= 800$ millimetres,
Let $f' = 4$ millimetres,

then by (1)

$$r = 1600 \cdot \frac{f'}{796} = 2.01f';$$

and by (2)

$$r = 1600 \cdot \frac{f'}{800} = 2.00f'.$$

The value of r by (2) is therefore too small by $0.01f' = 0.01 \times 4$ millimetres $= 0.04$ millimetre, which is within the limit of error in observation.

In the right hand member of (3) neglecting r, which is small compared with f, and in the left hand member of (3) substituting for f' its value $\frac{1}{2}r$ derived from (2) we have, as a sufficiently close approximation, the simplified equation

$$r = 2f \cdot \frac{\text{length of image}}{\text{length of object}}.* \qquad (4)$$

The results obtained by Kohlrausch, also by Senff (1846),[3] who carried the investigation somewhat farther, correspond very closely with measurements which are now generally accepted. The later development of ophthalmometry has been in the direction of perfecting the instrument for purposes of scientific investigation, and of adapting it to clinical use.

The ophthalmometer was perfected, as an instrument of scientific research, by Helmholtz (1854).[4] With the addition of a large graduated circle, arranged to carry lamps, it was employed by Donders and Middelburg to measure the curvature of the cornea in different meridians.

The ophthalmometer of Helmholtz is essentially an adaptation of the heliometer of Clausen (1841).[5] A divided plate of thick glass with parallel surfaces, is mounted in a cubical box fixed in front of the objective of a small astronomical telescope constructed for observing at a distance of from 0.5 metre to 1 meter, so that each half of the glass plate covers half of the objective. The two halves of the divided plate are arranged to turn in opposite directions on a common axis at right angles to the axis of the telescope, and the amount of rotation is read to tenths of a degree on a graduated disk fitted with a vernier. So long as the two halves of the glass plate are in the same plane, perpendicular to the axis of the instrument, an object seen through the telescope appears without displacement and single, but any rotation of either half of the plate gives rise to a displacement of the image formed by the corresponding half of the objective, and this displacement increases with the rotation. As the two halves of the plate are rotated simultaneously in opposite directions the displacement of the images is also in opposite directions, and the total displacement is double what it would be if either half of the plate were rotated separately through the same angle.

The object (three points of light disposed in a row) as seen by reflection at the surface of the cornea, is focussed by the telescope through the glass plates in the zero position—*i.e.*, with both plates set at right angles to the line of vision. The graduated disk is then turned until the two images are seen touching each other, but not overlapping, in which position of the plates the displacement of each image is exactly equal to half the length of the image. The amount of displacement (x) of either

* To test the error involved in the use of (4) compare the values of r derived from (3) and (4), in a special case. For example, as in the previous note:

Let $f = .8$ metre $= 800$ millimetres,
Let $f' = 4$ millimetres.

Then by (3) [using for r in the right hand member and for f' in the left hand member their values as given by (1),]

$$r - \frac{r}{2.01} = (800 + 8.04) \cdot \frac{\text{length of image}}{\text{length of object}} \text{ millimetres},$$

whence

$$r = 1608.08 \cdot \frac{\text{length of image}}{\text{length of object}} \text{ millimetres},$$

and by (4)

$$r = 1600 \cdot \frac{\text{length of image}}{\text{length of object}} \text{ millimetres}.$$

The value of r by (4), is therefore too small by

$$\frac{8.08}{1600} = 0.005 = \text{about } \tfrac{1}{2}\% \text{ per cent.}$$

It should be further remarked that the use of the equation,

$$\frac{1}{f'} - \frac{1}{f} = \frac{2}{r},$$

is permissible only on the assumption that the diameter of the convex surface at which rays are reflected to form the virtual image is small in comparison with the radius of the sphere. This implies that the image must be small in comparison with the radius of curvature of the cornea, or, what amounts to the same thing, that the object must be small in comparison with its distance from the observed eye.

image depends on the index of the refraction (n) of the glass of which the plate is made, the thickness (h) of the glass plate, and the angle (ϕ) through which the plate has been rotated as expressed in the equation

$$x = h \cdot \frac{\sin(\phi - \phi')}{\cos \phi'},$$

the value of ϕ' being dependent on that of ϕ, as expressed in the equation,

$$\sin \phi = n \cdot \sin \phi';$$

as the displacement of each image is equal to half the length of the image, we have

$$\text{length of image} = 2x = 2h \cdot \frac{\sin(\phi - \phi')}{\cos \phi'}. \qquad (5)$$

In practice all calculation is dispensed with by making use of a table of successive values of $2x$ corresponding to different readings of the ophthalmometer, as ascertained by experiment.

As the distance of the object is quite large in comparison with the radius of curvature of the cornea, it is admissible to calculate the latter by the use of the simplified equation

$$r = 2f \cdot \frac{\text{length of image}}{\text{length of object}}. \qquad (4)$$

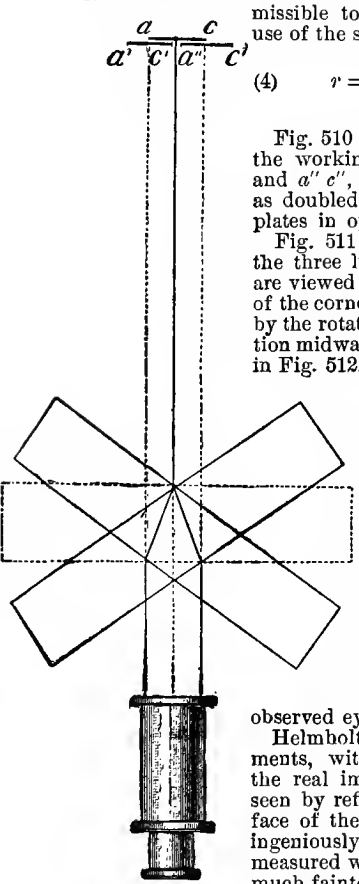

Fig. 510.

Fig. 510 shows the arrangement and the working of the glass plates, a' c' and a'' c'', representing the image a, c, as doubled by the rotation of the two plates in opposite directions.

Fig. 511 shows the arrangement of the three lights, whose double images are viewed by reflection at the surface of the cornea; the image of 1 is brought by the rotation of the plates into a position midway between 2 and 3, as shown in Fig. 512.

It will be seen from (5), also from inspection of Fig. 510, that the size of the image is determined by the amount of rotation of the plates as indicated by the reading of the graduated disk, and is independent of the observing distance; also that, from the principle of construction of the ophthalmometer, the measurements may be made with great accuracy and without being materially impeded by slight movements of the observed eye.

Helmholtz also made direct measurements, with his ophthalmometer, of the real image of a pair of lights as seen by reflection at the posterior surface of the crystalline lens, and by an ingeniously devised indirect method he measured with the same instrument the much fainter virtual image formed by reflection at the anterior surface of the lens. By repeated measurements made upon the same eye in a state of accommodative relaxation and in accommodation for the near, he obtained the necessary data for calculating the radii of curvature of both surfaces of the lens in each of these two conditions. The measurements of Helmholtz were repeated with some modifications of the technique by H. Knapp (1860).[6] Knapp also measured the curvature of the cornea, mostly in the horizontal and vertical meridians, in a series of cases of astigmatism (1862).[7]

To adapt the ophthalmometer to the measurement of the curvature of the cornea in any required meridian, Donders and Middelburg (1863)[8] added a graduated circle, bearing lamps (see Fig. 513). They measured the curvature of the cornea in a large number of eyes in twelve

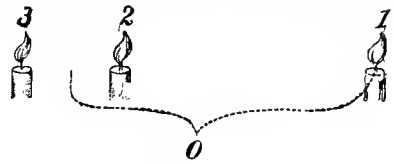

Fig. 511.

meridians, thereby adding greatly to what had been previously known regarding the different forms of astigmatism.

Coccius (1867)[9] substituted a fixed plate cut from a

Fig. 512.

doubly refracting crystal of Iceland spar for the movable glass plates used by Helmholtz. The amount of displacement of the image formed by the extraordinarily refracted rays is determined by the thickness of the

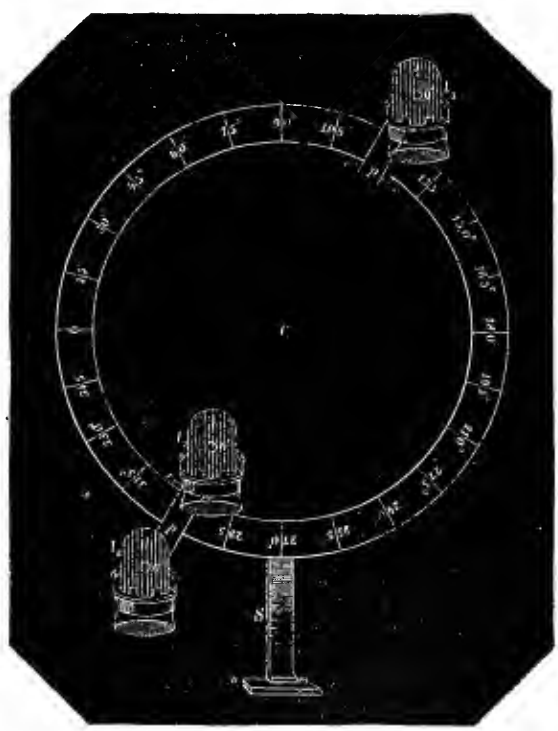
Fig. 513.

plate, and is constant; the size of the object (distance separating the lights) is therefore varied, until the two images are seen to touch each other without overlapping.

The radius of curvature of the cornea is found from the simplified equation.

$$(4) \qquad r = 2f.\ \frac{\text{length of image}}{\text{length of object}}$$

The ophthalmometer of Javal-Schiötz (1881)[10] is especially designed for the clinical investigation of the curva

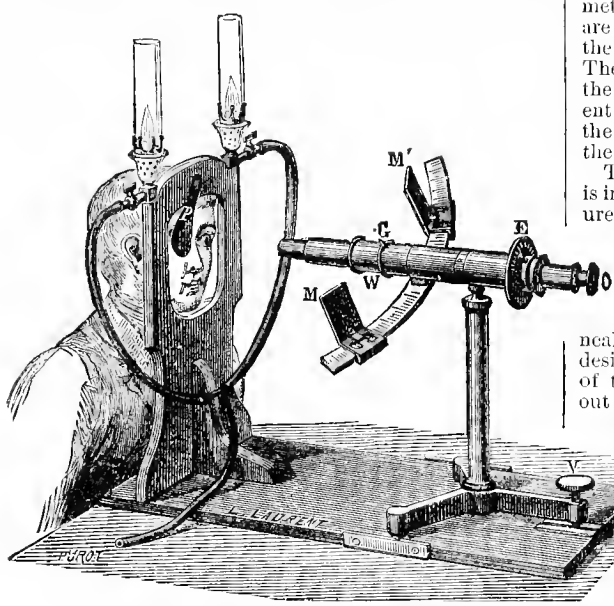

FIG. 514.—Ophthalmometer of Javal-Schiötz, Original Model.

ture of the cornea in all meridians, and is admirably adapted to its purpose. Two strongly illuminated targets (*mires*) of white enamel replace the lights, and the doubling of the image is effected by means of a doubly refracting prism of Iceland spar, which is achromatized, and at the same time a little more than neutralized for the ordinary rays by the addition of a prism of flint glass turned in the opposite direction. With this construction of the prism, the two images of the pair of targets, formed, the one by the ordinary and the other by the extraordinary rays, are displaced equally in opposite directions; the aggregate displacement of the images for the distance at which the eye is observed, is three millimetres. The two targets, MM', Fig. 514, are arranged to slide on a graduated arc of .35 metre radius, turning with the tube of the telescope. The head of the patient is supported by the head-rest, so that the centre of curvature of the cornea shall lie approximately at the centre of curvature of the arc. A more exact adjustment of the distance is then secured by moving the telescope, with its stand, until the doubled images of the two targets are seen sharply defined by reflection at the surface of the cornea; the telescope is constructed for distinct vision at the distance of the image, which is formed about four millimetres behind the centre of the cornea. The doubly refracting prism is in the part of the tube marked GW, and the meridian in which the arc and targets stand is read on the graduated disk at E. The eye under examination is directed upon the end of the telescope; the other eye is covered by the pivoted screen P.

As the effect of the doubly refracting prism (at the constant distance, $f = .35$ metre, of the targets from the eye) is to separate the two images exactly three millimetres, it is evident that when the length of the object (chord M M', separating the outer sides of the two targets) is so adjusted as to allow the two images to touch each other without overlapping, the length of the image must be just three millimetres. We have then, approximately,

$$(4) \quad r = 2f.\ \frac{\text{image}}{\text{object}} = 700.\ \frac{3}{\text{chord M M'}}\ \text{millimetres.} = \frac{2100}{\text{chord M M'}}\ \text{millimetres.}*$$

It will be observed that in this solution, $2f$ ($=2 \times .35$ metre $= 700$ millimetres) and *image* ($= 3$ millimetres) are constants, consequently r (the radius of curvature of the cornea) is an inverse function of the chord M M'. The length of this chord is read from the graduation on the arc. The radius of curvature of the cornea in different meridians may be calculated from measurements of the chord M M', made after turning the telescope, with the arc and targets, about its axis.

The great value of the Javal-Schiötz ophthalmometer is in its remarkable adaptation to the detection and measurement of corneal astigmatism, and for such examination it has won general recognition as indispensable to the ophthalmic practitioner. In astigmatism the essential thing to be considered is the difference in refraction in the two principal meridians, and it is for the measurement of such differences in the corneal curvature that the instrument has been especially designed. In the use of the ophthalmometer the length of the object (chord M M') remains unchanged throughout the observation of the eye in its two principal meridians, and it is only the difference in the length of the image when the arc is adjusted successively for the corneal meridians of greatest and least curvature, that is regarded. The observation consists in simply noting the amount of overlapping of the two images in the second position of the arc, after having first brought them into exact contact in the first position.

The device for reading the amount of overlapping of the images is shown in Fig. 515. The outer side of one of the rectangular targets is cut in the form of steps of such width that each step approximately represents a difference of corneal curvature corresponding to 1 D of ocular refraction.†

* It will be remarked that, by the construction of the Javal-Schiötz ophthalmometer, the distance of the targets from the observed eye is rather small, and the image is rather large in comparison with the radius of curvature of the cornea (see page 702, foot note). In the use of equation (4) there is, therefore, a considerable margin of error, though not enough to detract from the usefulness of the instrument in clinical work.

It will be remarked that r, by this solution, is the radius of a circular arc whose chord measures three millimetres, which arc is assumed to be of the same curvature as a section of the corneal surface by a plane passed through the visual axis and the axis of the telescope. But the configuration of the cornea is approximately that of a segment of a prolate ellipsoid, and supposing the axis of this ellipsoid to coincide with the axis of the telescope, r will be the radius of a circle whose curvature is equal to that of the elliptical section of the cornea at the two points in which the direction of the reflecting surface determines the length of the image, *i.e.*, at two opposite points on the ellipsoid each one and a half millimetres distant from its axis. Under these conditions it is evident that r will be greater than the radius of curvature of the cornea at its centre.

As a rule, the visual axis does not coincide with the axis of the corneal ellipsoid, but makes an angle with it (angle α), which angle is sometimes as great as 12°. The axis of curvature of the cornea is, therefore, not ordinarily in a line with the axis of the telescope, and the two points in which the direction of the corneal surface determines the length of the image are not symmetrically placed with reference to the axis of the ellipsoid. As the curvature of the ellipsoid at these two unsymmetrical points is unequal, it cannot be represented by a spherical surface. In any case, however, the value of r by equation (4) is greater than the radius of curvature of the cornea at its centre.

† Inasmuch as different eyes present considerable variation in corneal curvature, necessitating a corresponding variation in the separation of the targets in order to bring their images into exact contact, it is evident that a step on the target does not always represent the same fractional part of the chord M M'. In the case of a relatively flat cornea the targets must be set nearer together, and each step will then represent a larger fractional part of the chord M M'; conversely, when the cornea is of greater than average curvature the targets must be set wider apart, and each step will then represent a smaller fractional part of the same chord. It follows that in the former case each overlapping step in the image must represent somewhat more, and in the latter case somewhat less, than 1 D of corneal astigmatism. It is well, therefore, always to note the length of the chord M M', so that a correction can be made for it if deemed necessary.

The number of overlapping steps is taken as the number of dioptries of astigmatism attributable to inequality of curvature of the cornea in its two principal meridians.

Fig. 516 shows the doubled images of the targets in the position of contact; in Fig. 517 the same images are

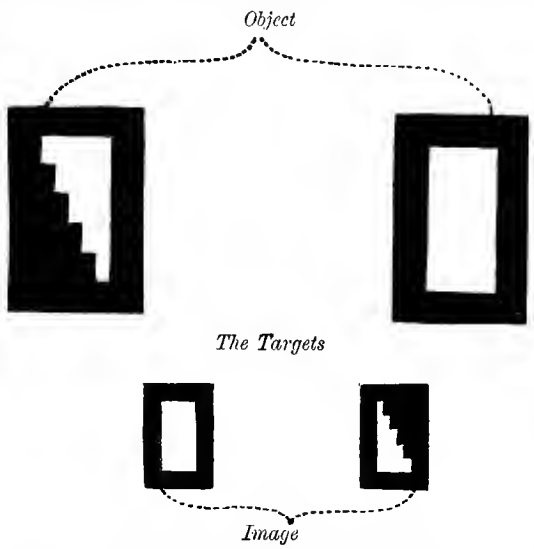

Fig. 515.—Corneal Image as seen Through the Telescope without Intervention of a Prism of Iceland Spar.

shown with two steps overlapping, indicating 2 D of corneal astigmatism. It will be observed that in both these positions the images are rectangular, also that they lie exactly in the same line.

This rectangular form and linear direction of the images of the four targets is seen whenever the curvature of

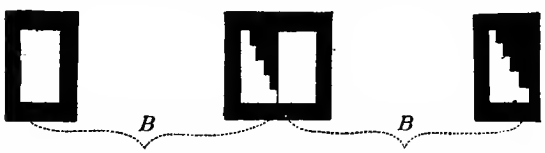

Fig. 516.—Corneal Image as Seen Through Telescope and Prism. Double images in touching position.

the cornea is symmetrical with reference to the plane of the arc. When the cornea is a surface of revolution, with its axis passing through the centre of the arc, this condition is fulfilled for all positions of the targets, but when the cornea is of a configuration approaching an ellipsoid of three unequal axes, the position of the arc

Fig. 517.—Overlapping of Double Images — As = 2 D.

must be such that its plane shall bisect the ellipsoid in one or the other of its two principal planes. In all other positions of the arc the images of the four targets appear more or less distorted, and the images of the two pairs of targets are not in the same line—see Fig. 518.*

This distortion and oblique displacement of the two images, in all but two positions of the arc, reveals at a glance the presence of corneal astigmatism. To find the meridian of greatest corneal curvature, the arc is turned until the images are seen in a line and most widely separated.* The two targets are then moved inward or outward on the arc, until the images are brought into the position of contact. Lastly, the arc is turned through an angle of 90°, or until the images are again seen in a line, and the number of overlapping steps, which represents the number of dioptries of corneal astigmatism, is

Fig. 518.—Double Images not on a Level.—Astigmatism Present.—Arc not in a Principal Meridian.

noted. The examination of the two eyes need not consume more than two or three minutes.

The measurements of corneal astigmatism as made with the ophthalmometer agree remarkably, in most cases, with the results obtained by the use of methods which show the total astigmatism of the eye. The agreement in the direction of the principal meridians is especially close, so that in by far the greater number of cases the direction of the axis of the correcting cylindrical glass may be taken directly from the reading of the instrument. In respect to the grade of astigmatism the agreement is less exact, for the reason that the observed corneal astigmatism is often modified by an astigmatism attributable to an oblique position of the crystalline lens. As a rule, the meridian of greatest corneal curvature is approximately vertical, and the meridian of greatest lenticular refraction is approximately horizontal; the total astigmatism is therefore generally somewhat less than the corneal astigmatism when the meridian of greatest corneal curvature is approximately vertical, and greater when, contrary to the rule, it is approximately horizontal.

In a comparatively small number of instances the total astigmatism is found to vary very widely from the cor-

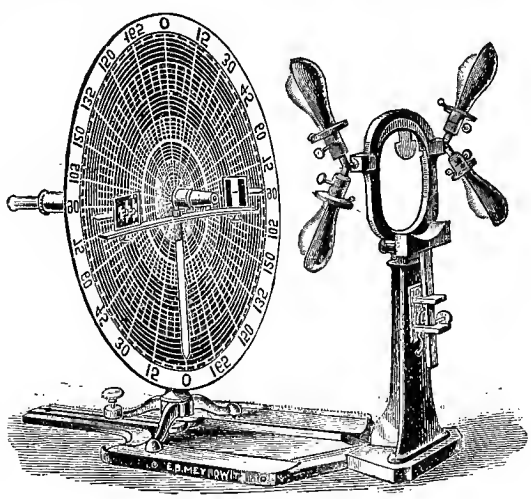

Fig. 519.

neal. For example, a relatively high grade of lenticular astigmatism may so far dominate a corneal astigmatism as largely to control both the direction of the principal meridians and the grade of the total astigmatism. Again,

* For an analysis of the phenomenon of distortion of the image formed by a mirror of asymmetrical curvature, also of the same phenomenon as it occurs in the case of a lens of asymmetrical refraction, see a paper by the writer: Ein Beitrag zur Theorie der Cylinderlinsen: Graefe's Archiv, 1887.

* By interchanging the targets the images may be brought into the position of contact when the arc is set in the meridian of least corneal curvature, and the overlapping steps counted in the second position of the arc; in practice this is found to be more convenient, for the reason that the meridian of least curvature is, as a rule, approximately horizontal, and it is easier to adjust the targets in the horizontal and to observe the overlapping of the images in the vertical meridian.

it is not uncommon to find a low grade of astigmatism, oftenest with the meridian of greatest refraction horizontal or nearly horizontal, in the absence of corneal asymmetry. Lastly, the ophthalmometer occasionally reveals an anomalous condition in which the corneal meridians of greatest and least curvatures are not at right angles to each other.

Not only has the Javal-Schiötz ophthalmometer greatly advanced our knowledge of astigmatism but it affords, also, most important special information in every case of investigation of the refraction of the eye.

The instrument-maker Kagenaar (Utrecht, 1887)[11] has somewhat cheapened the original Javal-Schiötz ophthalmometer by substituting a pair of weak glass prisms, turned in opposite directions, for the doubly refracting prism of Iceland spar. Leroy and Dubois (1888)[12] have also produced a low-priced ophthalmometer, in which the doubling of the image is effected by means of two plates of thick glass as used by Helmholtz. Javal has lately (1889)[13] brought out a new model—see Fig. 519—in which the shape of the targets has been somewhat altered; and the direction of the meridians of greatest and least corneal curvature is read on the reflected image of the large disk which now constitutes the most conspicuous feature of the instrument. *Carl Koller.*

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[13] Bulletin de l'Académie de Médecine de Paris, 27 Août, 1889.

OREXIN. (Phenyl-di-hydro-quinazoline hydrochloride). This name, derived from the Greek word signifying appetite, is applied to a derivative of quinoline, its chemical formula being C_6H_4 NCH CH_2N C_6H_5 HCl + $2H_2O$. It originally was produced in bright, colorless, lanceolate crystals, without odor, containing two molecules of water, which effloresce on exposure. More recently it has been supplied as a grayish powder. It has a bitter, pungent, and almost caustic taste, it irritates the mucous membrane of the nose, and at times causes a burning sensation in the throat and œsophagus. It is freely soluble in hot water.

Chloride of orexin was introduced by Professor Penzoldt, of Erlangen (*Therap. Monat.*, February, 1890), as a stomachic of decided value, as it was found to exert a tonic influence over the digestive organs, and a stimulant action on the appetite. It possesses neither antipyretic nor antiseptic properties. Penzoldt used it in a great number of cases in anorexia in healthy individuals, as well as in others suffering from various diseases accompanied by loss of appetite. Its use is contra-indicated when there is gastralgia, acute catarrh, ulcers, or any condition in which there is hyper-sensibility of the mucous lining of the stomach, on account of its local irritant action. It was found that the secretion of hydrochloric acid was increased, and that food was digested in from half to three-quarters of an hour sooner when orexin was given than under ordinary circumstances. The increase in the appetite occurred in some cases after the first few doses, in others the treatment had to be continued for several days before its effects began to show themselves. The class of cases in which it proved most serviceable were those in which the stomach was not diseased, but where the loss of appetite was due to some general condition, such as anæmia, phthisis, or debility. It was of special value in commencing pulmonary tuberculosis, its employment being followed by a considerable increase in body-weight. The dose is from three to seven grains, once or twice a day. It was at first used in the form of a pill, prepared as follows: hydrochloride of orexin, two grammes; extract of gentian, q. s.; powdered marshmallow, q. s.; to be made into twenty pills. From three to five to be taken daily. Subsequently it was found that the pills were not as effective as the powder given in wafers, on account of its insolubility, and when gelatine coating was added they were still more insoluble and inactive. Penzoldt now recommends that wafers are to be preferred. It is advised to give a cup of beef-tea, broth, or cocoa with each dose, on account of the pungent properties of the remedy.

Since its introduction many conflicting statements have been made, and there is a great deal of uncertainty regarding its action. The failures were undoubtedly in many instances due to an inferior quality of the drug, and in others to the mode of administration. Not a few practitioners have obtained the same satisfactory results as those indicated by Penzoldt, and the drug certainly appears to exert a favorable action in certain cases, but its employment is restricted to a limited class of cases, and is liable to cause great irritation where the local condition is such as to require sedative remedies, instead of stimulation.

According to Egasse, one-twelfth to one-third of a grain, given to frogs, paralyzes the motor nerves of peripheral origin. In rabbits, three-quarters of a grain for each two and a half pounds of body-weight, produces no toxic symptoms; in doses of four grains it causes toxic phenomena, trembling, spasms, enfeebling of the respiration and of the cardiac muscle. The blood becomes dark-colored, the blood corpuscles are diminished in size, and methæmoglobin is produced. *Beaumont Small.*

OREZZA. A spa in Corsica, the chalybeate waters of which are largely exported.

LOCATION.—Orezza is picturesquely situated in the interior of the beautiful island of Corsica. It is about two thousand feet above the level of the sea, and is, therefore, cool enough to merit its reputation as a summer resort. The climate is said to be equable and invigorating. The little village is not easy of access, and is, therefore, never crowded.

ANALYSIS. — The cold ferruginous waters of Orezza bubble up through several springs. One thousand grammes contain, according to Poggiale:

	Gramme.
Carbonate of lime	0.602
Carbonate of magnesia	0.074
Carbonate and oxide of iron	0.128
Sulphate of lime	0.021
Chloride of potassium / Chloride of sodium	0.014
Silicic acid	0.004
Alumina	0.006
Traces of carbonate of lithia, of oxide of manganese and cobalt, and of arsenic acid	0.849

The water is palatable, owing to its large proportion of free carbonic-acid gas.

INDICATIONS.—Although often employed as a mere table-water, the Orezza springs are useful in anæmia, chlorosis, atonic conditions of the organs of digestion, certain diseases of women, and in all morbid states where a mild iron tonic is indicated.

ACCOMMODATION.—Although there is a thermal establishment and so-called hotels, everything is on a primitive scale at Orezza. *Edmund C. Wendt.*

ORTHIN. Is one of the numerous compounds introduced for its antipyretic properties. It is a combination of hydrazin and para-oxybenzoic acid; the base is an unstable body, but the hydrochlorate is a stable preparation, and is the salt supplied under the name of orthin. It is very soluble in water. The solution should always be freshly prepared and preserved from the light. It is recommended as an antipyretic in typhoid fever, pneumonia, rheumatism, and all febrile disorders. Robert, who introduced it into therapeutics, claimed that it was non-toxic and free from all ill effects. Its use, however, has been accompanied by sweating, prostration, and

other symptoms of poisoning. In some cases small doses produced remarkable oscillations in the temperature. The dose advised by Robert is from five to eight grains. Very large quantities have been given to dogs without producing a fatal result, and thirty grains were given by mistake to two patients ; in both cases vomiting and other toxic symptoms occurred, but no bad results followed. On the other hand, one and a half grain has given rise to dizziness, cold sweating, and nausea.

Beaumont Small.

ORTHO-OXYETHYLANAMONO-ACETYL-AMIDO-QUINOLINE. This is the chemical name of Analgen, one of the most recent analgesics. It is reported that its synthetic composition was thought out before any actual formation of the compound was attempted, the aim being to produce a substance of high physiological power by combining with quinoline definite groups of molecules having a known acute pyretic action. Its mode of preparation has not been made public.

Analgen is a white crystalline powder, in the form of delicate needles. It is almost insoluble in water, but soluble in hot water, alcohol, and dilute acids. It is recommended for its valuable analgesic, antipyretic, and anti-rheumatic properties in doses of fifteen grains. It, however, must be administered with caution, as its therapeutic action is not, as yet, very thoroughly known.

Beaumont Small.

OSPEDALETTI. A new health-resort on the Riviera, midway between Bordighera and San Remo. Ospedaletti is a very small place, fronting the Mediterranean Sea. Great hopes were at one time entertained of its speedy transformation into a fashionable resort. But while nothing came of these expectations, Ospedaletti nevertheless has climatic advantages inferior to those of no place on the Riviera ; and the very fact of its extreme quietude will recommend it for a sojourn to some patients, to whom noise and crowds are intolerable. In the *Medical Record*, September 10, 1892, the writer mentions this little-known Riviera station about as follows :

Apart from the huge white Casino, the commodious new *Hotel de la Reine* (under Swiss management), a few minor pensions, several villas, and the rather dirty old village, constitute all there is to Ospedaletti. For undergoing a course of absolute quiet and repose in a sunny, well-protected situation, no more suitable place has yet come to my notice on the Riviera. American physicians could do worse than recommend it, where that line of treatment promises well for their patients.

Although most Riviera books only vaguely intimate it, there is no doubt that little Ospedaletti is more effectually protected from winds than almost any other resort on this coast. Moreover, it gets the sun early and keeps it late. There is also less blinding calcareous dust there than, for example, at Hyères, Cannes, or Nice.

Ospedaletti spreads out for something like a mile along the head of a small crescentic bay. The eastern headland of this bay is formed by Cape Nero, and the western extremity, much farther from the village than the former, by Cape Sant' Ampeglio. Thickly planted olive-hills surround the place, relieved in the plain by orange and lemon trees, and the usual array of graceful palms. Successive girdles of mountains protect it from the icy northern blasts, but less in a northeasterly than in a northwesterly direction. It is fully exposed only to the warm westerly marine breezes.

Immediately behind the village there rises a hill of gentle slope, and a number of mountain torrents of mild proportions trace their undulating course seaward. The place is so hedged in as to constitute a veritable sun-trap. There is little prospect of its ever being transformed into a town of any size. To some people this will seem an advantage rather than a drawback.

It is a pity that the railroad tracks are laid down close to the sea, as the beach is a sandy one, and a pleasant promenade along the shore has thus been practically ruined. As at Bordighera, the evening chill is less sudden and less intense than at resorts backed by bare rocks.

The drinking-water used at Ospedaletti is soft, sparkling, and pure. It is taken from the same mountain source as that which supplies San Remo, *i.e.*, Argallo. It could not be better, and is by long odds the best potable water to be found on the Riviera.

If the French speculators, instead of erecting a huge Casino, had utilized the hot sulphur springs found a few steps beyond the village, the permanent nucleus of an attractive sanitarium might easily have been established. As it is, this means of adding to the natural advantages of the place has been overlooked or neglected. Gouty and rheumatic elderly people should do particularly well at Ospedaletti, and a thermal establishment of modern type would soon be welcomed by discerning invalids belonging to that large class.

The fine natural situation of Ospedaletti, its pleasant surroundings, its proximity to the city of San Remo, its very solitude and smallness, in the opinion of the writer, entitle the place to a special and assured position among the health-resorts of the Riviera. *Edmund C. Wendt.*

OSTEND. One of the most fashionable and celebrated seaside-resorts in Europe. Ostend is situated in West Flanders, Belgium, about seventy miles from Brussels. It faces the North Sea. The season lasts from June to October, and the place is generally crowded by an international throng of visitors, who go there for noisy pleasure, or the vaunted benefits of surf-baths and bracing sea-air. The facilities for bathing are indeed excellent, and the beach is a remarkably fine sandy expanse. The place is expensive. It is doubtful if real invalids are much benefited there. But those needing "distraction" as a medicine, will not regret a season spent at Ostend, where every variety of seaside and other amusement is provided, and where the hotel accommodation is ample and of the best quality. During bathing hours the beach presents a scene of rare animation. The tide rises about fifteen feet in the harbor. There is a beautiful Kursaal, Casino, etc. Gambling is tolerated at most of the public and private establishments. There are a number of quiet seaside places near Ostend, such as Blankenbergh and Heyst. *Edmund C. Wendt.*

OUABAIN. A vegetable poisonous principle used by the natives of East Africa for the purpose of making their arrows dangerous and fatal. The exact source has not been determined, but it is obtained from the root of a shrub closely allied to *Carissa shimperi*, belonging to the order Apocynaceæ. Its action is very similar to that of Strophanthus, which is another member of the same order.

Ouabain is a glucoside, with the chemical formula $C_{30}H_{46}O_{12} + 7\ H_2O$, and appears to be a lower monologue of Strophanthin, the formula of which is $C_{31}H_{48}O_{12}$. It forms in rectangular crystals, which are white, transparent, colorless, and, to a very slight degree, bitter to the taste. It dissolves with difficulty in cold, but is very soluble in hot water. It is insoluble in chloroform, ether, and absolute alcohol. The best solvent is alcohol slightly concentrated. The part used by the Africans is the dried juice.

It is an extremely powerful poison, five to ten milligrammes producing death in animals in a very short time. It is estimated that one sixty-fifth of a grain introduced into the blood of man would prove fatal. It at first causes a severe cramp and convulsive movements. This is followed by prostration, great difficulty in breathing, retching, and vomiting, involuntary defecation and ultimately paralysis and death.

The local application of ouabain produces a condition of anæsthesia, and it has been found that a few drops of a 1 to 1,000 solution, instilled into the eye, causes an insensibility of the conjunctiva and cornea. This lasts for one or two hours, the pupil at the same time being powerfully contracted, and the tension of the eye increased. Some observers have failed to obtain this effect, and occasionally it has produced pain and irritation.

Therapeutically, ouabain has been employed as an antispasmodic in whooping-cough, by Dr. William Gem-

mell, of Glasgow (*British Medical Journal*, April 26, 1890). He reports the treatment of forty-nine cases, of which twenty-five had been dismissed cured, four had died, and the remainder were under treatment. The fatal terminations were due to diphtheria, meningitis, and progressive emaciation. From his observations, he arrives at the following general conclusions: 1. Ouabain is of marked benefit during all stages of whooping-cough, and if carefully used, produces gratifying results. In the first stage it cuts short the attack; in the second, it reduces the violence and frequency of the cough, and diminishes the number of whoops; and in the third, it hastens convalescence in a remarkable manner. 2. Ouabain is a drug which does not appear to be cumulative; its administration can be stopped suddenly without any ill effect beyond an exacerbation of the whooping-cough; it can be as suddenly resumed. 3. It should be given, at first, at any rate, in a dose of $\frac{1}{100}$ grain every three hours ($\frac{1}{125}$ grain daily). 4. For children under one year of age, the dose should not exceed $\frac{1}{200}$ grain every three hours. 5. In children of from six to twelve years of age, if the cough be very violent, and the whoops are numerous, $\frac{1}{50}$ grain may be given in each dose, but the action of the drug must be carefully watched. 6. Ouabain may be given alone, dissolved in water, or in combination with potassium bromide, or chloral hydrate. The simplest way is to dissolve one grain in distilled water, so that each minim of the solution shall be equal to $\frac{1}{100}$ grain ouabain, as: ℞. Sol. ouabain, ℥. 48; syr. aurantii, ʒ iv.; aq. ad., ℥ vi. M. Sig. A teaspoonful every three hours. 7. Under the administration of ouabain, it is found that the temperature, pulse, and respiration are, in uncomplicated cases, slightly below normal. When the drug is pushed, the respirations become very slow indeed; in one patient, aged four, they were often as low as sixteen per minute. It is from this that danger is to be expected. During the administration the action of the skin is promoted, the amount of urine is increased, and the movements of the bowels become more regular. Ouabain has also been used with equally satisfactory results by Dr. J. Lindsay Porteous, of Yonkers, N. Y. (*New York Medical Journal*, vol. liv., 345). He gave it in three cases, one adult and two children, and in all marked improvement was immediately noticed. To a child of fifteen months $\frac{1}{400}$ grain was given every three hours; to a child of four years, $\frac{1}{200}$ grain every four hours, and to the adult, $\frac{1}{50}$ grain every three hours. In all these cases the patient was entirely well at the end of a week.

The physiological action of this drug has been studied by Messrs. Gley and Rondeau, and by Dr. Joseph Sailer (*Therapeutic Gazette*, November, 1891). These observers differ in some points: the former considered that the drug acted on the central nervous system and produced a condition of asphyxia; the latter entertains a different view and considers that it acts on the peripheral nerves and produces death by paralysis of the heart.

The following are the conclusions of Dr. Sailer regarding its action on the nervous system and circulation: —1. It diminishes and finally abolishes reflex action by paralysis of the peripheral sensory nerves, and this paralysis then extends to the sensory nerve-trunks. 2. It paralyzes the striated muscles by direct action upon their tissue. 3. It paralyzes the motor nerves only when the action in the body is very prolonged, or when a strong solution is applied directly to the nerve. 4. There does not appear to be any action upon the central nervous system. Upon the circulation it produces, at first, a slowing of the pulse due to a stimulating action upon the cardio-inhibitory function, and perhaps partly to a direct action upon the heart-muscle. At the same time there is a primary vaso-motor spasm, due to an action, either upon the vaso-constrictor fibres or upon the muscular coats of the vessels. The slowing of the heart may be so marked as to overcome the vaso-motor spasm and cause a fall of pressure. Then there is a sudden and great increase in the pulse-rate, caused by depression and final paralysis of the vagi, and, at the same time, increase in pressure, due partly to increased heart action, and partly to continued stimulation of the vaso-motor system. At last the heart-muscle is paralyzed, and in a few seconds the pressure also falls to zero. *Beaumont Small.*

OXYGEN. Although oxygen is now being employed in the treatment of a great variety of diseases, it is only in conditions of asphyxia that it is used with any certainty of success. Where there is an excess of carbon dioxide in the blood, and a deficiency of oxygen, a few inhalations afford an almost instant relief, whether it is due to pneumonia, croup, diphtheria, phthisis, and many other diseases, or in poisoning by coal-gas, opium, diabetes, etc. Pneumonia is one of the most important diseases in which it can be utilized, and during the past few years in the great number of cases reported it has proved of very general benefit. It is not used as a remedy, but as a means of relief when the lungs are unable to carry on their function and the character of the blood is changed. Its use is indicated when there is shallow and labored breathing, commencing lividity of the ears, lips, and fingers, and other well-known signs of deficient aëration and commencing cyanosis, in which the vital powers are depressed and the system no longer responds to ordinary remedies. It is here that the inhalation of oxygen acts as no other medicine can; it renders the blood pure and arterial, and exerts a stimulating action on the heart and lungs, the expression becomes brighter, the skin changes to a more healthy hue, the cardiac force increases, and the dyspnœa is eased. Although all have not derived the same benefit, those who have been successful are loud in their praises of its usefulness, its ease of application, and its freedom from ill-effects. In many cases the condition of cyanosis returns when the inhalations are discontinued, and it becomes necessary to repeat the treatment at short intervals. At times life has been maintained for days until the morbid process ceased and the lungs regained their normal condition.

From one to two gallons of the gas is an ordinary dose, which may be administered once or twice a day, as occasion requires. In emergencies, when an immediate and effective action is required, there is no limit to the dose, and in some severe cases where a continuous action was required, enormous quantities have been used. In one case reported, nearly two hundred gallons were inhaled in the twenty-four hours. A moderate, and generally an efficient dosage, when its frequent use is required, is from half to one gallon every twenty minutes. The administration of the gas is usually managed with the aid of a tube and mask, which fits over the mouth and nostrils. The inhalation should be slow and as deep as the condition of the patient will allow. The rubber balloons afford an easy method of supplying the gas; it being heavier than air a very slight elevation will facilitate the flow, and this may be aided by gentle pressure. When the compressed gas is used it must be more cautiously managed, that the force be not too great nor conveyed too directly into the lungs. It may be found an advantage to fill the balloon with the quantity required for the dose, instead of using it directly from the reservoir. When an immediate action is not required it is recommended that the gas be conveyed by one nostril only, the other being free to inhale a supply of air to dilute the pure oxygen. In cases of insensibility, or when the respiration is feeble, it becomes necessary to assist by means of artificial respiration, and in some instances tracheotomy has been performed and the gas forcibly introduced into the lungs.

Formerly an obstacle to its employment was the difficulty with which it was obtained and the frequent contamination with irritating compounds of chlorine and nitrogen. This difficulty is now overcome, as it is plentifully supplied in all large centres, and its application is as simple as any form of inhalation. When the gas is not easily obtained, or when large quantities are required, its preparation must be considered. Oxygen is a gas that is readily obtained, and many methods of preparing a pure supply are devised. Some may be easily followed, but the others are complicated and dangerous, or expensive. The following has been suggested as a process that may be conducted by anyone, and one that produces a free supply of pure gas: A porcelain tube of

about twenty centimetres long and having an inside diameter of twenty millimetres, is filled with twenty or thirty grammes of baryta or barium monoxide in fragments of about the size of small nuts. This is gently warmed, and the air passing through the tube is deprived of its oxygen, and barium dioxide is formed. If one end of the tube is closed and the other carried to the mouth of a receiver, by way of a pneumatic trough, and heat applied to a low redness, pure oxygen is given off and easily collected. Barium dioxide yields about one-tenth of its weight of oxygen, and from ten grammes one gramme of oxygen is obtained, which measures about one litre.

Pure oxygen may also be readily and simply obtained by the decomposition of hydrogen peroxide (*q. v.*).

Other means of conveying the oxygen to the blood than through the lungs have been found efficacious. Dr. Francisco Valenzuela, physician to the Provincial Hospital, Madrid, administered it per rectum, in order to obtain a greater absorbing surface than might be possible in many cases of lung disease. He adopted this method in many cases and found the dyspnœa and other symptoms relieved in a remarkable manner. The gas was rapidly absorbed and carried by the portal vessels very directly to the lung tissue. It appeared to be as readily taken up as by the lungs, four injections of five litres each being absorbed in an hour. It has also been used by being introduced into the stomach, partly for its action on the system, as well as for its local effect on the walls of the organ. It is preceded by *lavage*, and the gas is then conveyed by means of an œsophageal tube. The patient is made to eructate the gas, and the process repeated two or three times.

The use of oxygen has been extended to numerous other diseases in which there is no interference with respiration, but only a depraved condition of the system in which the vital processes are carried on in a slow and feeble manner, as in anæmia, chlorosis, etc. It is a question, however, how far the inhalation of oxygen will benefit such affections. It is evident that the amount that can be absorbed is only such as the hæmoglobin present in the blood is capable of receiving. Physiology also teaches us that only a very small proportion of the oxygen in the air inspired is absorbed, so there cannot be any great deficiency in the supply. It must not be forgotten, however, that the presence of an increased supply of oxygen stimulates the reflex mechanism of the heart and lungs, and this may account for the beneficial effects that are often found to follow its use in such cases.

In gastric disorders, accompanied by a catarrhal condition of the mucous membrane, with anorexia and vomiting, it may be introduced directly into the stomach, or compressed in water and administered as oxygenated water. Its action in such conditions is said to give relief, but its use is not very general. In lithiasis it has been used as an enema, with the idea of aiding the conversion of uric acid into urea. It is found to produce a beneficial action very rapidly by lessening the uncomfortable symptoms and improving the general condition of the patient. In all cases in which it is desired to favor metabolism this mode of administering may be adopted.

The use of oxygen is usually quite harmless in acute pulmonary diseases, but in chronic phthisis, accompanied by hæmoptysis and destruction of tissue, it must be used with caution. It is dangerous in advanced heart disease in which there is degeneration of the muscular tissue and dilatation, particularly if the heart is engorged with blood. It must also be given slowly and with caution when there is atheromatous disease or aneurism of the aorta. *Beaumont Small.*

OXYQUINASEPTOL (Diaphtherin). This is one of the latest antiseptics introduced, and its authors claim that it is the most powerful compound that has yet been prepared. It was reported upon by Professor R. Emmerich, of Munich, at the Eleventh Congress for Internal Medicine, held at Leipsic in 1892. Its mode of preparation has not been made known, but its composition consists of two molecules of oxyquinolin and one of aseptol. It is a definite chemical compound with the formula of $C_6H_4(HOC_9H_6NHO)_2SO_2$.

It forms in amber-yellow transparent hexagonal crystals, which, when powdered, are soluble in one part of water, also soluble in dilute alcohol, very sparingly soluble in absolute alcohol. It melts at 185° F. without decomposition, but is not altered chemically at 212° F. Bacteriological experiments show that it is much superior to carbolic acid, the preparations of cresol and other ordinary antiseptics. It is stated that a three-tenths per cent. solution will kill the staphylococcus pyogenes aureus in a quarter of an hour, while a one-half per cent. solution of other antiseptics had no effect whatever. A one-tenth per cent. solution was found sufficiently strong to kill Koch's cholera bacillus in ten minutes, and the bacillus of diphtheria and other pathogenic bacteria were destroyed by a one-fifth per cent. solution in the same space of time.

It is recommmended as an antiseptic dressing in surgical practice, and for the treatment of ulcers, wounds, etc. A solution of one-half to one per cent. is said to be sufficiently strong for a lotion or to saturate dressings. It is deprived of all irritating properties, and not only disinfects the part and maintains it in an aseptic condition, but also exerts a very decided curative action on the wound. Its toxic action is very mild. Professor Emmerich injected eight minims into hedgehogs without any noticeable disturbance manifesting itself. Locally, he used solutions as strong as fifty per cent. without any injurious effect.

The sole drawbacks are said to be a tendency to act on instruments, causing a black deposit, and a tendency to discolor the skin and clothing. *Beaumont Small.*

PAMBOTANO. A Mexican plant, *Calliandra Houstoni*, Benth., which has a local reputation as a remedy for malarial fevers, and has been suggested as a substitute for quinine. The members of the calliandra group form an order of leguminous plants which are found as far north as California and extend southward to Buenos Ayres. The leaves are all bi-pinnate, but vary much in size and number. The flowers are very bright and showy, the corollas are small and hidden by the very numerous large stamens, which are usually of a bright crimson color.

The root is the part employed. It has not been analyzed properly, but is known to contain a large percentage of tannin, and a glucoside has been separated by Bocquillon. The active principles are soluble in water and alcohol. In Mexico it has undoubtedly proved of much service in the treatment of intermittent fevers, and recently it has been used in France in malarial, typhoid, and other fevers as an antiperiodic and antipyretic with decided benefit. The decoction is the usual mode of preparing the remedy, the dose of which is from one to two and a half ounces. *Beaumont Small.*

PANARITIUM ANALGICUM. This rare affection of the nervous system is commonly called "Morvan's disease," from the name of the physician of Lannelis, in Brittany, who first described it in 1883. It is regarded by many observers as merely a special clinical type of syringo-myelia, to which it may be closely related in its pathology, and which it certainly resembles in many of its symptoms. Its most characteristic clinical feature, which gives it the name by which, in the present uncertainty as to its pathology, the disease should be called, is the occurrence of a succession of usually painless whitlows, commonly followed by more or less complete destruction of the terminal phalanges of the fingers (analgic panaritium.)

Symptoms.—The patient may first seek advice for the relief of neuralgic pains in one hand and forearm, less frequently in both, or in the upper and lower limb of the same side. At this time a correct diagnosis can hardly be expected, as there is nothing characteristic about the neuralgia. In some cases the initial pains are slight, or entirely absent. The case, then, first presents itself as one of whitlow, which is always severe and deep-seated. The first whitlow may be painful, but the later ones,

which appear at intervals, perhaps of weeks, and often of years, are entirely painless. It is this peculiarity which is most striking, and which first attracted Morvan's attention.

A further examination shows that whitlows are only the most noticeable of a series of trophic disturbances in the affected limb. The hand and forearm are atrophied, often to a marked degree. Deep-seated ulceration has been found in the hand, and abscess in the forearm, without any known injury, and presumably of trophic origin. The skin of the hands and the nails are cracked and fissured.

The changes in sensibility are, next to the whitlows, the most striking phenomenon, and are of especial interest in connection with the differentiation of the disease from syringo-myelia. In fully developed cases all forms of sensation have disappeared—contact, pressure, heat, cold, and pain, are all unfelt. The loss of sensation extends often beyond the apparent atrophy. It may include the whole arm, and at times the adjacent parts of trunk and neck, and even the face.

There is marked weakness of the affected limbs. The electrical reactions gradually disappear as the disease advances. The reflexes remain unchanged, or, as has been observed in the lower extremities, are somewhat increased. Vaso-motor disturbances are usually marked, the hand and forearm being livid or pale, and feeling cold to the touch.

The joints are not affected as a rule, though lesions of the wrist and shoulder, resembling those of tabes dorsalis, or dry arthritis, have been observed. Scoliosis occurs in a considerable number of cases, constituting another point of resemblance to syringo-myelia.

As the disease progresses the lesser peculiarities develop, such as the cracks in the skin and nails. The whitlows recur, and being always deep seated, result usually in complete destruction of the phalanges on which they are situated, so that in the course of time several fingers of each hand are shortened to one or two phalanges. The fingers become distorted by a contraction of the interossei muscles, so that they are fixed in an attitude of partial flexion. The longer the disease has lasted, the more likely are the lower extremities to be attacked by symptoms similar to those of the upper extremities, though less severe.

The great variety observed among the small number of cases yet reported makes precise and unqualified assertions as to symptoms impossible, especially in regard to the points of resemblance to syringo-myelia. The gradation of symptoms affords an unbroken series of clinical types, connecting the two diseases.

Pathology.—The disease has only been known for ten years; it is very rare, very slow in its progress, and involves little danger to life. Hence it is not surprising that our knowledge of its pathology is extremely limited. To consider first the undisputed points, the most obvious lesion is whitlows.

The term whitlow, or felon, is an unfortunately vague one, as generally used, but in this disease it is precise enough. The lesion is always a periostitis, followed by the necrosis of the affected phalanx and its ultimate exfoliation. The pathological changes in the skin appear to be nothing but the effects of impaired nutrition and have no especial character.

The peripheral nervous system is profoundly affected in the diseased limbs. The amputations which the progressive ulcerations and periostitis have in some cases required, have materially increased our opportunities for studying the pathology of the peripheral nerves; and these amputations, with what autopsies have been obtained, have established one pathological fact, which, it seems to the writer, may be regarded as the key to the nature of the disease. There is in all cases a marked degree of neuritis, great increase in the connective tissue, with degeneration or complete disappearance of the nerve-fibres themselves. These lesions are most intense at the peripheral ends of the nerves, and gradually diminish toward the nervous centres in a manner characteristic of an ascending neuritis.

Our knowledge of the changes in the cord is more limited, and affords much more conflicting evidence. The cord has been found, in at least one case, much less affected than the peripheral nerves. The posterior horns and posterior columns were the seat of a mild degree of diffuse sclerosis in the cervical region. The sclerosis included the vessels of the affected parts, and had resulted in more or less complete occlusion. There were no cavities in the cord. In other cases cavities have been found, as in syringo-myelia. In one the cavity extended about the whole length of the cervical and dorsal regions. The sclerosis of the posterior horns and posterior columns harmonizes with the disturbances of sensations observed in life.

This is really all that we certainly know of the pathology of panaritium analgicum. Yet it is enough to afford strong arguments to those who advocate the identity of the disease with syringo-myelia. However, the constant occurrence of peripheral neuritis, as the most severe lesion found, and the preponderance throughout the symptoms of the phenomena of trophic disturbances are facts of fundamental importance which cannot well be reconciled with the identity of the two diseases.

Differential Diagnosis.—A well-marked case of analgic panaritium can hardly be overlooked by any one who has the disease in mind while examining the patient. But it has already been remarked that there may be a great deviation from the characteristic type. The diseases to be considered are syringo-myelia, anæsthetic leprosy, two forms of scleroderma, symmetrical gangrene and tabes dorsalis.

In syringo-myelia the trophic changes are absent, except the atrophy of the muscles. The characteristic forms of sensation by which the sense of contact is preserved, while the senses of pain and temperature are lost, is one of the marked symptoms of syringo-myelia. It may exist in analgic panaritium, as the equal loss of all forms at the same period does not by any means always occur. But the separation of the different forms of sensibility, if marked and continued under prolonged observation, would be strongly against the diagnosis of Morvan's disease.

Anæsthetic leprosy is distinguished by the history of infection and the presence of characteristic lesions in other parts of the body. Moreover, the loss of digits is due to a true ulceration extending inward from the surface, and not to a periostitis. Such ulcerations can usually be traced to some slight abrasion of the skin or other injury.

Scleroderma, in the form known as sclerodactyla, leads to marked changes in the fingers, but the fingers are flexed in a characteristic manner, that is, only at the metacarpo-phalangeal joint, the other joints remaining nearly straight. The skin of the hands is glossy and adherent to the bone, and the same peculiarity occurs in the skin of the face, presenting the peculiar mask-like appearance characteristic of sclerodactyla.

Ainhum is so rare that it need be mentioned only for the sake of completeness. It is confined to tropical regions. It rarely attacks persons of European race, and the loss of the digits, more often of the toes than of the fingers, takes place by a process of constriction somewhat resembling the growth of a band of connective tissue and consequent gangrene.

Symmetrical gangrene, or Reynaud's disease, lacks the peculiar disturbance of sensation. The vaso-motor changes are much more profound, and are a source of much more discomfort to the patient. The ultimate gangrene, which results from the vaso-motor changes, does not really offer many points of resemblance to the periostitis of analgic panaritium. True deep-seated whitlows are at least very rare in symmetrical gangrene, and it may be doubted if they occur.

Tabes dorsalis is too well marked to need discussion, except to point out that the perforating ulcers which occur in it have little resemblance to whitlows, and that the Romberg symptom, the Argyle-Robertson pupil, the loss of knee-jerk, etc., are all lacking in Morvan's disease.

Etiology.—By far the greater number of cases have

been observed in Brittany; but reports of single observations come from other districts of France, and the disease has been seen in other countries of Europe and America. The locality of most of the cases in a fishing community, and the occupation of a large number of the patients necessitating the handling of fish, has led to a suggestion that the disease is a neuritis of infectious origin; which seems the most probable hypothesis in the present condition of our knowledge. The lesions in the cord, which are constant, are simply sclerotic, and these may be conceived as secondary to an ascending neuritis. In rare cases injuries have been reported as causes, but there are no cases in which any close connection has been made out between trauma and the occurrence of the disease. If the disease is really a form of syringo-myelia, or primarily a disease of the cord, congenital malformation might be considered as a probable explanation; but we must confess that our knowledge is too limited to afford any definite conclusion as to the origin of the disease. The disease occurs at all periods of life, from twelve years to old age, and is more common in men than in women. Unlike most nervous diseases, it is, as is obvious from what has been said, less common in great cities than in, at least, one country district.

PROGNOSIS.—The prognosis is at present necessarily unfavorable as to recovery, though there are few cases in which the patient has died from the disease. There are a sufficient number of characteristic cases which have very much improved, almost recovered, to afford a reasonable hope in any case where the ulceration or formation of whitlows is not so malignantly active as to compel repeated amputations. If the hypothesis of an infectious ascending neuritis, as the primary lesion, is correct, great hopes may be entertained of recovery, if the patient can be removed from exposure to the source of infection.

TREATMENT.—Little can be accomplished in the treatment of this disease. The hackneyed recommendation about general care of the health, tonics, and liberal nourishment may be repeated. The local treatment of the whitlows is of great importance, and early and free incision should, of course, be made, and the wound should be treated with every antiseptic precaution. Where there is any reason to suspect that we have under observation an early stage of this disease, the sources of infection to the hands should be closely inquired into, and thorough antiseptic washing of the parts, great care of all cracks and abrasions in the skin, should be advised. There is some reason to believe, from past experience, that cases in the early stage may be cured, at least for a time, by these measures. *Frederic Coggeshall.*

PANCREATIN. This is a mixture of various organic substances extracted from the fresh pancreas of some animal, usually the hog. It contains, with other things, four organic ferments or enzymes, and to these it owes its value. One of these has the power of converting albuminous substances into peptone, the second converts starch into sugar by hydrolysis, the third emulsifies fats, and the fourth, like rennet, curdles milk. The proteolytic or peptone-forming body bears the name of trypsin, the amylolytic, or sugar-producing one amylopsin, while the fat-emulsifier is called steapsin by some authors, and pialyn by others. The rennet-like body has not been named.

Trypsin digestion, while resembling that of pepsin in some particulars, is quite unlike it in others. The most marked difference is found in the fact that, whereas pepsin digestion can only be conducted in an acid medium, that of trypsin finds its most favorable condition in an alkaline one. In neutral, and even very feeble, acid solutions traces of its activity are revealed. This increases in degree with every increase of the quantity of sodium bicarbonate added until 1.2 per cent. has been reached, after which it again declines. At this point its maximum power is reached. Hydrochloric acid solutions as weak as 0.2 per cent. quickly destroy it. Therefore, to give pancreatin combined with pepsin and hope to get good results from each is a delusion. As soon as pepsin is fairly at work the trypsin is destroyed. Trypsin further differs from pepsin in that it digests more rapidly, causes no swelling up or transparency of fibrine, but eats away its surface slowly by a sort of corrosive action, produces as a first product alkali albumin, instead of syntonin, has greater power over elastin and some other difficultly digestible substances, and instead of stopping at the production of peptone, continues its activity until this substance is broken up into simpler bodies like tyrosine, leucine, asparaginic acid, etc.

Amylopsin is the diastatic body of pancreatin. It hydrolyzes starch, converting it into sugar. In this it distinctly resembles ptyalin from saliva, and the sugar-forming enzyme common to almost every tissue of the human body. It acts with much greater promptness than ptyalin or the other kindred ferments, and while they all produce malt sugar, it alone can, in the brief time allotted to digestion, change this into dextrose. The dextrin produced by both ptyalin and amylopsin differs from the dextrin of diastase in not reacting with iodine. Wet pancreatin is easily destroyed by heat, but if perfectly dry it can be raised to a temperature of 162° C. (323.6° F.) without seriously injuring the amylopsin. Above 100° C. (212° F.) its power is slightly impaired.

Steapsin, the fat-emulsifying and fat-splitting enzyme, has never been isolated in anything like a pure state. Its existence is therefore only inferred from the nature of its work. It is very sensitive to alcohol and all acids not of the fatty series. Small quantities of these quickly render it inert, hence the great difficulty of securing a first-class article. It is soluble in water, and in the absence of acids not fatty it can be taken up with glycerine. Dilute alkaline solutions of sodium carbonate with sodium bicarbonate form the best medium for its extraction yet devised. It readily decomposes any fat, releasing the glycerine and its acid.

Less is known of the rennet-like ferment than of any of the other three. It has never been isolated even imperfectly, and is only known by the power it possesses of coagulating casein.

The study of pancreatin, as found in the pancreas, was first earnestly begun by Valentin, in 1844, when he showed its diastatic action. Eleven years later, Bernard published the fact that he had succeeded in digesting egg albumin therewith. Near this time Kroger reported the isolation of the amylolytic ferment. In 1862 Danilewsky first isolated trypsin, and about ten years later Kühne purified it sufficiently to believe that he could, by ultimate analysis, determine its exact composition. His percentage results are as follows:

Carbon	47.22 to 48.09
Hydrogen	7.15 to 7.44
Nitrogen	12.59 to 13.41
Sulphur	1.73 to 1.86

The pancreatin of commerce is usually of doubtful quality. Many samples are innocent of all power as ferments, others, while fairly good as samples of one enzyme, are deplorably deficient in one or more of the others. This renders the analysis of them somewhat tedious. Each enzyme requires a separate test. The National Formulary has supplied a standard for the trypsin value of pancreatin by the amount of casein it can peptonize. The following is its method;

"If there be added to 4 fluidounces of tepid water, contained in a suitable flask or bottle, first, 5 grains of pancreatin and 20 grains of bicarbonate of sodium, and afterward one pint of fresh cow's milk previously heated to 38° C. (100.4° F.), and if this mixture be maintained at the same temperature for thirty minutes, the milk should be so completely peptonized that, on adding to a small portion of it, transferred to a test-tube, a slight excess of nitric acid, coagulation should not occur" (278).

In saying that coagulation should not occur, it slightly overstates the fact. However perfect the digestion may be, a slight coagulation can be observed, but it is not sufficient to hide the completion of the reaction or to render it doubtful. In peptonizing milk for the sick, pancreatin is almost exclusively used, hence the importance of the

National Formulary test and of the instructions given by that volume regarding the character of the product. It says: "Peptonized milk as prepared by the above process, or when the process is allowed to go on to the development of a very distinct bitter flavor, should not have an odor at all suggestive of rancidity. Milk has simply a marked bitter taste when thoroughly peptonized." When it is known that the bacteria of putrefaction are likely to exist in solutions of pancreatin that have been imperfectly prepared, or in the dried extract that happens to be hygroscopic in character, or made from a stale pancreas, the advantage of this warning is apparent. The process for making the standard pancreatin of the National Formulary is the following:

"Pancreas of the hog, fresh,
Water,
Alcohol.....each, a sufficient quantity.

"Reduce the fresh pancreas of the hog, freed as much as possible from fat and membranes, to a fine paste by means of a suitable chopping machine. Mix it with half its weight of cold water, and knead it thoroughly and frequently during one hour; then transfer the mass to a strainer, express it forcibly, filter the liquid as quickly as possible through flannel, and add to the filtrate an equal volume of alcohol. Collect the precipitate, drain it, and free it by pressure from as much of the adherent liquid as possible. Then spread it on shallow trays, dry it by exposure to warm air, at a temperature not exceeding 40° C. (104° F.), reduce it to powder, and keep it in well-stoppered bottles" (Formula 278). In working up large amounts of pancreas, especially during warm weather, septic changes are likely to occur before the task is completed, unless some means are taken to prevent the same. In such cases chloroform or thymol is usually added as a preservative agent, since they are found to possess but little inhibitory power on the action of the ferments.

The value of the amylopsin present in any given specimen of pancreatin is determined by ascertaining how much starch it can convert into sugar in five minutes at a temperature of 40° C (104° F.). One gramme of the pancreatin is digested for four or five hours in 100 c.c. of distilled water. Of a one per cent. solution of starch 10 c.c. are diluted to 100 c.c., and 1 c.c. of the pancreatin solution added. If in five minutes this is found free from starch by its failing to give a blue color to a very dilute solution of iodine, then a larger quantity of the starch solution is tried with the same amount of pancreatin. By continuing the increase the point can be found where the color first appears, and the amount of starch changed easily calculated. If the blue color is present on the first trial, then instead of taking 10 c.c. of the starch solution, 9, 8, 7, or some lower number of cubic centimetres can be tried, until the point is discovered where the blue color fails to appear.

"Pulvus Pancreaticus Compositus," the peptonizing powder of the National Formulary, is composed of five grains of pancreatin of standard strength triturated with 20 grains of bicarbonate of sodium. One such powder is to be added to 4 fluidounces of tepid water in a suitable flask. To this is next added one pint of fresh milk that has been warmed to 38° C. (104° F.). After standing at this temperature for half an hour the flask is removed to a cool place. It must not be used if kept over twenty-four hours, or if it has developed a distinctly unpleasant, bitter taste. *Robert G. Eccles.*

PAPAIN, PAPOID, PAPAYOTIN. These names are indiscriminately given to the active principle of the juice of *Carica papaya* Linn., the papaw tree of southern tropical countries. An attempt has been made to apply the term papain to the juice itself, and papayotin to the active principle obtained from the juice, the latter being four or five times stronger in its action. Originally these terms were used with a different meaning; papayotin was the name given by Peckolt, of Rio Janeiro, to the deposit that results from fermentation of the juice, and papain was given by Wurtz and Bouchet, who made known the peculiar properties of the plant in 1889, to the product that is precipitated from the juice by the addition of alcohol.

The trunk, the leaves, and the fruit of the tree contain an abundance of the milky juice, which is used by the natives to soften and make tender their meat-food. This effect is obtained by simply wrapping the meat in the larger leaves of the tree, or by rubbing the juice of the fruit or leaves over the surface.

Papain is a powerful vegetable ferment which possesses digestive properties resembling those of pepsine. It acts upon albuminoids, hydrating them and converting them ultimately into peptones. It also converts starch into maltose, and emulsifies fats. It is antiseptic in its action and prevents abnormal fermentation in the stomach and intestines. Its action is not checked by antiseptics, and papain may be administered with salol, carbolic acid, and even corrosive sublimate without its action being interfered with. It acts at all temperatures, but is most effectual when the temperature is slightly elevated. Some difference of opinion has arisen as to the effect of acids and alkalies on the ferment. It is generally stated that it acts equally well in alkaline, acid, and neutral solutions, but recent experiments indicate that its greatest activity is attained in the alkaline media. If the acidity is not marked and the quantity of ferment very great, the digestive process is continued, but in the normal degree of acidity of the stomach its action is at once checked. The ferment is not destroyed by the acid, as it continues to act if the acid is neutralized and the media rendered neutral or alkaline. Papain has no action whatever on living tissues, and may be given freely without producing any ill effect. It is frequently spoken of as a substitute for pepsine, but its chemical properties indicate that it is a very different substance, and could not be made to replace it under normal conditions. Experiments that have been made to determine the relative digestive powers of the two ferments are misleading, as papain is most active in alkaline solutions, while in acid solutions pepsine exerts a more powerful action.

Therapeutically, papain serves to replace pepsine in the conditions of the stomach in which pepsine is unable to act. When the secretions are normal and acid, the use of papain is of no service unless it be to continue, in the alkaline secretions of the intestines, the digestion of such albuminoids as have passed from the stomach unchanged. It is especially useful where there is indigestion due to deficient secretion of gastric juice, or an absence of hydrochloric acid. In such case the use of an alkaline solution of papain favors digestion both directly and indirectly; first, by disintegrating and digesting the food, and second, by its property of stimulating the secretion of the peptic glands, while the alkaline solution induces the secretion of a more acid gastric juice. It also acts beneficially by checking putrefactive changes. Under these circumstances a combination of papain, bicarbonate of soda, and nux vomica has proved most serviceable. Papain also exerts a beneficial action by dissolving and removing the accumulations of mucus that collect in the stomach, and this action is favored by following it with copious draughts of water. It is also said to exert a sedative action in persistent vomiting and in all conditions of irritability of the stomach. The following table of conditions in which this vegetable ferment is indicated is given by Dr. Frank Woodbury:

1. In actual or relative deficiency of the gastric juice, or its constituents.
   - (*a*) Diminished secretion of gastric juice as a whole.
     Apepsia.
     Anæmia and deficient blood-supply.
     Wasting diseases.
   - (*b*) Diminished proportion of pepsin.
     Atonic dyspepsia.
     Atrophy of gastric tubules.
   - (*c*) Diminution of hydrochloric acid.
     Achlorhydria.
     Carcinoma.

(*d*) Relative deficiency of gastric juice.
Over-feeding.

2. In gastric catarrh.
(*a*) Where there is tenacious mucus to be removed, thus enabling the food to come in contact with the mucous membrane.
(*b*) Where there is impaired digestion.

3. In excessive secretion of acid.
To prevent duodenal dyspepsia.

4. In gastralgia, irritable stomach, nausea, or vomiting.

5. In intestinal disorders.
(*a*) In constipation due to indigestion.
(*b*) In diarrhœa, as a sedative.
(*c*) In intestinal worms. This claim the writer has not personally verified, but as the intestinal mucus which shields the worms is removed by papoid, it is easily understood that their removal would naturally result after its administration).

6. In infectious disorders of the intestinal tract.
(*a*) Where there is abnormal fermentation; by its antiseptic action, which may be heightened by combination.
(*b*) Where there are foreign substances present its detergent effect may be utilized in cleaning out the *débris* from the intestinal contents by digestion.

7. In infantile indigestion; here papoid not only readily peptonizes cow's milk, but the resulting curds are also soft and floeculent, resembling those of breast milk.

The dose is one or two grains, but much larger amounts may be given without any injurious effects. It may be given in pill form, in solution, or in powder, but in the latter form it should always be enclosed in waxed paper, as it readily absorbs moisture and undergoes changes. In whatever manner it is prescribed, the preparation should always be freshly made, and the drug itself should not have been exposed to the air, or carelessly preserved. Bicarbonate of soda is generally added, either to the powder or the solution, and vegetable bitters, ipecacuanha, rhubarb, etc., may be also combined at the discretion of the prescriber.

It is also said to possess an anthelmintic action, but this property has not received much attention. In the West Indies the unripe fruit and the seeds are used for this purpose.

As a local application, its solvent properties are taken advantage of to remove the false membrane in diphtheria and croup. A five per cent. solution in water or glycerine, applied freely, every hour if the symptoms require urgency, or less often if the condition of the patient will permit, will rapidly clear the throat by removing the membrane and mucus. Its use should be preceded by a cleansing gargle, that the solution may come directly in contact with the membrane. The conditions that are present are those that are favorable for the action of the ferment. The media are neutral, the temperature suitable for its most energetic action, and no further dilution of the solution takes place. In addition to the benefit that follows the removal of the impediment to free respiration, the application also exerts a disinfectant action, removing all fetor and preventing the absorption of the products of the specific poison, or of suppuration. In urgent cases, when the applieation is made every hour, the membrane is generally removed within three or four hours, in other cases, when it is applied every three or four hours, the membrane is not destroyed for two or three days, but it is under control from the first application, and after three or four paintings its character is changed and it becomes thin and glairy. In some instances the powder itself has been applied, and in laryngeal or post-nasal diphtheria the powder may be blown through a glass tube, or a spray of the solution employed.

It has also been used locally for the removal of warts, corns, condylomata, and other blemishes from the skin. The following solution is recommended for this purpose: papain, twelve grains; borax, 1 drachm; water, two drachms. *Beaumont Small.*

PARIS, PARISETTE. An herbaceous perennial plant, *Paris quadrifolia* Linn., belonging to the order *Liliaceæ*. It is a native of Europe, and is closely allied to the *Trillium*, which is so common as an American wild flower. It sends up a single stem, bearing near its summit four whorled large, ovate, acute leaves, and a single terminal large green flower. The flower is distinguished by having six to ten spreading or reflexed sepals, anthers, with their cells fixed one on each side of an awl-shaped filament, and a three- to five-celled berry. Chemical analysis of the plant has obtained a glucoside *Paridin*, which is decomposed into paridol and glucose.

The study of this plant, as well as the allied trilliums, has recently been undertaken by Dr. F. Heim. He has obtained from the plant one or more alkaloids which are as yet undetermined. These may be obtained by exhausting the dried plant with boiling alcohol, to which a little oxalic acid has been added. The alcoholic extract is filtered and distilled, and the residue treated with warm water. After precipitating by neutral acetate of lead and filtering, there is obtained a liquid which contains the alkaloids, and a precipitate which contains the glucoside.

Dr. Heim experimented with an extract made from the leaves, rhizome, and fruit. It acts on the sensibility, the mobility, the respiration, and the heart, by its influence upon the medullary centres. The primary action is the production of a short period of excitation, which is followed by a diminution of sensibility and reflex action, and a slowing and weakening of the respiration and heart-beats. The final action is a depression of the excito-motor force and failure of vital power.

A further study of this plant and the trilliums is recommended on account of the resemblance of its action to that of aconite. The indications are that in our common flora there is to be found a succedaneum for aconitum napellus. *Beaumont Small.*

PATELLA, FRACTURE OF THE. INDICATIONS AND CONTRA INDICATIONS FOR OPERATIVE INTERFERENCE. A review of some reported cases of fracture of the patella, treated by immediate suturing of the fragments, in which extensive suppuration followed the operation, suggests certain pertinent inquiries. These relate, first, to the persistency with which quite a number of cases so operated upon developed infectious inflammatory complications; second, to the fact that in the majority of cases the primary points of infection took place in the intermuscular planes in the thigh, and not in the knee-joint itself, although the latter became involved secondarily; third, to the immunity of the thigh structures from infection when these were uninjured, even in cases in which direct infection of the joint itself occurred and suppuration of the latter followed; fourth, to the fact that when excessive traumatism and infection were both absent, remarkably rapid healing took place; fifth, to the perfectly undisturbed course which cases pursued when the operation of wiring the fragments was performed as a secondary procedure, as compared with the primary operation.

In addition, attention has been called to the fact that in cases in which very slight or no distention whatever has occurred following the injury, as well as in those in which, effusion having taken place, the application of a firm bandage resulted in its prompt disappearance, the primary operation was followed by rapid and decided infection with resulting abscess of the thigh. On the other hand, the immunity from septic complications is to be noted in those cases in which no amount of bandaging that could be borne by the patient sufficed to prevent the occurrence of effusion within the joint cavity, or led to its removal or diminution if applied after it had taken place.

An interpretation of these facts, based upon the anatomical peculiarities of the knee-joint, as well as the observations of Riedel, of Jena, have led to some modification of the views of those who have heretofore advocated immediate arthrotomy and suture of the fragments. It cannot be doubted that very positive contra-indications may exist to the operation as a primary procedure, and

that these are found to relate principally to the occurrence of a rupture of the joint capsule, especially at the upper limit or that portion which lies beneath the vastus medius or rectus femoris muscle.

A glance at the anatomy of the knee-joint will readily suggest the case with which the first mentioned of these may enter as a most important factor in any given case. In the cavity of the knee-joint is found the largest synovial sac in the body. It follows the capsular investment of the joint, which is formed anteriorly by the quadriceps extensor tendon, the ligamentum patellæ, and the patella itself. For some distance above the articular line of the expanded condyles of the femur it forms a cul-de-sac, which passes upward beneath the quadriceps extensor tendon in front of the femur. In some instances a bursa communicating with the synovial sac prolongs the latter for some distance farther. This bursa is interposed between the tendon and the bone and communicates directly with the cavity of the joint.

The vastus internus and crureus, constituting as they do practically but one muscle, make up the lesser portion of the great quadriceps extensor. It arises from nearly the entire length of the internal, anterior, and external surfaces of the shaft of the femur; its attachment above is limited by its aponeurotic connection with the lower portion of the line which extends from the inner side of the neck of the femur to the linea aspera. It is also attached to the entire length of the latter at its inner side. A transverse partition is formed by this muscular plane between the anterior and posterior structures of the thigh for at least three-fourths of that portion of the femur which lies below the level of the hip-joint. The lower fourth of the anterior surface of the femur is separated from the crureus portion of the vastus internus by the intervention of the synovial membrane of the knee-joint. Thus it will be seen that the cavity of the knee-joint extends in an upward direction upon the anterior surface of the femur for at least one-fourth of the entire length of the latter, there terminating upon the plane of the attachment of the vastus internus. In case, therefore, of a rupture of this upper recess of the cavity of the knee-joint there would necessarily occur the passage of serum and blood from the latter. This would pour out upon the muscular plane above referred to, passing thence upward, and if sufficient in quantity, or forced out from the cavity of the knee-joint by the application of a bandage, it would find its way along this muscular partition until arrested by the aponeurotic attachment at its upper limit.

The occurrence of the unfortunate results of opening the knee-joint immediately following a fracture of the patella finds a reasonable explanation in cases in which every provision against septic infection had been taken and yet extensive suppuration, commencing in the structures in the thigh, took place, when it is borne in mind that the same force which produces the injury to the bone, *i.e.*, the sudden and violent contraction of the powerful extensor muscle, may, and in all probability does, inflict the further injury of tearing the reflection of the synovial sac lying between the muscle and the bone. After the patella gives way, the continuance of the same force as that which fractured it will, if continued, tear the joint capsule, and in a certain proportion of cases the latter will give way beneath the muscle itself, rather than upon the sides of the patella, where it is reinforced by the aponeurotic fibres from the lateral portions of the muscle.

It is not difficult to understand, in the light of these facts, that, in spite of every precaution, the opening of the knee-joint in these cases will render the patient liable to septic complications of a serious nature. It becomes almost impossible to accomplish disinfection along the route taken by the effused fluids that have escaped from the joint cavity. On the other hand, infection will occur with the greatest facility and will reach portions of the thigh practically inaccessible to the operator from the cavity of the knee-joint. The route of infection, in these cases, extends along the plane of the vastus externus muscle, between the latter and the anterior surface of the femur. The application of dressings and the bandaging will only tend, after the operation, to further the extension of the infection by forcing the effused fluids from the joint cavity through the rent in the upper recess.

The researches of Riedel * are very interesting in this connection. This observer, in a series of experiments, endeavored to demonstrate the resistance which the capsule of the knee-joint would bear to hydrostatic pressure. With the limb in the extended position, in the cadavera of strong males, 200 c.c. of fluid under a pressure of 3.5 to 4 metres produced rupture of the upper recess of the joint capsule. In this connection it may be said, however, that much less pressure may be sufficient to produce this effect in the living individual. It is a well-known fact that when rigor mortis is well marked an additional support is furnished to this portion of the knee-joint by the rigid muscular structures. It is more than likely, however, that the rupture takes place by direct tearing force rather than by increased pressure within the joint cavity.

Two cases are reported by Riedel in which opportunity was given for demonstrating the existence of rupture of the upper recess of the cavity of the knee-joint. One was a case of fracture of the patella, the patient dying upon the table during an attempt at immediate suturing of the fragments. An examination revealed the existence of rupture of the upper recess of the joint. In a second case, that of injury to the knee from direct violence, the effused fluid, mainly blood, found its way from the seat of the original injury and infiltrated itself along the muscular plane above described.

A larger amount of extravasation and consequent swelling need not necessarily occur in these cases of rupture of the upper recess. In fact, the surgeon's attention would scarcely be attracted by any change in the thigh itself. A condition, however, which should never fail to attract attention and arouse suspicion is the occurrence of but slight swelling and distention of the joint capsule, or, this having taken place, the fact that it has rapidly disappeared. On the other hand, increase of pain and tension produced by the application of a bandage would indicate that the joint cavity is still intact.

The extravasated fluids may find their way into the popliteal space in exceptional instances. From the fact, however, that the vasti have their origin high up, and that more space is present here for the extravasated fluid to find its way into than in the compact structures below and posteriorly, the former will find its way in an upward and anterior direction by preference. Discoloration of the skin, due to the hemorrhage and extravasation, will first make its appearance upon the inner aspect of the thigh, later on appearing at the outer side: in the course of time the infective process may find its way down into the leg.

A convincing proof of the occurence of rupture of the upper recess of the synovial cavity, in connection with severe injuries to the knee-joint and the readiness with which the effused fluid may find its way beyond the limits of the knee-joint capsule and become extravasated along the muscular plane above alluded to, is furnished by that class of cases in which the single application of a rubber bandage has resulted, in a few hours, in the complete disappearance of the effusion in the joint which has followed a severe injury to the knee-joint. The fluid has been heretofore claimed to have been reabsorbed, under these circumstances, in an incredibly short space of time, the joint resuming its normal appearance. In reality these are cases of rupture of the joint capsule occurring either from the injury itself directly or as a result of rapid effusion and hydrostatic pressure. This view is supported by the fact that this result cannot be produced in any other joint, nor yet in the knee-joint in cases in which the effusion is due to causes other than traumatism. There is no reason for believing, therefore, that, in this joint, pressure would hasten the resorption in this extraordinary manner, under conditions involving traumatic influences, and yet the same result not be at-

* Centralblatt f. Chirurgie, 1890, No. xii.

tainable in other joints or in this joint in effusions of a simple inflammatory character. The truth of the matter is that resorption does not occur at all; what really happens is that the fluid is forced through a rent at the point indicated and into the neighboring inter-muscular spaces. It may happen, however, that a distention of the upper recess may occur when a bandage is applied, no rupture having taken place, and while the pressure is kept up, the normal appearance of the joint is restored. It is not to be denied, likewise, that the application of an elastic or other bandage may be instrumental in producing reabsorption of the fluids both in the joint and along the plane of the vasti muscles; that it occurs, however, other than by the usual and slow process is open to doubt.

In addition to the occurrence of this accident there is another condition which furnishes a positive contra-indication to suturing the fragments, as an immediate operation in fracture of the patella. Allusion is here made to the occurrence of extensive and severe contusions in the neighborhood of the knee-joint itself. The lessened vitality of a part diminishes its resistance to infection even though the involved structures be highly organized. The occurrence of extensive contusions undoubtedly operates to lower the vitality of the tissues and hence invites the occurrence of septic infection. It is an open question whether such a thing as rigid and absolute asepsis in an open wound is ever obtained. It is more than probable that a typically aseptic wound is of rare occurrence. The question is simply one of dosage, as far as the entrance of infectious agents is concerned, and the conditions present in the tissues themselves and their power of resistance will decide the question for or against the patient, rather than the aseptic or antiseptic precautions taken or the activity of the germs which have run the gauntlet of the dressings applied. In spite of every effort an infinitesimal portion of the noxious agent may find its way into structures but little calculated, because of their damaged condition, to resist the inroads of infection. In addition to this the presence of a greater amount of fluid in the connective-tissue spaces, the opening up of these to a greater or less extent, and the increase of local heat undoubtedly favor not only the primary occurrence of infection, but the rapid spread thereof. In each individual case, therefore, it becomes a question of serious import, both to the surgeon and to the patient, whether or not a period of time should be chosen for the performance of the operation when the tissues have had opportunity to return, through the reabsorption of infiltrated materials, to their normal condition.

It certainly will not be claimed that the operation of suturing the patella is imperatively demanded in the very beginning of the treatment. Save in those rare cases in which the occurrence of a hæmarthrosis complicates the patellar injury, an immediate arthrotomy can but rarely be called for. Both the possibility of the occurrence of rupture of the joint capsule in the situation here described, indicating delay until this has been closed by nature's efforts, and the condition of the tissues in the neighborhood of the joint itself, should be taken into account in deciding the question of time of operating. If but slight contusion or other disturbance of the parts involved in the intended incision is present, the surgeon, before proceeding to operate, should turn his attention to the probable integrity of the joint capsule. The test of this is the behavior of the joint under a Martin's elastic bandage. If apparent rapid disappearance of the effusion follows the application of the bandage, this should be interpreted to mean that the joint capsule is ruptured beneath the muscular structures and that the effusion has been forced into the inter-muscular spaces. Under these circumstances, in the light of recent experience, the surgeon is not justified in proceeding with the proposed operation. In other words, the presence of devitalized tissues, or rupture of Riedel's space, or both, are positive indications for the postponement of the operation and the substitution thereof of ordinary routine measures of treatment for from ten to fourteen days. At the end of this time a secondary operation may be performed. *George Ryerson Fowler.*

PEDALIUM MUREX, L. ("Gokhru"). A shrub of the order Pedaliaceæ, indigenous to India and Ceylon. It is a tall, succulent annual, very common near the sea-coasts. The plant has long, stalked, opposite, ovate, toothed leaves and rather showy yellow flowers, produced singly in the axils of the leaves upon short stalks which are furnished with glands near the base. They have a small five-parted calyx with the upper lobe shorter than the others; a tubular corolla small at the bottom and wide at the mouth, expanding into five round lobes, the lowest of which is the largest; four stamens in pairs of different length, with the anthers forming a cross, and a thread-like style bearing a bifid stigma. Its fruits, which do not open when ripe, are four-sided and somewhat conical in shape, with four sharp prickles upon the corners near the base: they are divided into three cells, one of which is empty, while each of the others contains two seeds. All parts of the plant give off a musky odor when rubbed, and the plant when fresh contains an abundance of mucilaginous substance, upon which its medicinal properties depend. Simply drawing the branches through water is said to render it thick and mucilaginous. The seeds are used for making poultices. This plant has been proposed as a remedy well worthy of attention, as in the East it is highly prized. The infusion is employed extensively as a drink for the relief of dysuria, incontinence of urine, nocturnal emissions, and all painful and inflammatory affections of the urinary organs. The fruit or capsule is the part preferred. An infusion is made by adding one ounce of the bruised fruit to one pint of boiling water, allowing it to macerate for two hours, and then filtering. This quantity is sufficient for twenty-four hours, to be given in doses of two ounces. The infusion is to be freshly prepared each day. *Beaumont Small.*

PEGLI. This little place is a suburb of Genoa and is usually described as a Riviera resort. It is undeniably a more sheltered and equable place of residence than the windy city of Genoa. But it hardly belongs to the more typical Riviera resorts. For one thing, it is not yet the winter home of a large international colony of health-seekers, nor can it lay claim to being adequately supplied with all those comforts now demanded by exacting invalids. Nevertheless, the climate of Pegli has its advantages, and the luxuriant vegetation of the place clearly shows that it is much warmer than Genoa. It is also less dusty than some of the better known Mediterranean health-resorts, and the atmosphere holds more moisture.

It is claimed that sufferers from asthma do specially well at Pegli. Recurrent winter colds, neurasthenia, anæmia, and even phthisis are some of the principal diseases for which Pegli is said to offer favorable climatic conditions.

The Italians frequent Pegli in the summer on account of its fine sandy beach. An interesting feature of the place is found in the presence of many beautiful gardens belonging to wealthy Italians. The famous Villa Pallavicini has one of the most magnificent horticultural collections known. Dr. Sparks surmises that the asthmatics who do well at Pegli are sufferers from emphysema and bronchitis, but a number of other observers maintain that the purely spasmodic type is more apt to find relief there. The writer spent too little time at this resort to permit a personal judgment, but he believes that Pegli is a good enough intermediate station for travellers to or from the Riviera proper. It is not to be forgotten that Pegli is directly on the sea and that some invalids are unable to sleep on account of the noise made by the waves. The hotels are not of the best, but fairly satisfactory accommodations are provided. Prices are lower than on the French Riviera. *Edmund C. Wendt.*

PENTAL. This is the name applied to *Trimethylæthylen*, a product of amylenhydrate heated with acids. It (C_5H_{10}) occurs as a colorless liquid, of low specific

gravity ; its boiling point is 38° C. ; it burns with an illuminating flame and is readily inhaled without affecting the membranes of throat or passages. It is insoluble in water, but miscible in all proportions with alcohol, chloroform, or ether, and being inflammable like the latter, must be protected from possible ignition. It is exceedingly volatile, but does not decompose on exposure to air or light.

PEPSIN. The quality of this substance has improved more during the past few years than that of any other article of the Materia Medica. At the present date the tests and descriptions of existing pharmacopœias and dispensatories are wholly antiquated and inadequate. The United States Pharmacopœia of 1880 described as the best article at the date of its issue one that could only digest fifty parts of egg albumin in six hours. The new revision of 1890, when published, is expected to describe one capable of digesting three thousand parts in the same time, and another diluted one of three hundred times. There are pepsins upon the market that are fully equal to the task of digesting six thousand parts in six hours. The writer has tested a specially prepared sample that succeeded in converting twenty-five thousand times its own weight of albumin into peptone in standard time. The production of so high a grade as the last mentioned is at present too costly to enable any manufacturer to put it upon the market at a reasonable price. It shows, however, how far we yet are from an absolute pepsin.

Notwithstanding the very great proteolytic power of such an article, there are reasons for believing that it is still one-half foreign admixture. What, then, must have been the quantity of impurity present in the supplies of a decade ago which had only one five-hundredth part of this strength ? Until a perfectly pure article has been isolated nothing can be done toward determining the chemical composition of this ferment.

It has recently been ascertained that pepsin, like albumin, is coagulated by heat. Slightly acid solutions of it containing a small amount throw down a light, flocculent precipitate on boiling, if mucus, sugar, or other substance capable of holding it in suspension are absent. Where these are present the solution merely acquires a milky appearance as a result of the application of heat. Using this as a test the eye can readily learn how to distinguish the relative proteolytic value of most brands, and the time consumed, instead of extending into hours, need occupy but a few minutes. The old plan of ascertaining the value of a pepsin by giving it an excess of albumin to act upon and then drying and weighing the residue so as to find how much was converted into peptone during six hours is now abandoned. The results were always untrustworthy. Now, after several trials with varying proportions, the exact amount capable of completing digestion within the time named is what is sought for.

Since the best pepsins of a decade ago now rank as very inferior, the description of a good article now must differ from that given then. A first-class article to-day should be totally free from any offensive odor ; easily soluble in one hundred parts or less of water acidulated with 0.2 per cent. of hydrochloric acid ; should not become wet or sticky in damp weather, and should have a mildly acid, agreeable taste, usually followed by slight bitterness. If in scales they should be nearly or quite transparent and of a pale, straw color. If in powder it should be fine and white. The reaction should never be alkaline, but always slightly acid or rarely neutral. When a small amount is burnt on platinum foil, only a trace of residue should be left. Any pepsin that fails to answer to these requirements cannot be expected to give the best results. Offensive smelling, insoluble, and easily putrescent pepsins may be positively injurious instead of beneficial to patients. Highly hygroscopic ones contain an excess of peptone and give unsatisfactory results unless very large amounts are used.

Pepsin is incompatible in some degree with nearly every remedy. Some substances completely destroy it. Such alkaline remedies as bicarbonate of soda, carbonate and bicarbonate of potash, solution of potash, Fowler's solution, carbonate of ammonia, aromatic spirits of ammonia, lime water, and chalk mixture should never, on any consideration, be prescribed with it. The slightest alkalinity renders a pepsin solution totally inert. An actual examination of the prescription files of several pharmacies shows that to a large proportion of reputable physicians this fact is not known. Bicarbonate of soda and pepsin constitute a favorite combination of theirs. Probably the excess of soda benefits the patient, and they give the credit to the combination. Iron reduced by hydrogen and all substances that combine directly with acids check the action of pepsin by rendering the solutions neutral. They do not, like alkalis, destroy the ferment. The following inorganic substances in a solution of pepsin and albumin inhibited digestion the number of minutes given when only fifteen centigrammes were added to fifty grammes. When no drug was present the digestion was complete in two hours. When the drug named was present digestion was delayed beyond the two hours the number of minutes given :

	Minutes.		Minutes.
1. Chloride of ammonium	320	26. Benzoate of potassium	110
2. Chloride of calcium	250	27. Sulphide of potassium	650
3. Chloride of sodium	200	28. Sulphate of ammon. and alumin	750
4. Chloride of antimony	160	29. Sulphate of copper	720
5. Chloride of potassium	90	30. Sulphate of magnesium	690
6. Chloride of lithium	60	31. Hypophosphite of manganese	80
7. Bromide of iron	360	32. Hypophosphite of sodium.	60
8. Bromide of ammonium	200	33. Hypophosphite of potassium	40
9. Bromide of lithium	120	34. Chlorate of sodium	280
10. Bromide of sodium	100	35. Chlorate of potassium	200
11. Bromide of cerium	90	36. Acetate of sodium	30
12. Bromide of potassium	60	37. Acetate of ammonium	30
13. Iodide of potassium	200	38. Sulphocarbolate of zinc	140
14. Iodide of arsenic	190	39. Sulphocarbolate of sodium.	80
15. Iodide of sodium	180	40. Phosphate of iron	60
16. Iodide of ammonium	170	41. Phosphate of sodium	30
17. Iodide of lead	60	42. Salicylate of sodium	690
18. Iodide of calcium	5	43. Salicylate of potassium	560
19. Nitrate of sodium	450	44. Valerianate of ammonium.	60
20. Nitrate of potassium	390	45. Valerianate of zinc	30
21. Nitrate of strontium	380	46. Ammon. citr. of iron	410
22. Nitrate of uranium	310	47. Ammon. citr. of bismuth	90
23. Benzoate of sodium	160		
24. Benzoate of ammonium	160		
25. Benzoate of lithium	140		

Tinctures and fluid extracts have a decided retarding effect beyond that of their contained alcohol. Essential oils from the same botanic orders retard in very nearly the same degree, while those from unlike orders are broadly contrasted. It is evident from this that pepsin is best administered alone.

The habit of giving pepsin in every form of deranged digestion merits only condemnation. Its long-continued use in chronic cases is also generally reprehensible. When more proteids have been swallowed than the stomach can unaided dispose of, then it is beneficial, but the dose must be commensurate with the work required of it. A few grains of weak, saccharated pepsin are useless. As it is in no sense poisonous, there is no danger of an overdose. All the danger lies the other way. Give plenty in a single dose after the meal and then stop. As a means of dissolving diphtheritic membranes and allowing thereby antiseptic sprays or gargles to reach the imbedded germs, it has been highly lauded. For this purpose the most powerful brands should be used, so as to gain prompt results. In surgical practice it has proven an efficient agent in removing gangrenous tissues. The various elixirs and wines of pepsin are of questionable value in any case unless the alcohol itself is reckoned upon for its utility. The quantity in any of these is too small to give calculable results. The average saccharated pepsins, containing, as many of them do, scarcely enough of the ferment to digest little more than an equal weight with themselves of albumin, can only answer in a prescription as a placebo. With the advance in the quality of pure pepsins these have deteriorated. It is time they should be dropped entirely. In no other medicine do physicians voluntarily order adulterated goods, and what is the large bulk of sugar of milk but an adulterant ?

Robert G. Eccles.

PERITONITIS, SEPTIC. The terms "septic peritonitis" and "suppurative peritonitis" are apt to be confused. Indeed, it is difficult to make a clear distinction between these two forms of disease. With our present knowledge we must grant that the cause is the same in each form, viz., the entrance into the peritoneal cavity of the pyogenic bacteria in sufficient number to cause an attack of peritonitis which differs in all its features from the plastic or adhesive form. The streptococcus pyogenes is the variety most frequently and most abundantly found; less often and less abundantly the staphylococcus pyogenes aureus; and the bacillus coli commune, and occasionally other varieties, are present. Our knowledge is as yet imperfect, and it is to be hoped that we shall soon be in a position where we can judge in at least an approximate manner of the gravity of the attack from the presence of certain varieties of bacilli. Attacks of these forms of peritonitis differ so much in duration and in severity that it would be of the greatest service for our prognosis and treatment of such cases if we could estimate the character of the attack from the existence of certain bacteria in the exudate. Such information would also be of great diagnostic aid in telling us which of the abdominal organs had been the etiological factor in the case. The manner in which these organisms gain entrance into the peritoneal cavity has been fully described in the original article on peritonitis. Neither there nor elsewhere, as far as I know, is there any definite description of how we may reach conclusions as to the cause of the disease in any specific case. I do not now refer to cases which may have been watched for weeks or months and suddenly develop peritonitis, but to those patients which every surgeon connected with hospitals with a large ambulance service must frequently encounter, where cases are first seen after septic peritonitis has been fully established, and where no previous history of value can be obtained. Such cases are met with in private practice also, and anyone who has encountered them must know how difficult they are of diagnosis.

The development of the disease is very much favored by lesions or diseased conditions of the peritoneum. The presence of fluid, especially blood, also favors the development of the pyogenic bacteria. On this account, after abdominal operations great care is taken to render the cavity as clean and dry as possible. Loose shreds of tissue with low vitality, and also tissue which will become necrotic, afford conditions which favor the attack of peritonitis.

The tendency of suppurative peritonitis is to become localized, septic peritonitis is always general. If we acknowledge that the cause is the same in both cases, we should on theoretical grounds arrive at certain conclusions to explain why in certain cases suppurative and in other cases septic peritonitis results. The two forms of disease, however, are so closely allied that in certain cases it is difficult to say which is the proper term. It seems reasonable to conclude that when the disease assumes a suppurative form the poison, consisting of the pus microbes, is either less in amount or less virulent in quality, or else that the local conditions are less favorable for the spread of the poison and its absorption into the circulation. In the septic form the development of the bacteria is so rapid and extensive that a general peritonitis is immediately established, and the absorption into the blood is so rapid that the system is at once overwhelmed by the poison.

(*a*) *The Septic Form.*—This is always diffuse or general. In many cases the disease is so rapidly fatal (12 to 24 hours) from acute sepsis, that but little evidence can be obtained at the post-mortem examination. The intestines are deeply congested, somewhat distended, and the exudate is but scanty—a cloudy, sometimes bloody serum with particles of lymph, which on microscopical examination is found to be rich in pus-cells. While many of such cases die at an early stage, yet it seems certain that the disease may begin in this form though with less virulence, and progress to the putrid purulent peritonitis, with abundant foul-smelling, purulent exudation, and with the intestines covered by thick layers of lymph (coagulated fibrin), which also floats in large flakes throughout the fluid.

The first symptom of the disease varies according to the cause. If from some perforation, it may be ushered in by signs of collapse, with severe localized pain, subnormal temperature, and rapid feeble pulse (150). In other cases if the perforation be a minute one, or after surgical operations, the onset is less sudden and often painless. The temperature may vary but little, and the only indication at first may be the rapid small pulse and the look of extreme anxiety which is expressed in the face of the patient. In either case vomiting, hiccough, or "gulping up" of fluid, is one of the first and most important and most distressing symptoms. At the same time the abdomen becomes rapidly tympanitic, and considerable discomfort is produced from this cause. The temperature is a very unreliable symptom. Occasionally it remains subnormal during the entire course of the disease in the rapidly fatal cases. More generally there is a slight elevation, but it seldom rises above 101°, unless perhaps, ante mortem. In my experience I have met with many cases where for days the temperature ranges between 98½° and 100°F, and never has risen above this latter point, even when the patient has lived for six or seven days. A chill is not common, cyanosis is a common symptom in the very severe cases, and is a sign of a fatal termination not far off. The most diagnostic symptoms are the gulping up of greenish material into the pharynx, the vomiting, and generally the obstinate constipation and the peculiar anxious look of the patient. As a rule, the mind remains clear, the senses acute, and the voice strong. In many patients, especially where the disease occurs after abdominal operations, their appearance to one unaccustomed to such cases is very deceptive. The face, beyond a pinched, eager look, does not show evidence of severe disease; questions will be asked and answered intelligently and clearly; and it may not be recognized until the hand is placed upon the pulse that such patients have but an hour or two to live. In other cases the restlessness is extreme, the countenance expresses the greatest distress, and the extremities are cold and cyanosed. This latter symptom is sometimes very marked, and may appear twelve or twenty-four hours before death results. It is as marked in some patients as is the algid stage of cholera, and when it appears, perhaps early in the attack, is a symptom of the gravest significance.

(*b*) *The Suppurative Form.*—In many cases this is probably a later stage of what has been termed the septic form. For certain reasons the disease has not assumed such a virulent form as to end fatally before free suppuration has been established. What these reasons are we do not know. Whether it is a peculiarity in the general condition of the patient, an environment unfavorable to the development of the germs, the introduction of a smaller quantity or of less poisonous forms of germs, we do not know. In other cases some of the causes unfavorable to the propagation of the germs are still more predominant, and instead of a general suppurative peritonitis, the serous membrane tries to localize the poisonous collections by casting out a fibrinous exudation, and adhesions are thus formed which surround the collections of pus and prevent general infection. These may be small and numerous in different parts of the peritoneal cavity, or one large collection may occupy nearly all the cavity, the intestinal coils being crowded aside and, united by adhesions, form the walls of this intra-peritoneal abscess. Such cases cannot be called examples of general suppurative peritonitis. The prognosis, if proper treatment be used, is vastly more favorable than in the diffuse form, and the symptoms less severe. A case may progress for some days in this manner as a localized suppurative peritonitis, and suddenly the diffuse form develop from rupture of the abscess into the general peritoneal cavity. An abscess, which at first was extra-peritoneal, may also rupture and discharge a large quantity of pus into the peritoneal cavity and excite at once general suppurative inflammation, varying in severity with the virulence of the pus which has excited the attack.

The symptoms are more pronounced than in the form

described as septic. Occasionally the disease begins with a chill. Pain is common, indeed nearly always present at some stage of the disease. At first it may be localized: later it becomes general. The temperature generally rises, and may reach 103° or 104°. Other cases, however, have comparatively little fever (100° to 100½° F.). Vomiting, tympanitic distention, and constipation soon follow. Should the disease be localized the symptoms become less severe. The temperature may remain as high, but is intermittent, and often accompanied by chills and sweating. The vomiting, however, subsides to a certain extent, and constipation may give place to diarrhœa. The tympanites also diminishes. Should the disease begin and continue as a general or diffuse peritonitis, the symptoms continue without much change, and the patient gradually succumbs to exhaustion and toxæmia. Death may result in three or four days, or may be delayed for from six to eight days.

Prognosis.—In both forms of general peritonitis the prognosis is absolutely bad. Without surgical interference a fatal termination is certain. Even with early and skilful surgical interference the prognosis still remains very unfavorable. The great majority of such cases die. If the suppurative form remains localized the prognosis is changed, and then, if appropriate surgical treatment be adopted, is favorable.

Treatment.—Medical treatment is of no avail in the treatment of *general* peritonitis, whether called septic or suppurative. Before the peritonitis is fully established drugs are of some avail. In the form which threatens the patient after laparotomy an early dose of some cathartic will often ward off the attack, and where tympanitic distention, and perhaps vomiting, show themselves after such operations, a cathartic should be at once administered. If we can ascertain that a perforation or rupture of some abdominal organ has taken place, opium should be administered for the purpose of localizing the infectious process, and, if the perforation is a small one, the peritonitis may, by this means, be circumscribed. In all other cases opium is injurious. By it the symptoms are masked, diagnosis made more difficult, and paralysis of the intestines favored by the narcotic influence of this drug. If the perforation has been sudden and extensive, stimulants may be needed to revive the patient from a condition of collapse. If the disease is clearly a general peritonitis, laparotomy (cœliotomy) is the only treatment which will give any hope of cure. The earlier in the course of the disease that the abdomen is opened the better the chances are for recovery. If left to itself, or to treatment by drugs, the disease is certainly fatal, and therefore laparotomy should be resorted to in cases where otherwise operation would be an unjustifiable procedure. The abdomen should be opened at as early a date as possible in all cases, unless the patient is so weak that death on the operating-table is inevitable. In every case the desperate nature of the disease, and the possibility of cure by laparotomy, should be explained to the patient's friends. The surgeon may be apt to shrink from operation in such cases where a fatal termination is most probable, and death during or immediately after the operation possible. It is his duty, however, to give such patients their only chance of relief, even if it be a very slight one, and the conscientious man will so regard it. Successful cases have been rare, and the majority of them have been operated upon within the first forty-eight hours, but a few cases operated upon as late as the fourth and fifth day have recovered.

Successful results have been reported where the patients seemed to be almost beyond hope, with the pulse at 140 and the temperature subnormal. In one of my own successful cases, operated upon on the second day of the attack, the temperature was 96¼°, pulse 140, and extremities cold and cyanotic. It is only within recent years that the utter hopelessness of medical treatment and the possibility of cure by operation have been fully recognized. For this reason the cases have been generally handed over to the surgeon after many precious hours have been wasted in trying to control the peritonitis. If cases could be operated on at an earlier stage the results would be more favorable. Even if there be some doubt as to the correct diagnosis, an exploratory laparotomy should be performed, for almost surely some condition will reveal itself which can only be relieved by operation. The differential diagnosis between intestinal obstruction and peritonitis is very difficult to determine. The same symptoms accompany each disease, and at an early stage it is often impossible to distinguish between these two conditions. In doubtful cases the question will nearly always be between obstruction and peritonitis, and operation is as much demanded in one case as in the other. It is impossible to state what proportion of cases recover. Probably all the successful results are reported, and not nearly all the fatal ones. A score or more of recoveries from general septic peritonitis have been reported out of several hundred operations. In my own experience I have done laparotomy on fourteen patients for diffuse septic peritonitis, and eleven have died and three recovered. This may represent perhaps a fair average of the result of other operators.

Operation.—An anæsthetic should be administered, at least until the abdominal wall has been cut through. The incision should be made in the median line, three or four inches in length. If no indication as to the cause exists, the incision should be made between the umbilicus and symphysis pubis. If symptoms point to a perforation in the stomach, it should be made over this organ: if to disease of the appendix vermiformis, then it should be made external to the right rectus muscle. When the peritoneum has been opened the purulent fluid will escape, and perhaps gas, if the intestine or stomach has been perforated. The fluid should be allowed to escape, and a rapid search made for the cause. If the patient's condition is good this search may be carefully carried out, and the cause removed if possible. Generally, however, the patient's condition is such that prolonged search is unjustifiable, and the operation must be completed as rapidly as possible. The remainder of the operation consists in freely irrigating, with hot sterilized water, the entire abdominal cavity. In certain cases the intestines will have been removed in the search for the original lesion, and in patients whose strength will admit of it, it is often advisable to do this in order to cleanse more thoroughly the abdominal cavity. Often, however, this is unjustifiable, and the irrigation must be made without removing any of the intestinal coils. A forcible stream from the irrigator is carried to different points of the cavity, and an attempt made to wash out by the hand as much of the secretion as possible. The water runs out either through the open abdominal wound or through other tubes inserted for this purpose. The water is allowed to run until it emerges comparatively clear. Two full-sized drainage-tubes should then be left projecting out of the abdomen, one in the upper and the other in the lower angle of the wound. In addition to these, counter-openings may be made in each loin, and drainage-tubes inserted in these regions to effect more perfect drainage. The abdominal wound is then closed and the patient freely stimulated per rectum. The after-treatment consists in free and full stimulation by hypodermatic injections, by rectum, and later by the mouth. This must generally be continued vigorously for days. As soon as the stomach can retain cathartic medicine the bowels should be freely moved. Such is the general plan of procedure. Many modifications have been tried, but without important results. Antiseptic solutions alone have been used for irrigation, or have been followed by hot water. Irrigations repeated every hour or so have been employed for one or two days after the operation. If the intestines have been removed from the abdomen it may be found necessary to open the gut by small incisions to give vent to the gas before they can be returned. Puncture by perforated needles is comparatively useless for this purpose. Drainage may be accomplished by iodoform gauze, but as a rule tubes are preferable. They drain for twenty-four, perhaps thirty-six or forty-eight hours, and are then shut off from the general cavity by intestinal adhesions, and may be removed.

What is accomplished by this treatment? The secre-

tion is in part, at least, removed, and though the poisonous microbes can never be completly exterminated, yet their number is much diminished and their culture fluid very much diluted. By after-drainage the secretions, and with them a certain number of bacteria, escape from the abdomen instead of remaining shut up to add to the toxæmia which already exists.

By removal of pressure the sufferings of the patient are lessened, and the action of the heart and lungs improved. An opportunity is also given to remedy the original lesion, and this may be easy to accomplish, and often is of vital importance. In most of the cases, unfortunately, a sufficient dose of the poison has been absorbed previous to operation to overwhelm the patient, but in a small proportion the vital force is sufficiently strong to conquer the toxæmia, and the result is recovery. It is true that this proportion of successful results is small; perhaps ten per cent. of recoveries would be a fair estimate. It is certain, however, that could patients be operated on at an earlier period the result would be more favorable. It is especially upon physicians that this fact should be impressed, for as a rule it is the family physician who first sees these patients, and it is his duty to be alive to the urgency of the case and the necessity for immediate laparotomy.

Andrew J. McCosh.

PERITONITIS, TUBERCULAR. The peritoneum is very susceptible to tubercular infection. This membrane is more easily infected by the tubercular bacillus than it is by the pyogenic bacteria. It can safely dispose of a considerable number of the latter bacilli, but a very small inoculation with the former is enough to excite a tubercular process.

Etiology.—The direct cause is the bacillus tuberculosis. Tuberculosis of the peritoneum is rarely primary. As a rule the process has extended from some other organ; in some cases by direct contact, in others by metastasis. The primary disease may be situated in the intestinal tract, in the lungs, in the joints, in the bones, in the sexual organs, both male and female, or, indeed, from any tubercular process in the body the peritoneum may become secondarily infected. In young children the original focus is apt to be situated in the intestines. In adult females the process most often extends from the Fallopian tubes; in adult males from the lungs. On theoretical grounds it would seem probable that tuberculosis of the peritoneum would rapidly disseminate itself through the system. This, however, is not the case. There is a distinct tendency to limitation.

Age.—No period of life is exempt. It may occur in very young children and in old age. The most common period for its development is between the ages of eighteen and forty-five.

Sex.—Statistics differ as to the relative liability of the two sexes to the disease. Of patients operated on, the great majority have been females, only about twelve per cent. males. Before the twelfth year, or before the genital organs have become developed, about an equal number of males and females have been subjected to operation. In the autopsy-room, however, the proportion is reversed. The number of cases among males is largely in excess of that among females, in the proportion of about three to one, according to most observers. The reasons given for this discrepancy are that the abdomen of females is more easily, and generally more carefully, examined; that the diagnosis in a certain proportion of cases among females has been accidentally made when the abdomen has been opened on the supposition that a tumor existed; that in males the peritoneum is apt to be infected from the lungs or intestines at a later period of the disease, when the secondary involvement is completely overshadowed by the original disease. From observations, however, by clinicians and surgeons, the disease seems to be more common among females, and careful investigation on the part of the pathologists will probably prove that this view is correct.

Pathology.—Various anatomical classifications have been made. Osler divides the disease into the following categories:

1. Acute miliary tuberculosis, characterized by a sudden onset, a rapid development, and a serous or sero-sanguineous exudation.

2. Chronic caseous or ulcerating tuberculosis, characterized by larger tubercular growths, which tend to caseate and ulcerate, leading often to perforations between the intestinal coils and a purulent or sero-purulent exudation, often sacculated.

3. Chronic fibroid tuberculosis, in which the process may from the outset be subacute, or may represent the final result of the miliary form. There is little or no exudation.

In the first form the peritoneum is thickened and everywhere studded with miliary tubercles, there is present a considerable amount of ascitic fluid, and the coils of intestine may become agglutinated. In the second form the intestines are apt to be matted together, their walls thickened, œdematous, and often covered by a thick, grayish membrane. There are apt to be local accumulations of fluid, generally purulent, shut off by adherent coils of intestine. This process may be limited, or all the intestines may be so matted together and covered by thick membrane and caseous masses that it is difficult to distinguish their coils, and the impression may be given in such cases, before the abdomen is opened, that a solid abdominal tumor is present. In such cases the abdominal wall is apt to be œdematous, and is boggy to the touch. In all forms the mesenteric glands may be enlarged, and often to such a size that they can be distinctly felt by abdominal palpation.

Osler calls attention to "omental tumors," which result from a puckering up of the omentum till it forms a roll below the transverse colon. Such cases are seldom accompanied by much exudation, and are apt to be mistaken for malignant growths. It is important to decide in what cases the disease is confined to intra-peritoneal tissues. It is more apt to be local in females than in males, on account of the greater liability of extension from a Fallopian tube. Probably in twenty-five to thirty per cent. of all cases in women the disease is confined to the peritoneal cavity. In males the proportion of cases with such limitation is very small.

Symptoms.—The mode of onset of the disease is very variable. It may be acute and sudden, or it may be so uneventful and its course so insidious that its nature is not suspected until revealed by autopsy or operation. Between these two extremes the disease may be ushered in by symptoms which are very variable both in their character and severity. In the acute form the symptoms from the first are severe. There may be a chill, though as a rule this is absent, and elevation of temperature is the first sign of importance. This may reach from 103° to 104.5° F., and gives rise to the subjective symptoms which accompany fever. At the same time the signs of an ordinary attack of acute peritonitis show themselves: abdominal pain and tenderness, tympanitic distention of the intestines, rapid, small pulse, and occasionally vomiting. Cases with such a severe onset are not common, and generally occur in the course of an acute miliary tuberculosis. The disease is more apt to assume a semi-acute form. In such patients a general malaise with slight elevation of the evening temperature is first noticed. The fever gradually and steadily increases, and for two weeks or more may be the only prominent symptom. The tongue is coated and the prostration considerable. By the third week the evening temperature is apt to be about 102.5° or 103° F., and the morning temperature a degree or two lower. In such cases the symptoms are almost identical with those of typhoid fever, and for several weeks it may be impossible to make a correct diagnosis, especially when diarrhœa is present, as is sometimes the case. Generally about the third week attention is attracted to the abdominal distention, which is partly due to exudation and partly to tympanitic distention. This symptom increases, and soon a peculiar boggy feel is derived on abdominal palpation, or perhaps a distinct sense of fluctuation. In the latent form,

with the exception of slight malaise there are no symptoms of importance until it is noticed that the abdomen begins to enlarge. This distention increases slowly, but is accompanied by so little discomfort and so little fever that a diagnosis of cyst, probably ovarian, is apt to be made, or perhaps of ascites due to some other cause. In such cases, however, there is generally a slight elevation of the evening temperature, perhaps of one or two degrees (F.). It is very apt to be overlooked. In a few cases, on the contrary, a subnormal temperature may be present and may continue for several weeks. Of the special symptoms ascites is the most common. In nearly every case there is a certain amount of fluid in the peritoneal cavity. It is generally light straw-colored, occasionally bloody, and usually is free in the general cavity. In cases where caseous and ulcerative processes are present there is very little fluid exudation, and what there is is generally purulent. The temperature is a very variable symptom. In most cases there is a slight elevation, in a few, marked febrile reaction, and yet in others, subnormal temperature. Abdominal pain and tenderness are not common. Except in the very acute cases, which are rare, no severe pain is experienced. In many patients a feeling of discomfort exists from the commencement, and will generally increase in proportion to the amount of exudation. Tympanites is a rare symptom. Pigmentation of the skin, especially of the face, has been noticed in a few cases (Osler). Attention is called by Edebohls to plaque-like thickenings of the subperitoneal tissues.

Diagnosis.—The history of the patient and the presence of tuberculosis in other organs are the most important points in arriving at a correct diagnosis. The acute form must be distinguished from idiopathic peritonitis. The latter disease progresses in a more violent and rapid manner, and is accompanied by more tympanites and by persistent vomiting. The subacute form must be distinguished from typhoid fever; inoculation may be of aid. The latent form must be distinguished from abdominal cyst. In certain cases this is impossible except by exploratory laparotomy. The fluid may be more or less encysted. Reliance must be placed on palpation by an experienced hand; percussion in abdominal tumors is but of little value. Mistakes between these two conditions are constantly made by the most experienced observers, and much of our knowledge of the disease has been derived from such mistakes.

Prognosis.—Without surgical interference the prognosis is bad. Spontaneous healing is not uncommon in children, but in adults it is very rare. If laparotomy be resorted to as a curative measure, the prognosis is very much improved and may be said to be favorable. The majority of patients operated on are permanently cured of the peritoneal tuberculosis. In my own experience I have had two patients who at the end of three and five years respectively after operation were in perfect health. In another case, at whose operation I acted as assistant to Dr. T. G. Thomas, eleven years have elapsed since the laparotomy, and there is no sign of return of the disease. Cases have been reported in perfect health at the expiration of more than twenty years after operation.

Treatment.—In children who have been living in an unfavorable environment dietetic and hygienic treatment may be tried for a time, and will occasionally result in a cure. In all other cases, where the other organs are free from tubercular deposits, abdominal section (cœliotomy) is the only appropriate treatment. It should be resorted to as soon as the diagnosis has been made. In cases where other organs are diseased each case must be decided on its own merits. If the disease is such as to allow the patient but a short lease of life the peritonitis had better be disregarded. If the disease, however, is in its earlier stages, and is not such as will lead to a speedily fatal termination, an attempt should be made to cure the peritonitis by means of laparotomy. I have under observation one woman on whom I operated two and a half years ago. She had then, and still has, a consolidation of the apex of one lung. The process, however, is but slowly progressive, and she has not had a sign of return of the peritoneal tuberculosis which at the time of the laparotomy was pronounced.

The method of operation is as follows: An incision should be made in the median line, between the symphysis pubis and the umbilicus, large enough to admit the hand, or at any rate two fingers. The ascitic fluid should be allowed to escape by turning the patient on the side. A complete diagnosis should now be made by the hand thrust inside the peritoneal cavity. If the original focus can be ascertained and removed, this should be done. If it be a Fallopian tube, this can usually be done with comparative ease. If it be an intestinal ulcer or caseous lymphatic glands, the operation may be attended with great difficulties. No rules can be laid down for such cases. The cause should be removed if possible; but this must be decided by the surgeon at the moment of operation. The entire peritoneal cavity should now be irrigated with hot sterilized water. This should be thoroughly carried out, and continued until the water comes out perfectly clear. A glass drainage-tube should be inserted in the lower angle of the wound and the abdominal incision closed by suture. It is well before closure of the abdomen to remove a portion of membrane for future microscopical examination. The drainage-tube should be left in as long as it drains the peritoneal cavity. Its action in this capacity will probably cease in from two to five days, and it should then be removed. Occasionally, however, drainage will continue for many weeks. This on the whole is the most reasonable method, but many modifications have been practised. The results, however, are not more favorable. Instead of plain water different chemical solutions are used, most often Thiersch's solution (boro-salicylic acid solution). The peritoneal surface may be carefully sponged or wiped with gauze. Iodoform pencils may be left in the abdomen. Drainage may be made by iodoform gauze. An emulsion of iodoform in glycerine may be injected, and the good results which are now obtained from the use of this drug in tuberculosis in other parts, especially in joints, would be a strong argument in favor of its use in the peritoneal cavity.

While it is certain that laparotomy effects a cure in many cases, it is uncertain how this cure is brought about. Several theories have been offered in explanation, but none are thoroughly satisfactory. The behavior of the tubercular process in the peritoneum is so unlike that in other organs that some doubt has been cast upon the diagnosis of such cases. In so many of them, however, has microscopical and bacteriological examination proved the existence of the bacillus, that we must believe that the diagnosis in the great majority of cases has been correct. Many tumors of the abdomen, especially of the female genital organs, behave in a somewhat similar manner, for it is certain that simple abdominal section will result in marked improvement and in occasional cure of solid growths of the uterus and ovaries, and in malignant disease a decided amelioration of the symptoms often follows and continues for months. The growth of the tubercle bacillus is undoubtedly stopped, and retrograde curative changes induced by the laparotomy. Osler says: "In some way the operation renders the condition of the peritoneum more favorable to the fibroid changes by which alone healing is induced." Phillips claims that it results from encapsulation of the tubercular tissue by means of connective tissue, as occurs in tubercular joints. Such, however, is not always the process, for cases have been reported where masses of considerable size have entirely disappeared and no trace of tumors or irregularities remained, such as would have been found had the tubercular material been surrounded or replaced by connective tissue. In a case of my own, at the time of operation, in addition to several quarts of ascitic fluid, there existed many nodules in the abdominal cavity, varying in size from a pea to a hen's egg. Two years later I did a laparotomy in this patient for strangulated hernia, and took advantage of the opportunity to make a thorough examination of the peritoneum, which was found everywhere smooth, and not a nodule or irregularity to be felt. A similar case

has been reported by Schede. We know that the peritoneum has a great capacity for the absorption of poisonous substances. The operation removes pressure by the escape of the ascitic fluid, and in this way a certain stagnation in the blood-vessels may be removed. Sponging and irrigation, and perhaps the entrance of air, causes a certain irritation of the vessels and nerves of the peritoneum, and an increased capacity for absorption may be thus imparted to the lymphatics and blood-vessels. This reasoning, however, is purely theoretical, and some better explanation is needed of the processes by which a cure is effected. *Andrew J. McCosh.*

PERSONAL IDENTITY OF THE SOLDIER. This subject, with the methods that may be used in establishing identity, has an ever-present interest, not only to the medical, but to every other officer of the army: to the medical officer in drawing his attention to the physical peculiarities that the necessarily painstaking examination may develop, and in fixing the habit of minute search for surface indications of diseased action or of defects in person that might otherwise readily escape notice in an ordinary inspection; to other officers in the facility afforded for recognizing men who, having previously served in the army through partial or full terms of duty, seek readmission, but for reasons of their own conceal the fact of a previous service; in other words, who attempt a fraudulent enlistment. This class is made up of deserters, of men who have been discharged by sentence of military courts or by order of the Department "for cause" or for disability, or those who have served a term of imprisonment as military convicts, an undesirable class whose members are to be kept out of the army by any means that can be devised for the purpose.

Except for the identification of deserters, who when convicted could be legally punished for their crime, there seemed but little profit in applying any test to the remainder of this class of delinquents, because the imperfection of the law was such that if discovered there could be no punishment for them other than by dishonorable discharge, which really gave an offender the opportunity to repeat his infamous practice; a sufficient number, however, remained undiscovered until their desire to repeat their fraud led them to desert, and the increase thus made in the percentage of this crime, together with its demoralizing effect upon the army, led the authorities to seek a reliable system by which this portion of the class at least might be eliminated from the service. After careful observation and a discussion of the many methods presented, the system devised by the writer was finally adopted and has been attended with a success in its application that has given universal satisfaction. The passage by Congress of an Act making fraudulent enlistment a military offence and punishable by court-martial under the 62d Article of War, now extends the usefulness of the system and enables it to be of practical effect in dealing with the entire class.

In the discussion of the subject four methods were proposed, viz.:

1st. By tattooing at a designated spot the person of every recruit.

2d. By photographing each recruit.

3d. By the application of M. Bertillon's system of bodily measurements.

4th. By a systematic record of bodily markings and peculiarities.

The first method, which was suggested and urged by many, among whom were officers of rank and influence, was met by legal objections and by the probable danger of specific or septic infection of the recruit in the operation; it was accordingly promptly laid aside.

To the second, objection was made that the presence or absence of the hair and beard, the facial expression, the physical condition of the individual, the dress, the pose, the light in which the pictures might be taken, would present such differences between the present and the past photographs that recognition would be very difficult, if not almost impossible, and this, added to the other difficulty in systematizing or arranging the pictures for easy and rapid comparison, demonstrated its impracticability.

To the third, or so-called "Bertillon method" of bodily measurements, there was the ethical objection that it was devised and used solely for the identification of criminals. "The citizen who desires to enter the army of the United States does so under the belief that he is engaging in an honorable profession, and the code which is presented to him, both in the language of his enlistment contract, in the Articles of War, and in the Regulations of the Army, is drawn with a view to sustain and strengthen this belief. The effect of meeting him at the threshold of his enlistment with a system of identification which is stamped with criminal associations, and presupposes an intent on his part to violate his contract, cannot but be fatal to his honorable purpose, and result either in driving him in disgust from the recruiting rendezvous, or in suggesting a future escape from a service into which present necessity has forced him." While excellent results are said to have been obtained by this method, there was further objection to it because of the impracticability of securing properly instructed men to use the required instruments of precision, and because of the expense in procuring these instruments.

Recruiting in this country is carried on not alone at fixed stations in cities, but by peripatetic parties in the rural districts as well as at all military posts. The *personnel* of the recruiting service is constantly changing with ever-shifting military exigencies, and neither the opportunities to instruct nor the men to be instructed in anthropometry are obtainable. All recruits are promptly assigned after enlistment to military stations, where their thorough physical examination is made by the officers of the Medical Department on duty thereat, and the opportunity is thus presented of securing, through responsible and reliable officers, professional accuracy in determining the existence of bodily markings; this being done, moreover, with the least offence to the sensibility of the recruit, who naturally and willingly submits to complete exposure of his person in the anticipated examination of his physical fitness for military duty.

To the fourth method there was no apparent objection, and its basis had the favorable opinion of M. Bertillon, who says that "they (permanent bodily marks) offer a greater guarantee for identification than measurements, and that they would take their place altogether if it were possible to use them as a basis for classification." Upon its adoption the following order was issued by the War Department placing it in operation:

"Hereafter, a record of such indelible or personal marks as may be found upon the person of an accepted recruit will be made upon an outline figure-card, as illustrated upon accompanying pages of this order, and forwarded promptly on completion to the Surgeon-General of the Army. No letter of transmittal is required. The outline cards will be furnished by the Adjutant-General.

"The examination and record of marks of recruits belonging to the General Service will be made by the medical officer at a depot; of recruits enlisted at military posts, by the post or attending surgeon; and of recruits enlisted at other places where the services of a post or attending surgeon cannot be obtained, by the enlisting officer. In the cases referred to in section one, the record of marks will be made at the second examination.

"The object of this record is to obtain evidence for the identification of men who have had previous service in the army, and its successful accomplishment depends upon a rigorous precision in noting on the card all personal markings or peculiarities. The following directions should therefore be strictly observed:

"Directions for Recording the Personal Markings on Accepted Recruits.—Make a careful search of the body, front and rear, on each side of the median line, separately, commencing at the scalp and ending at the foot, for any scars, moles, tattoo marks, etc., that may exist, indicating their position on the body by a dot made with pen and ink at a corresponding point on the figure-card; on its blank fly-leaf note the *general inclination*, whether vertical, oblique, or horizontal; the *form*,

DESERTERS = Blue Eyes,.....

ANTERIOR.

No.	Name.	Right.																					Left.																					
		Head.	Neck.	Shoulder.	Thorax.	Abdomen.	Groin.	Hip.	Thigh.	Knee.	Leg.	Ankle.	Foot.	Toes.	Arm.	Elbow.	Forearm.	Wrist.	Hand.	Fingers.	Penis.	Nose.	Head.	Neck.	Shoulder.	Thorax.	Abdomen.	Groin.	Hip.	Thigh.	Knee.	Leg.	Ankle.	Foot.	Toes.	Arm.	Elbow.	Forearm.	Wrist.	Hand.	Fingers.

(Cut along this line, place the lower piece to right of upper, to get fac-simile of Right Side of "Register.")

.....inches high.

POSTERIOR.

Left.																	Right.																
Head.	Neck.	TRUNK. Upper.	TRUNK. Middle.	TRUNK. Lower.	Hip.	Thigh.	Knee.	Leg.	Foot.	Shoulder.	Arm.	Elbow.	Forearm.	Wrist.	Hand.	Fingers.	Head.	Neck.	TRUNK. Upper.	TRUNK. Middle.	TRUNK. Lower.	Hip.	Thigh.	Knee.	Leg.	Foot.	Shoulder.	Arm.	Elbow.	Forearm.	Wrist.	Hand.	Fingers.	MISCELLANEOUS.

(Below this line is represented the Left Side of the "Register.")

DESERTERS = Blue Eyes,.....inches high.

DESCRIPTION OF TATTOOS AND DISCOLORATIONS.

ANTERIOR.			POSTERIOR.			
No.	RIGHT.	LEFT.	LEFT.	RIGHT.		No.

Fac-simile of a double page from the Register of Deserters and other Delinquent Soldiers.

rectilineal, curved (inward or outward), oval, circular, undulated, or oblong; the *character*, if scar, whether recent, permanent, or transient; if mole, hairy or otherwise, etc.; and the distance of the mark from some fixed anatomical point, for example, 'Scar, from burn, one and three-fourths inches above and one inch to the right of left nipple, oblique, curved inward.'

"When numerous small scars are found on the back, from pimples, or on the fingers, from cuts, note them as 'numerous scars,' or describe the principal one and add the words 'and many others;' describe briefly tattoo marks and distortions of the finger- and toe-nails, *i.e.*, the striated or split nail of the finger, or the hypertrophied nail of the great toe.

"If, after careful search, no personal marking is found, the fact should be noted on the figure-card.

"For the purpose of securing uniformity in the description of color of eyes and hair, observe the following:

"*Color of Eyes.*—To be described as:

Blue { Light. / Dark. / Slate. } Brown { Light (or hazel). / Dark. }

Black.

"'Slate blue' takes the place in description of *gray*, which is inexact and vague.

"Black is seldom found except in negroes; the so-called black eye is, properly speaking, a dark brown.

"Malformations of, or abnormal discoloration in, the iris, and marked differences in color between the eyes should be noted.

"*Color of Hair.*—To be described as:

Blond { Light, and sometimes flax-colored. / Deep. } Red { Brick. / Sandy. / Auburn. }

Brown { Light. / Dark. } Gray { Light. / Mixed (iron). }

Raven black. White.

"Note name and organization, age in years and months, and height in inches and quarters thereof. Care should be taken in measuring for height that the occiput, the sacrum, and the heels touch the vertical rod."

To insure accuracy of description in the color of the eye, two cards are issued bearing lithographic plates of the various shades of blue and brown colors that are found in the human eye, each plate being designated by a numeral that may be used for notation on the figure-card.

Further instructions from the War Department require all officers concerned to transmit to the Surgeon-General, within twenty-four hours after the fact, a brief report of the name, company, and regiment of every soldier who deserts or is discharged the service for cause.

The figure-cards of recruits are filed immediately upon receipt, in the Bureau of Classification, in suitable boxes that are arranged alphabetically, and when the reports of men who have been eliminated from the service are received they are sent to the same place, where the work of comparison is carried on as follows:

A study of the figure-cards showed that the work could be most satisfactorily performed by using the colors of the eye, of which there are practically but two, as the initial division into sections for comparison, and that the other divisions could be best used when grouped upon a printed form in a register which consists of two volumes, one for the blue-eyed, the other for the brown-eyed men, and is divided, according to height, as follows: 64 inches and under, 64½, 65, 65½, 66, 66½, 67, 67½, 68, 68½, 69, 69½, 70, 70½, 71, 71½, and over. Each register is ruled in columns for the various regions of the body, as "anterior, posterior, right, and left," for the general divisions, with head, neck, shoulder, thorax, abdomen, groin, hip, thigh, knee, leg, ankle, foot, toes, etc., for the specific locality.

As a primary step, the report of discharge or desertion (which it should be remembered contains only the name, company, and regiment of the individual, and the date of discharge or desertion) is completed by taking from its place in the file box the figure-card that was made at the time of enlistment, and from the completed report a transcript is made on the register, the selection of volume to be used being determined by the color of eye.

Immediately upon arrival of a morning's mail, such figure-cards of recent enlistments as may have been received, are compared with the register after this manner: The color of eye indicates the volume of the register, and the height indicates the page in which search has to be made. In this latter item, an inch below and a half inch above the height recorded on the figure-card is allowed for variation or defective measurement. Each section of height is again divided, and men having tattoos are entered apart from those having no tattoos, for a deserter having tattoos is very likely to have the same when reentering the service, and a recruit coming in without tattoos is not likely to be found among those with tattoos; recruits coming in with tattoos are, however, examined over those deserters who did not have such marks, as these different devices might have been put on while at liberty.

The abbreviations used in entering descriptions of deserters are almost self-explaining, as: V. = vaccination; S. = scar; T. = tattoo; B. = birth-mark; M. = mole; S. P. = small-pox; C. P. = chicken-pox, etc.

The first comparison is for name, after which it is continued for tattoo marks, and if their peculiar design or locality give suspicion of identity, an inspection of the sectional form on the opposite page of the register is made by glancing from left to right along the line bearing the record of the individual who has the suspicious tattoo, for any further mark of identity. If there is a sufficient number of similarly located and described marks to increase the suspicion of identity, the form of physical examination and the enlistment papers are brought into requisition for comparison of signature of the recruit, and for his general history, and should this be enough to justify moral certainty of identity, the case is reported to the Adjutant-General for further action.

Should there, however, be no tattoos recorded on the figure-card that has been received, note is taken of the next prominent mark, which may be a birth-mark, a hairy mole, a scar from burn, etc., or a small permanent scar in an unusual location, such as in the popliteal space, finding which, a further and more careful search is made for other marks that may be confirmatory of identity; failing in this, any other mark or peculiarity of person is examined, such as abnormal nasal septum, prominence or not of ear; or, if nothing is found, identity fails, and the papers are placed in the files of the Bureau. The time consumed in making one of the examinations averages fifteen minutes, although in plain cases but a few minutes are required.

At the date of this paper 31,138 outline figure-cards have been received, and the number of cases reported as having left the service for cause is 5,765, of whom 4,096 were deserters and 1,669 delinquents from other causes.

Three hundred and twenty-eight cases of identity have been reported since the introduction of the outline-card system, and seven cases were reported as probably identical. The following is the result of the investigation made in the cases:

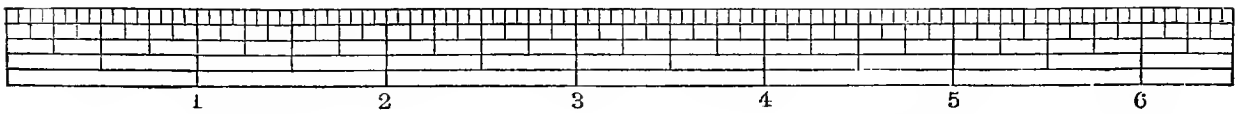
a. Identity established and final action reported by military tribunal	198
b. Reported identity and accepted by the War Department	115
c. The suspect deserted before investigation	5
d. Ex-convict; had permission to re-enlist	1
e. Insane soldier; discharged for insanity before investigation	1
f. Doubtful cases, reported as probably identical	7
g. Failures, identity not established by military tribunal	4
h. Recent cases, investigation pending	4
Total	335

a. This group of cases includes all in which identity was claimed without reservation because of the similarity

of record on the figure-cards, and was subsequently established by the proper military tribunals.

b. This group embraces cases in which the evidence of identity was conclusive, but as the suspects were out of the service, the cases were reported for correction of the enlistment papers. The Adjutant-General has accepted the identity in all of the cases.

f. These cases were reported as probably identical; although more or less prominent points of resemblance were present the discrepancies were such that no positive statements were justified, the evidence being submitted for what is was worth. In only one case was the identity absolutely disproved; in four the negative statement of the officer conducting the inquiry was accepted without further inquiry, and in the sixth case inquiry was dropped, the officer charged with it reporting that he had no funds to secure a desired photograph.



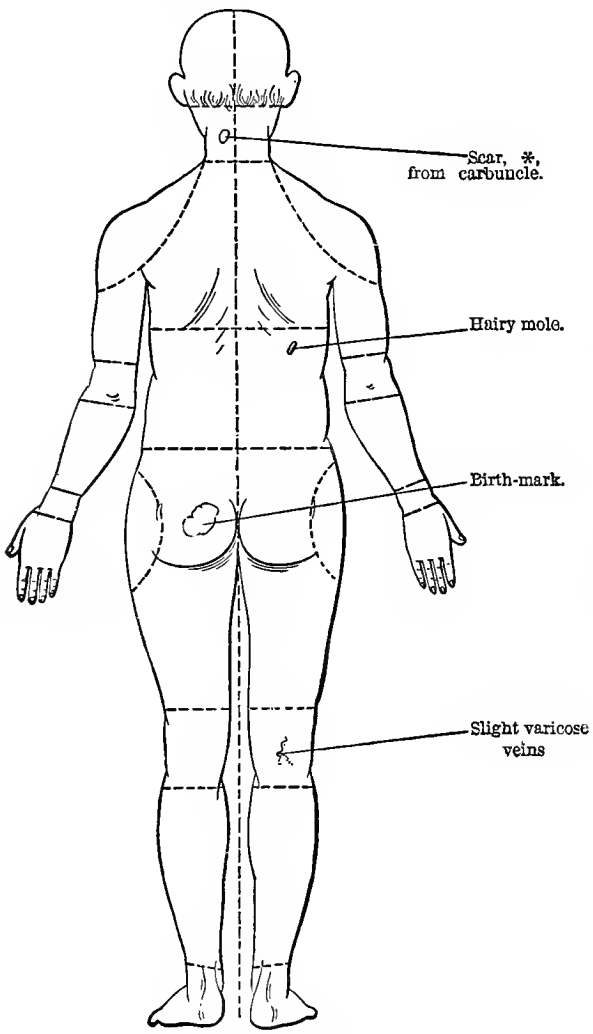


FIG. 520.

Age: 22 years 4 months.
Height: 64¾ inches.
Color of hair: Red.
Color of eyes: Slate blue.
Place of enlistment: Cleveland, Ohio.
Date of enlistment: April 5, 1890.
Prior U. S. Service?: No.
Name: John Smith.
Organization: G. S. Recruit.

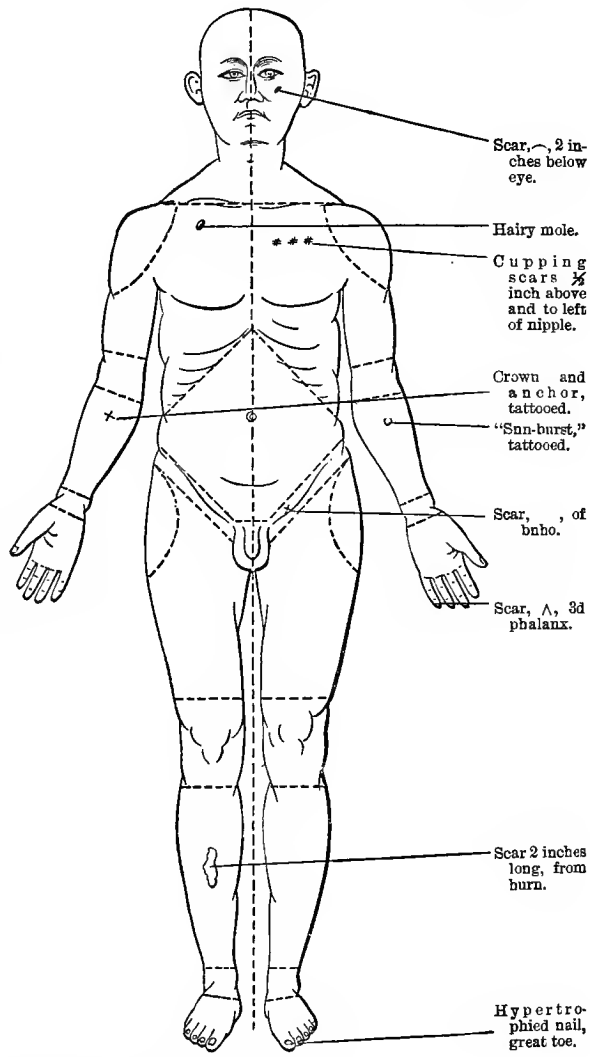


FIG. 521.

Station: Columbus Barracks, Ohio.
Date: April 10, 1892.

.....
Surgeon, U. S. Army.

c. These cases were reported as identical, but no investigation could be made because the man in each case deserted a short period (in some cases a day or two only) before or after identity was reported. After several of this class had thus succeeded in escaping, the telegraph was made use of in ordering arrests. As may be surmised, they occurred only among the earliest cases of identity.

g. Two of these cases were submitted with class *a* through error. The card record did not present sufficient evidence to warrant complete identity, and they should have been submitted with class *f*; they were failures. One case was identified by the Examining Surgeon, but was acquitted by the Court, and one case was

a failure, doubtless due to erroneous entry on the card by the recording officer.

The following is a synopsis of an interesting and somewhat complicated case:

There was submitted to the Department, October 28, 1890, a set of figure-cards indicating that one *George Howie*, who was enlisted October 10, 1890, was probably identical with *George Harrison*, who deserted August 6, 1889. Howie positively denied his identity with the deserter Harrison. His company commander, who conducted the investigation, although admitting that there was "a remarkable similarity in the two outline cards," reported that in his opinion the two persons were not identical, supporting his views with an enumeration of the discrepancies presented by the two cards. Under date of November 12, 1890, a restatement of the case was made, with recommendation that the "suspect" should be confronted with some of his former comrades, and a non-commissioned officer, who was supposed to be acquainted with Harrison, was accordingly selected for the purpose, but failed to recognize Harrison in the alleged Howie. Tracings of the signatures of Howie and Harrison were then made, and as they were strikingly similar, they were added to the evidence previously submitted, which was again referred to Howie's commanding officer, requesting further comparison. He replied: "I agree with the Surgeon-General that there can be but little doubt as to the identity of these (seemingly) two men. But still there is a doubt in my mind as to the identity." He points out the failure of the non-commissioned officer to identify the man, and remarks with reference to the striking similarity in the tattooing that he does not attach as much importance to it as it seems to warrant, from the fact that he has seen on a number of occasions as many as four men "tattooed exactly alike, as far as the location and shape of the figure was concerned." He admits that the coincidences are remarkable, and were it not for the fact "that Sergeant Cook failed to identify the man," he would have him arrested and tried for desertion. The arguments of the company commander were met, and final request was made to confront Howie with several witnesses who had known Harrison, but this was declined by the War authorities, with the following final statement:

"The best evidence that this case is a case of mistaken identity is the fact that the soldier, knowing that he was not only under suspicion, but under investigation, has remained with his company and performed his duty up to last muster, February 28, 1891."

This "best evidence" was overthrown within a few days by Howie's desertion, after ascertaining that additional evidence had been submitted connecting him with a dishonorable dismissal by sentence of a court-martial in 1887.

Charles R. Greenleaf.

PHARMACOPŒIA. Since the publication of the article on this subject in the main work (Vol. V., pp. 622–629), a number of new national pharmacopœias have been issued, while several others are in course of preparation. The labor bestowed on these recent issues has been, comparatively, much greater, and, being shared by the professions of medicine and pharmacy, the work has been much more evenly divided than has been the case in the past. A natural consequence of this is the greater recognition of these works as authorities, both for medical practice and for the decision of legal questions involving the purity of articles of food and drink, or of drugs. Their usefulness, however, can be extended still further in the future, it being only needed that a thorough weeding out of old-fashioned and antiquated notions be inaugurated at some favorable time. The increasing number of synthetic chemicals of recognized medicinal value, the discovery of more proximate principles upon which the activity of many vegetable and even some animal drugs depends, and the better understanding of the sphere of action of these agents of constant composition will eventually cause to be thrown out of the pharmacopœias a multitude of remedies, simple and compound, the reputation of which rests on empiricism, often of a very problematical character. A sudden transition from the present condition of things to the prospective purism in medicine can, however, not be expected. The transition must be gradual, due account being taken of the older generation of practitioners of medicine and pharmacy. Still, with each succeeding decennium the ratio of innovation and improvement may become more progressive, until the time be reached when the old ballast may be completely thrown overboard.

ARGENTINE REPUBLIC.—The previous commission appointed for the preparation of a national pharmacopœia having accomplished nothing, a new one was appointed in June, 1892.

AUSTRIA-HUNGARY. — After an interval of twenty years, a new Pharmacopœia Austriaca (Editio VII.) was issued in 1889, and went into effect on January 1, 1890. It contains 578 articles, 43 more than the preceding edition.

The Hungarian Pharmacopœia was revised, and appeared in its second edition in 1888, under the title: "Magyar Gyógyszerkönvy · (=) Pharmacopœia Hungarica. Második Kiadás: (=) Editio Secunda." It contains 516 articles. Both in title and in arrangement of text it is very similar to the first edition, the text being in Latin and Hungarian, on opposite pages.

The first Croatian Pharmacopœia appeared in the same year, under the title: "Hrvatsko-Slavonska Farmakopœa: Pharmacopœia Croatico-Slavonica. [8° Zagreb (= Agram), 1888]." It contains 518 articles, and is, practically, a duplicate of the Hungarian (II.), having the Slavonic and Latin text on opposite pages.

BRITISH EMPIRE.—In 1886 the General Council of Medical Education and Registration of the United Kingdom—generally designated by the shorter title: "British Medical Council"—appointed Professor John Attfield, one of the editors of the British Pharmacopœia, as "Reporter on the British Pharmacopœia to the Medical Council," the office being intended to be permanent, for the purpose of gathering up, during each year, from the current literature, whatever has a bearing upon the contents of the British Pharmacopœia, and to make suggestions for its future improvement. In accordance with this new departure, annual reports have been issued since 1887, each covering the literature of the preceding year.

In 1888 the third reprint of the British Pharmacopœia of 1885 was issued, and in December, 1890, appeared the first supplement, under the title: "Additions made in 1890 to the British Pharmacopœia of 1885," etc., which contained 44 new articles. In the preparation of this addendum the pharmaceutical profession of Great Britain was, for the first time, invited to participate, at least so far as to be asked to suggest desirable additions, or improvement of existing formulæ. It is to be hoped that, at a subsequent revision, the pharmacists will be given an opportunity of assisting the editor during the actual work of revision.

In order to prepare a uniform guide for the preparation of the most commonly used unofficial remedies, the British Pharmaceutical Conference undertook the publication of an unofficial formulary, which appeared in 1887, under the title: "Unofficinal Formulary of the British Pharmaceutical Conference." This contained 37 articles. In 1889 a supplement to this was issued, containing 9 articles. The formulary is generally designated by the abbreviation, U. F. B. P. C.

CROATIA.—See Austria-Hungary.

DENMARK.—A new Danish pharmacopœia was published in the spring of 1893, which was ordered to go into effect on August 1, 1893. The text is in Danish, only the titles of the articles being in Latin.

GERMANY.—A permanent Pharmacopœia Commission was created by Government in 1887. This body held its first session in April, 1888. In 1890 appeared the third edition of the German Pharmacopœia, under the title: "Arzneibuch für das Deutsche Reich. Dritte Ausgabe. Pharmacopœia Germanica. Editio III." Excepting the titles of the pharmacopœial articles, the text is entirely

in German, the Latin language having been abandoned in accordance with the modern views of educational authorities, which have recently been carried into practical effect by curtailing the time and degree of attention heretofore devoted to classical languages in the Latin schools and gymnasiums. This issue of the German Pharmacopœia had the advantage of a much more careful preparation than any of its predecessors, chiefly through the careful study of the more important articles on the part of the Pharmacopœia Committee of the German Pharmaceutical Association (Deutscher Apotheker Verein) under the chairmanship, first of Dr. O. Schlickum, and subsequently under that of Dr. G. Vulpius.

The example set by the United States (1886 to 1888) and Great Britain (1887), in preparing national formularies of unofficial preparations was followed by the pharmacists of Germany in 1891, when the German Pharmaceutical Association published a similar work under the rather awkward title: "Arzneimittel welche in dem Arzneibuch für das Deutsche Reich (Dritte Ausgabe; Pharmacopœia Germanica, Editio III.) nicht enthalten sind" (="Remedies which are not contained in the Arzneibuch," etc.). This contains 811 articles.

Hungary.—See Austria.

Italy.—After many delays and changes the commission charged with the preparation of a national pharmacopœia completed its labors and published the work in 1892, under the title: "Farmacopea ufficiale del Regno d'Italia" (8°, Roma). The main titles of the pharmacopœial articles, of which there are 597, are in Italian, with Latin synonyms. This pharmacopœia contains many features of importance, though some of them are of questionable utility. Thus, for instance, in the case of powerful drugs, the percentage of active principle which they contain, or may be expected to contain, is given. For instance, under belladonna it is stated that "the root and the leaves contain about 0.5 per cent. of hyoscyamine and atropine." Under jaborandi: "Contains pilocarpine (about one per cent.)," etc. Under colchicum: "The bulbs contain 0.08 to 0.20 per cent. of colchicine; the seeds 0.2 to 0.4 per cent.," etc. Yet in none of these and a number of other cases is there a process of assay given. This is, no doubt, owing to the fact that our methods for the quantitative determination of many proximate principles are not yet sufficiently reliable to be officially prescribed in a pharmacopœia. For this reason, however, it is illogical to make a demand of definite limits of alkaloidal strength in the case of any drug where no definite method of assay can be prescribed.

Japan.—The second edition of the Japanese Pharmacopœia was published in 1891, under the title: "Pharmacopœia Japonica. Editio altera. Tokyo, Anno XXIV. Meiji (1891)." It is wholly in Latin. It resembles its predecessor in general appearance and construction, but in the nomenclature of chemical substances the last German and Austrian Pharmacopœias have been followed as guides.

Netherlands.—A Government Commission for revising the pharmacopœia was appointed in 1884, and the new edition appeared in 1889, under the title: "Nederlandsche Pharmacopee. Derde Utgave (= third edition). 's Gravenhage, 1889." Excepting the titles of the official articles, the text is entirely in Dutch. This was soon followed by a Latin edition, under the title: "Pharmacopœa Neerlandica. Editio tertia. Hagæ Comitis, 1889." It was specially decreed, however, that the Dutch edition was to be considered as the official one.

In 1891 the Rotterdam Branch of the Netherlands Pharmaceutical Society (Nederlandsche Maatschappij ter Bevordering der Pharmacie) followed the lead of other countries, by issuing an unofficial formulary under the title: "Supplementum op de derde Utgave der Nederlandsche Pharmacopee. . . 's Gravenhage, 1891." It contains 573 articles.

Mexico.—The Mexican Pharmacopœia is not published by authority of the National Government, but by the Mexican Pharmaceutical Society. Two editions have so far appeared. In 1890 the Society published a supplement under the title: "Apéndice á la segunda edicion de la Nueva Farmacopea Mexicana de la Sociedad Farmacéutica de México. Escrita por la Comision Permanente de la Farmacopea." This work is a literary curiosity, teeming with blunders of fact, orthography, and nomenclature. (See review in *American Druggist*, New York, 1891, p. 291.)

Russia.—The fourth edition of the Russian Pharmacopœia was published in 1891. Like its predecessors, its text is in Russian, the titles of the articles, of which there are 808, being in Latin.

Switzerland.—The new pharmacopœia for Switzerland—Pharmacopœa Helvetica, Editio III.—has been completed and will be issued some time in the year 1893.

United States.—In May, 1890, the Decennial Convention for Revising the Pharmacopœia met at Washington, and resulted in the election of a Committee of Revision consisting of twenty-six members located in different sections of the country. Among the instructions given to this committee was, to employ the metric system of weights and measures in place of "parts by weight." At this time (June 16, 1893) the revision of the text has been completed and the work is passing through the press. A great amount of labor has been bestowed upon the new text by the members of the committee, and it is expected that it will be found to have maintained its rank among other works of this kind. It may be stated here that ninety articles, formerly official, were dismissed, and eighty-eight new ones introduced.

In 1886 the American Pharmaceutical Association undertook the publication of a National Formulary, which should provide standard formulas for the most commonly used unofficial preparations. This work was completed and published in 1888, under the title: "The National Formulary of Unofficial Preparations. First Issue. By Authority of the American Pharmaceutical Association." It contains 435 articles.

Universal Pharmacopœia.—In this place should be mentioned the work by Dr. Bruno Hirsch, of Berlin, entitled: "Universal-Pharmakopöe. Eine vergleichende Zusammenstellung der zur Zeit in Europa und Nordamerika gültigen Pharmakopöen" (= Universal Pharmacopœia. A comparative Digest of the Pharmacopœias in force at the present time in Europe and in the United States). This work contains practically the whole text of the several pharmacopœias (except that of Portugal) in such a way that the similarities and differences of the requirements of the several texts are shown at a glance in connection with each subdivision of an article. It is a work of reference indispensable for every Revision Committee in this and other countries for many years to come.

International Pharmacopœia.—The project of an international pharmacopœia does not appear to be any closer to its realization at the present time than it was five years ago. But instead of attempting the almost impossible, the advocates of uniformity in medicines appear to be willing to bring about the desired end by natural means, that is, by first causing the consolidation of the pharmacopœias of contiguous countries, particularly those in which the same language is spoken. Thus, Germany has long ago displaced the host of local pharmacopœias in existence previous to the establishment of the empire by a single national work. Italy has just done the same. The Scandinavian countries also contemplate doing this. A plan has recently been presented for the establishment of a common pharmacopœia for the American continent. This is too wide a scope to be feasible at present. But it *is* feasible to prepare a pharmacopœia for all the Spanish-speaking countries in Central and South America, provided all political differences are waived for the sake of the benefit which may accrue from the result. After some uniformity has been reached in Central and South America, it remains to be seen how much further it can be carried. It is easy to foresee that there never will be an international pharmacopœia which will replace each individual national one. The

best that can be hoped for is a work containing the description, definition, requirements of purity and strength of what may be called international remedies, single or compound, and even this cannot be introduced without risking danger from the administration of preparations the strength of which as contained in the international pharmacopœia differs from that prescribed in the national pharmacopœia of the dispenser. *Charles Rice.*

PHENACETINE. (Para-acet-phenetidine.) This well-known and popular derivative of coal tar was introduced in 1887 by Dr. O. Hinsberg and Professor A. Kast.[1] Its chemical formula is $C_6H_4OC_2H_5NHCH_3CO$. The following method is given for its preparation: para-nitro-phenol is first prepared by the action of nitric acid upon melted phenol, ortho-nitro phenol being separated by distillation, sodium para-nitro phenol is then formed by the addition of soda, and this is converted by the action of ethyl iodid into para-nitro phenetol; the latter is reduced to para-amido phenetol (para-phenetidine) which by prolonged boiling with glacial acetic acid yields para-acet phenetidine. The chemical relation of phenacetine to allied compounds will be readily understood by reference to the following formulæ:

Acetanilide, $C_6H_5{<}^{H}_{NH\ CH_3\ CO}$.

Exalgine, $C_6H_4{<}^{CH_3}_{NH\ CH_3\ CO}$.

Methacetine, $C_6H_4{<}^{OCH_3}_{NH\ CH_3\ CO}$.

Phenacetine, $C_6H_4{<}^{OC_2H_5}_{NH\ CH_3\ CO}$.

Phenocoll, $C_6H_4{<}^{OC_2H_5}_{NH\ CH_2\ NH_2\ CO}$.

Phenazone, or antipyrine, which is therapeutically allied to the above, is related only so far as all are derived from phenyl compounds; its formula is

$$C_6H_5N{<}^{CO\ CH}_{N\ CH_3\ C\ CH_3}.$$

Phenacetine forms in white, glistening, scaly crystals, without odor or taste. It is slightly soluble in cold water, 1 part in 1,500; more soluble in hot water, 1 part in 70; and freely soluble in rectified spirits, 1 part in 16; it is also soluble in glycerine. The crystals melt at 275° F. A recognized test for phenacetine is the production of a deep-red color when chromic acid is added to a cooled and filtered solution of one grain in twenty minims of hydrochloric acid diluted with ten times its volume of water. Sulphuric acid should dissolve it without color, and burned with free access of air it should leave no residue. The presence of para-phenetidine may be detected by melting forty grains of chloral hydrate in a water bath, and adding eight grains of phenacetine and well shaking; a solution takes place which is colored violet, reddish, or bluish in tint, according to the proportion of the impurity present. Another test, though less delicate, is to add eight grains of phenacetine to one and a half drachm of iodine solution, 1 in 20,000; when filtered a pure salt yields a colorless liquid; a pink tint indicates the presence of para-phenetidine. Phenacetine does not form a bromine compound as acetanilide does, and this reaction furnishes a test for the presence of the latter salt; the addition of bromine water to a saturated solution of the suspected salt, imparts a yellow color; if acetanilide is present the solution becomes turbid, if it is absent it remains clear. The presence of acetanilide, exalgine, or methacetine may be detected by adding two grains to twenty minims of concentrated hydrochloric acid; phenacetine remains undissolved, the other salts enter into solution.

Phenacetine was introduced as an analgesic and antipyretic much superior to the other similar compounds, on account of its freedom from any toxic action. It rapidly established a reputation as one of the most safe of the numerous new antipyretics, and has been very extensively employed in all febrile diseases, and for the relief of pain in all its forms. Its action is not accompanied by the numerous unfavorable symptoms that are common to the coal tar derivatives. The only undesirable effect that is occasionally caused by its use, is the onset of sweating, more or less profuse. This accompanies a rapid decline of temperature, but it is not excessive, and is not followed by any sense of prostration or depression. Although its composition is such that it may cause the alterations of the blood that are produced by exalgine, acetanilide, etc., the instances in which any such condition follows its use are extremely rare. A few cases, however, are reported in which there was paleness and coldness of the extremities, free perspiration, precordial pain, dyspnœa, shallow respiration, feeble pulse, cyanosis, and other evidences of collapse. These cases of poisoning occurred in females, and generally followed the employment of large doses; but in one case only three doses of seven grains each were given. Very large doses have been given without any ill effects. A case is reported in which sixty grains were given daily for two weeks, as an anodyne; in another case one ounce and one drachm was given during one week to a patient with neuritis, and in a case of tetanus one ounce and five drachms were given in nineteen days. During experimental research upon animals, it has been given for a prolonged period in doses equal to one and two-thirds grain per pound of body weight without producing any derangement of the system, or causing any irritation to the mucous membrane of the stomach.

The effect of the drug on the heart, and the changes in the blood-pressure that may accompany its medicinal use, appear to be uncertain. There has been comparatively little done to determine the physiological action of phenacetine, and the prevailing opinion of those who have experimented with the drug is, that there is little or no action on the heart and no alteration produced in the blood-pressure. A series of experiments on animals by Drs. Cerna and Carter[2] have led them to different conclusions, which they sum up as follows: 1. Phenacetine in moderate doses, causes a rise of the arterial pressure by acting upon the heart, and probably likewise by a stimulating influence exercised on the vaso-motor system. 2. In large amounts it causes a reduction in the pressure, which is largely of cardiac origin. 3. In small doses it increases the force of the heart by a direct action. 4. It increases the pulse-rate chiefly by cardiac stimulation, and possibly also by influencing the cardio-accelerating apparatus. 5. In large quantities, the drug reduces the number of pulsations, primarily by stimulating the cardio-inhibitory centres, and later by a depressant action on the heart. They also found that in large amounts it caused a marked quickening of the respiratory movements by a direct action on the medulla, and that where sufficient quantities were given to produce death it was due to respiratory failure.

As an antipyretic it is given in doses of eight or ten grains, every hour or every two hours. It reduces the temperature slowly and effectively; during the first and second hour there is not much influence on the fever, but in the third hour its greatest effect is manifested. The continuation of the afebrile state varies, but usually after the fourth or fifth hour the temperature begins to ascend. The fall of the temperature results chiefly from a decrease in heat-production, with a slight increase in the heat-dissipation. The slow action of the drug is thought to depend on its insolubility. In chronic febrile troubles its action is not so marked, and a tolerance of the drug appears to ensue upon its prolonged administration. When there is pain, restlessness, and insomnia accompanying the fever, the beneficial effects of the drug are most marked. A sense of ease and comfort is produced, and a calm, refreshing sleep follows. By some it has been supposed to exert a decided hypnotic action, but careful observations in melancholia and mania have not confirmed this view. In typhoid fever it has proved of great service. From five to eight grains are generally sufficient to reduce the temperature to normal in about

three hours; when it begins to rise again a second dose will prevent any hyperpyrexia for twenty-four hours. Many prefer to employ it in smaller doses frequently repeated—two grains every two or three hours and continued throughout the period of pyrexia; in this way it maintains the temperature at a low point and the fever runs a mild and uncomplicated course. In children it proves beneficial in all febrile disorders; single doses of two grains will produce a lowering of temperature, or it may be given in fractional parts of a grain every two or three hours; one-third of a grain having proved sufficient to subdue the fever and allay restlessness. During the recent epidemic of "*la grippe*" it proved very serviceable, and replaced the older antipyretics to a very great extent. In this disease the small and frequently repeated doses were of little avail, a single dose of ten or fifteen grains being generally sufficient to relieve the fever and the severe cephalalgia with which it was usually accompanied. One of its earliest applications was as an antirheumatic. It has no influence in warding off the cardiac and other visceral complications, but it reduces the fever and lessens the pain and swelling in the joints; to be of any benefit it must be employed in much larger doses than in any other febrile affection. At least fifteen or twenty grains must be given three times daily, and some state that a better effect is produced by thirty grains given twice in the day. In children five grains three or four times a day may be required. In painful affections unaccompanied by fever, and in the various forms of neuralgia, it requires to be given in the same full doses to secure a relief from suffering. A single dose of fifteen to twenty grains will prove sufficient when any benefit is to be derived, while small and frequent doses exercise very little, if any, action in controlling the pain. Phenacetine has also acquired a reputation as a remedy for whooping-cough. It is given in doses of from half a grain up to two grains every four hours, and affords rapid relief to the severe paroxysms. It is also supposed to shorten the duration of the disease.

Compared with the allied drugs, phenacetine may be said to be more pleasant and safe, but less powerful and slower in its action; and perhaps less certain, as it frequently fails to produce the desired effect.

For the purpose of testing the relative action of antipyrine, acetanilide, quinine, kairin, sodium salicylate, thallin, and phenacetine, these antipyretics were given to a tubercuIous patient under, as nearly as possible, the same conditions in regard to the height of the fever.[3] It was found that fourteen grains of phenacetine lowered the temperature more than fifteen grains of antipyrine, quinine, or kairin, and more than three and a half grains of thallin; thirty-one grains of salicylate had no effect; five grains of acetanilide acted one hour sooner and lowered the temperature a few tenths more, but the antipyretic action was not of so long duration. It was also noticed that the perspiration was not so marked as after thallin and acetanilide: there was no ringing in the ears as after sodium salicylate, no dizziness as after quinine, and no chilly sensation such as often follows acetanilide.

Dr. A. Crombie,[4] Superintendent of the Government Hospital, at Calcutta, has given a very valuable *résumé* of his observations upon the comparative value of acetanilide, antipyrine, and phenacetine, as antipyretics, in which he arrives at the following conclusions:

"First, as regards efficacy, antipyrine comes first, and there is little to choose between antifebrine and phenacetine in the doses in which I have prescribed them.

"Second, that as regards safety, the advantage lies with phenacetine. I have never seen a subnormal temperature result from the use of that drug. I have seen subnormal temperatures as the result of the use of antifebrine, but never collapse, which I have once seen follow the use of antipyrine.

"Third, as regards rapidity of action, antipyrine, probably on account of its solubility, comes first, antifebrine second, phenacetine third. The fall after the use of phenacetine is more gradual, and the minimum is not reached for three, four, or even five hours after the administration of the drug.

"Fourth, as regards duration of effect, the advantage lies with phenacetine.

"Fifth, as regards certainty of action, I would quote them in the same order as that of rapidity—antipyrine, antifebrine, phenacetine. And here let me give a warning against the use of phenacetine tabloids. They are so hard as to be practically insoluble in the stomach, or at least to be so slowly dissolved that a very small quantity of the drug enters and circulates with the blood at one time, not sufficient to affect the temperature. It should be prescribed either in powders or in lozenges, which are soft and pliable.

"Sixth, as regards inconveniences, in the climate of India phenacetine is followed by just as profuse sweating as either antifebrine or antipyrine, and this, to my mind, is the great drawback in the use of antipyretics, patients having to change their clothing once or twice in a night after the use of any of these drugs. Whether or not an antipyretic will yet be found which will be capable of safely reducing abnormal temperature without causing profuse perspiration, remains to be seen, but as yet we do not possess one." *Beaumont Small.*

[1] Centralb. f. Gesam. Therap., April, 1887.
[2] Therapeutic Gazette, March, 1893.
[3] Sajous: Annual of Med. Science, 1890.
[4] The Practitioner, xliii., p. 266.

PHENAZONE. "ANTIPYRINE." "ANALGESINE"

(Phenyl-dimethyl-pyrazolone). C_6H_6N, COCH, NCH_3 CCH_2. This popular antipyretic was made known to the profession by Ludwig Knorr in 1884. It is a coal-tar derivative which is prepared after a patented process, by the action of acetyl-acetic ether upon phenyl-hydrazine. It is a base somewhat analogous to ammonia, and has the property of combining with an acid or an alkali to form salts.

It occurs in colorless, scaly crystals, without odor and possessed of a somewhat bitter taste. It is readily soluble in water, alcohol, and chloroform, less so in ether, about one part in fifty. The melting point is 110° C. Ignited with free access of air it burns without residue.

Antipyrine may be detected from all other organic compounds by the action of ferric chloride; this producing a deep red color which is discharged by the addition of dilute sulphuric acid in excess. Other compounds produce various colors and differ in the effect of the sulphuric acid. The bright-red color is clearly visible in 1 to 100 solution; in 1 to 100,000 a light brown, and in 1 to 500,000 a light yellow color is produced. Nitrous acid added to a solution forms a green color, and nitric acid a yellow color which deepens to crimson on warming. Both these tests are characteristic of antipyrine. The presence of acetanilide is also detected by the melting point of the suspected salt. The two compounds melt approximately at the same temperature, but a mixture of the two reduces the melting point very decidedly, equal parts melting at 45° C. Many other distinctive tests have been proposed. In 1 to 1,000 solutions, iodine and iodide of potassium produce a reddish-brown, potassio-mercuric iodide a white, and potassio-bismuthic iodide an orange-red precipitate. In 1 to 100 acidulated solutions, Nessler's reagent, mercuric or auric chloride, and tannic acid, produce colorless or yellow precipitates; picric acid a yellow; and ferrocyanide of potassium a bluish-green precipitate.

The solubility of antipyrine and its action as an alkaloidal base, render many drugs and preparations incompatible, and not infrequently some very unsightly as well as inert mixtures are ordered by the physician. E. J. Millard and A. C. Stark[1] describe a series of experiments made for the purpose of testing the compatibility of antipyrine with the whole of the drugs and preparations of the pharmacopœia that are likely to be prescribed in combination, together with many that are unofficial. The following is the list they have prepared and the changes that are produced:

Acid., carbolic.: precipitated.

Acid. hydrocyan. dil. : yellow coloration
Acid. nitric. dil. : faint yellow coloration.
Acid. tannic. : white insoluble precipitate.
Alumen (ammonia) : deep yellow coloration and precipitate.
Amyl nitrite (acid) : green coloration.
Arsen. iodid. : precipitate.
Chloral hydras : precipitates in strong solution, no apparent action in dilute.
Cupri sulphas : solution turns green.
Dec. cinchonæ : precipitate.
Ext. cinchon. liq. : precipitate.
Ferri sulph. : brownish-yellow color and precipitate.
Glycer. ac. carbol. . precipitate.
Glycer. ac. tannic. : precipitate.
Hydrarg. perchl. : precipitate.
Infus. catechu conc. : precipitate.
Infus. cinchon. acid. : precipitate.
Infus. rosæ acid. : precipitate.
Infus. uvæ ursi : precipitate.
Liq. arsen. et hyd. iod. : precipitate.
Liq. ferri perchlor. : }
Liq. ferri pernit. : } blood-red coloration.
Liq. ferri persulph. : }
Liq. pot. permang. . reduction quickly takes place.
Sodii salicylas : liquefies.
Spts. ætheris nit. (acid) : green coloration.
Syr. ferri iodid. : reddish-brown coloration.
Tinc. catechu : precipitate.
Tinc. cinchonæ : precipitate.
Tinc. cinchon. co. : precipitate.
Tinc. ferri perchl. : red coloration.
Tinc. gallæ: precipitate.
Tinc. hamamelid. : precipitate.
Tinc. iodi. : precipitate.
Tinc. kino : precipitate.
Tinc. laricis : precipitate.
Tinc. rhei : precipitate.

It was found that with dilute acids no change took place, as with sulphuric, hydrochloric, nitric, and phosphoric acids, soluble salts were formed. The changes that take place with amyl nitrite and nitrous ether only occur when the preparations are acid and contain free nitrous acid, but as this is generally present under ordinary circumstances, these compounds should never be prescribed with antipyrine. Calomel is considered to form a toxic compound when combined with antipyrine, but these observers were unable to notice any change, and mercuric chloride could not be detected in the mixture. Sodium bicarbonate, when triturated with antipyrine, causes a decomposition and disengages the odor of ether. Many substances combine with antipyrine to form stable and definite chemical compounds. Some of them have proved to possess important therapeutic properties and their number is constantly being increased. The most important of these are iodopyrine, salipyrine, and hypnal (*q. v.*). *Naphto-pyrine* is formed when antipyrine is triturated for a length of time with beta-naphthol, one part of the latter with two parts of the former. It assumes the character of a tough mass which gradually forms into crystals when kept for a length of time. It is insoluble in water, soluble in alcohol and ether. A more recent method of preparing the drug is by dissolving one hundred and fifty grammes of naphthol in ninety per cent. alcohol, and adding to it gradually one hundred and ninety grammes of antipyrine dissolved in the smallest possible quantity of water. The mixture is to be constantly stirred, and in a few minutes it becomes clouded and then clear ; the pure crystals being deposited.

Antipyrine benzoate is formed by the addition of antipyrine to a boiling aqueous solution of benzoic acid. It is slightly soluble in cold and boiling water, but very soluble in alcohol and ether. It has a pungent taste and a slight odor of benzoic acid. A *citrate* and *picrate* may be prepared in the same way.

Pheno-pyrine is prepared by mixing equal parts of crystalline phenol and antipyrine. It forms an oily liquid, free from color, insoluble in cold and sparingly soluble in hot water.

Pyrogallo-pyrine is obtained by the interaction of pyrogallol and antipyrine in substance or in solutions. It is a crystalline substance, sparingly soluble in hot or cold water, but soluble in alcohol and ether.

Resopyrine results from the interaction of solution of resorcine and antipyrine ; an oily mass is formed which solidifies into a hard, white, opaque body. From an alcoholic solution it forms in crystals. It is not soluble in water, but soluble in alcohol, ether, and chloroform. All these compounds are of recent origin, and their properties have not yet been studied ; they are introduced to secure the combined action of their constituents and are yet under observation.

The physiological effect of antipyrine has received more attention than many of the later derivatives of the same character ; but the manner in which it subdues pain is as yet uncertain. In medium doses it is found that antipyrine depresses the reflex functions of the cord ; larger doses cause convulsions, and these are followed by paralysis. The primary depression is considered to be due to the stimulation of the inhibitory muscular tracts ; a continued irritation exhausts the inhibitory mechanism, and in consequence convulsions follow and ultimately complete exhaustion and paralysis. The train of symptoms that follow the administration of a fatal dose to animals is very similar in all cases.[2] There is generally marked salivation and lachrymation very quickly following the dose, crying and other signs of distress, and in a short time ataxia. This is followed by a convulsive stage, during which spontaneous convulsions are frequent, and are easily caused by flashes of light, clapping of hands, etc. ; following this, paralysis, insensibility, and death. Respiration and the heart are greatly hurried, and death occurs during a convulsion or from paralysis of respiration. The heart generally continues to beat for some time, and is finally arrested in diastole.

Upon the sensory nerves, antipyrine acts as an anodyne both when administered internally or when locally applied. This effect is early manifested, and before the convulsive stage begins it has been shown that animals can be operated upon without causing any pain. The muscular sense is also lost early, the signs of ataxia being one of the first symptoms noticed and one of the last to pass off ; the special senses are at first rendered more sensitive, but this is quickly overcome and complete anæsthesia produced.

The antipyretic properties are considered due to the action of the drug on the heat centres. Some experimenters state that the decrease in the production of heat is greater than the dissipation, while others are of an opposite opinion ; all, however, concede that both factors exert their influence, and owing to their combined action the reduction of temperature is rapid and decided

Antipyrine exerts a very decided action upon the respiration. Even in small doses it has been known to greatly accelerate the number of respirations, and in all cases in which toxic doses are given the rapidity is excessive, and, as a fatal termination approaches, the expirations become spasmodic in character. This has been shown not to be influenced by the section of the vagus nerves, and is assumed to be due to a direct action on the respiratory centre in the medulla oblongata.

In moderate doses very little effect is produced on the circulation, but in large doses it weakens the heart and causes depression and collapse. Drs. Cerna and Carter[3] formulate the following conclusions, which, in general, coincide with the work of previous observers : (1) In small and moderate amounts it produces a rise of the arterial pressure, this stimulating effect being due to an action on the heart. (2) A lowering of the pressure by large and toxic doses is due similarly to a depressant action of the drug upon the cardiac organ. The remedy does not appear to affect the vaso-motor system. (3) Antipyrine causes an increase in the pulse-rate through paralysis of the cardio-inhibitory centres. The secondary decrease in the number of pulsations is of a purely cardiac origin, the drug exercising a depressant effect upon the heart itself.

Upon the blood there is no effect when moderate doses

are administered; in large quantities, however, it produces a chocolate coloration of the blood which is due to the alteration of the hæmoglobin into methæmoglobin. There is no alteration of the corpuscles caused by the drug itself, but ultimately its administration may lead to a diminution in number from the exhaustion and debility produced.

In many instances antipyrine exerts an irritant action on the stomach and causes nausea and vomiting. Another objection to its employment is the copious perspiration that is frequently produced, and which generally accompanies a rapid reduction of temperature. A rash of the character of urticaria, in some cases described as resembling measles and scarlatina, is caused in some patients. It generally follows the use of the drug for a length of time, but in many instances a single small dose has had this effect. The toxic symptoms produced when the drug has been given in very large doses are convulsive in character, and in accord with the symptoms observed in experimental research upon animals. In lesser quantities, and often in ordinary doses, very unfavorable symptoms occur, the result of a depressant action. Collapse of the most alarming character sometimes follows ten- and fifteen-grain doses, and this is often accompanied by cyanosis, and swelling of the eyelids and extremities. The milder symptoms of a toxic action are a rapid and weakened heart, shallow respiration, dyspnœa, oppression in the chest and in the head, giddiness, vertigo, numbness of the surface, irritation of the mucous membranes and skin, and many other symptoms indicating a depression of the circulation and nervous system. This undesirable action is the one great drawback of what is undoubtedly the most efficient antipyretic and analgesic compound that has yet been produced. To this is to be ascribed its decreased employment, as the frequent onset of alarming symptoms, often as sudden as they are unexpected, has caused the profession to avoid its employment in many cases in which it undoubtedly would prove of service. A careful consideration of cases in which it is given will generally enable one to avoid these dangers. It is advised to have caution in cases of cardiac debility and whenever the respiratory organs or kidneys are interfered with. The remedy must also be cautiously given to the aged.

Antipyrine is rapidly absorbed, its effects are quickly produced; its elimination from the system begins within a short time after its administration, and it is entirely removed within comparatively a few hours. In children it has been noticed that there is apparently a tolerance of the drug, as very large doses may be given without producing ill effects. That this might be due to a rapid elimination led to a series of observations,[4] which led to very interesting results. The urine of children, adults, and aged, to whom eight grains were administered, was systematically examined to determine the first appearance of the drug and the length of time it continued to be excreted. It was found that with all the subjects excretion began within fifty minutes, and within an hour the drug was present in abundance. The excretion, however, was most rapid in the children. With them it could not be detected after fifteen or twenty hours, with adults it was present for twenty-four or thirty hours, and with the aged its excretion was still more slow. When the dose was increased it was found that its first appearance in the urine was not changed, but its elimination was much prolonged.

When antipyrine was introduced as an antipyretic the dose recommended was thirty grains in a single dose, which was to be repeated in four hours if the pyrexia was present, and a third dose of fifteen grains was to be given in another four hours if there were any signs of a rising temperature. This medication produced a decided reduction in the fever, and maintained a condition of apyrexia for twenty-four or forty-eight hours; it was, unfortunately, often accompanied by the profuse sweating and signs of collapse, and was soon abandoned. It is now given in doses of ten to fifteen grains, which may be repeated at short intervals if no effect is produced. The fall of temperature generally begins in from half an hour to one hour, and the lowered temperature is maintained for several hours. In some instances the fall is very rapid, a decline from 103° to 96° F. taking place. Sometimes it is necessary to repeat the dose very frequently before any effect is produced, it, apparently, being necessary to saturate the system before freedom from fever is secured. In typhoid fever, and in all febrile disorders in which there is a periodic rise and fall of temperature, the time of its administration should be observed, as its action is much more marked when it coincides with the decline of the fever. In typhoid fever it is rarely employed as a mode of treatment by the continuous administration of the drug; it is only considered of value as a means of reducing hyperpyrexia. Its use in tubercular troubles is not looked upon with much favor, on account of the perspiration that is caused. It has been suggested to combine atropine with it as a means of counteracting this effect. In rheumatic fever it has been advocated by many as a remedy superior to the salicylate; in these cases it is given in fifteen- or twenty-grain doses five or six times a day. In many instances it has secured relief from pain when salicylate of soda has failed, but it has not proved itself equal to the older remedy in the treatment of rheumatism in any form when accompanied by fever.

Although introduced as an antipyretic, antipyrine was soon found to possess very decided analgesic and anodyne properties, and the latter application of the drug has almost eclipsed its earlier use. In all forms of pain of a neurotic origin, or in nervous diseases accompanied by pain, it has proved itself of especial value. It has been used with success in neuralgia, migraine, sciatica, and lumbago, in the pains of tabes dorsalis, in the pains of angina, and in those arising from aneurism. It has been found to replace morphine in renal colic and asthma, and even proved itself superior, as it in no way deranged the secretion. It has been used in all conditions in which the hypodermic use of morphine is generally resorted to, and has been found a very efficient substitute in the greater number of cases. As a remedy for headaches of a nervous origin it is very beneficial. In the forms peculiar to growing children, and in those accompanying anæmia and debility, it has been recommended by Germain Sée, who employed it in a large number of cases with marked success. The same observer also considers it of value in pain of a rheumatic character unaccompanied by fever. Although inferior to the salicylates in the febrile forms, he considers it decidedly superior to all other drugs when there is no fever. In the pains of dysmenorrhœa and other pelvic disorders it has also been employed with success. Its use in such cases is indicated when the suffering is of a nervous character, as the drug exerts no influence on the uterine contractions and fails to relieve the pains that arise from the efforts of the uterus to expel its contents. In obstetrical practice it has allayed much of the suffering that accompanies labor. Its effect resembles that of chloral. In the first stage, in primiparas and in neurotic patients, it lessens the rigidity of the os and allays the painful spasmodic action. In tedious labor it lessens the exaggerated nervous pain which often in a reflex manner interferes with the efficiency of the uterine contractions. It is useless for the pain of the second stage, which is mechanical in its character. For the after-pains, due to the expulsion of clots, it is without effect, but in those that are of a grinding or neuralgic character it affords marked relief. The employment of the drug does not in any way increase the tendency of post-partum hæmorrhage. It exercises no ecbolic action, and has proved of service in allaying the pains and checking the progress of threatened abortion. It has been recommended in cases in which it is desired to reduce the secretion of milk. Cases are reported in which doses of eight grains lessened the amount within a day and checked it altogether in three days. Its action is not always so effective, as it frequently fails to secure the desired result. As it is not excreted with the milk it may be safely given without affecting the child.

The action of antipyrine on the spinal cord and nerve-

centres has led to its employment in many diseases of a neurotic character. In chorea it has proved useful, both in cases traceable to rheumatism and in those in which there was no such history. In a report[5] of sixty cases in which it was used, it was found to benefit two-thirds, diminishing the severity of the attack and shortening its duration. Recurrence, however, was noticed in three-fifths of the cases. It was found necessary to give large doses, from three to six grammes daily being required. This was found to be well tolerated for several weeks, and serious symptoms of poisoning were never noticed. Antipyrine was suggested as a remedy for pertussis by Sonnenberger, in 1887, and it has been used for this purpose to a very great extent, with varying results. The dose should be from two grains upward, according to the age of the child. One and one-half grain for each year has been advised; for infants of a few months of age one-half to three-quarter grain is sufficient. In many of the cases reported remarkable effects have been announced, the disease having been cut short in a few days. This drug has also proved of service for enuresis, when of nervous origin and due to irritability of the bladder. It has also been employed in epilepsy, but not with encouraging results. From time to time cases have been reported of diabetes that have been successfully treated with antipyrine. The quantity given has ranged from two grammes to six grammes daily. In some instances the excretion of sugar was wholly checked; in the majority it was lessened in quantity and the patient relieved of all troublesome symptoms. The most marked effects were noticed in nervous patients and when the polyuria was excessive. The diet must not be neglected.

Antipyrine possesses a decided antiseptic action, and it has been suggested that this should be utilized both by internal administration and as a local application. It has been shown that a two and a half per cent. solution prevents the development of the bacillus of diphtheria in various cultures, and a five per cent. solution applied to a culture containing the bacillus destroyed it in twenty-four hours. It has also been found to exert a powerful neutralizing action on the toxins of diphtheria. Applications to the throat and the internal administration are advocated in this disease, but there has not yet been any evidences of its beneficial effects.

In stomachic disorders and diarrhœas of children it has been employed on account of its effect in checking fermentation. It is given in doses ranging from one-half to one or two grains.

The local application has proved of decided value as an astringent and anæsthetic remedy in various troubles of the nose, throat, and larynx; a solution of the strength of about four per cent., used as a spray or painted directly on the mucous membrane, allays the congestion and lessens the sensibility and irritability of the part. It at first causes a sense of heat and smarting, but this rapidly passes away and is followed by ease and comfort, and freedom from all the painful sensations that may have accompanied the inflamed condition. The sensitiveness of the nasal membrane is more marked than that of the pharynx, and an application of cocaine is often required before the antipyrine can be applied; in such cases it is advisable to begin with a one per cent. solution. The powdered drug, or concentrated solutions, have been found to exert an anæsthetic and very astringent action, and have been used for the treatment of tubercular disease and other painful affections, and in conditions where there is a reflex element present. When applied in these concentrated solutions the anæsthesia is complete, and lasts for one or two hours. It may be applied as a spray, or by means of cotton wrapped around a probe, or the impalpable powder may be blown upon the mucous membrane. The burning sensation produced at first is rapidly overcome and is followed by comfort and freedom from pain.

Antipyrine has also been used in the treatment of certain forms of eye disease. Weak solutions of from one to three per cent. have been used with advantage in simple acute or chronic conjunctivitis. Under the influence of three or four washings a day, the secretion diminishes and a cure is rapidly effected. The solution at first causes a sensation of burning, which may be painful, but this lasts only a few moments and is followed by relief from all distress. Antipyrine[6] has recently been used to replace jequirity in the treatment of scrofulous pannus which has resisted other methods. The eye is to be rendered anæsthetic with cocaine, and a thin layer of antipyrine is deposited on the cornea with a brush, or by means of an insufflator. In spite of the cocaine the patient complains of pain and burning, and there is more or less lachrymation. When this reaction subsides the eyeball is gently massaged through the closed lid. The inflammation that arises varies in intensity, and from one to several days must elapse before repeating the process. The contra-indications to this treatment are the presence of corneal ulcerations and phlyctenular keratitis. The most suitable cases are those in which there is extensive proliferation of the blood-vessels.

A very important property of antipyrine is its power of controlling hæmorrhage. When placed in contact with blood at its normal temperature it thickens and condenses it without causing coagulation. When a concentrated solution or the powdered drug is applied to a mucous membrane it causes an anæmia more or less marked, according to the strength of the solution. When applied to an animal's mesentery the blood grows darker in color, the circulation becomes slow and ultimately ceases, and the parts appear almost bloodless after the application of a fifty per cent. solution. This styptic action may be secured by applying a plug of cotton saturated with a fifty per cent. solution to the bleeding surface, or the powdered drug may be used. This action has been confirmed in numerous cases of epistaxis, bleeding tonsils, after the extraction of teeth, and even in cases of uterine hæmorrhage. In many instances it has been found that a ten per cent. solution was sufficient in ordinary hæmorrhage from mucous membranes. In hæmoptysis of phthisis its internal administration was thought to prove beneficial, but the large quantities required to produce this effect were accompanied by dangerous symptoms.

To secure the full benefit of antipyrine as an anodyne, and upon the nervous system, it requires to be given in doses of fifteen to twenty grains, and repeated hourly until the desired effect is obtained, or until sixty to ninety grains have been given. This quantity has been maintained for a prolonged period without any ill effects, and to children much greater quantities in comparison have been given. It is generally administered in solution, and it is considered advisable to combine it with alcohol, ammonia, or some diffusible stimulant to counteract the tendency to depress the heart. The hypodermic injections have been advocated when it is desired to secure a local anodyne action. The effect is noticed in ten or fifteen minutes, and lasts for six or eight hours. The usual dose is about four grains in ten minims of water, and when the painful area is great a number of injections are required. Cocaine often has to be added, as much pain is sometimes experienced. This method of administering the drug is not without its dangers, as it has produced gangrene of the toes when injected for painful affections of the foot. When the stomach is irritable and rebels against antipyrine, or when a local action on the pelvic organs is wished for, it may be given as an enema: antipyrine, 10 to 20 grains; tinc. opii, 5 minims; aquæ, 4 ounces. It may also be prepared as a suppository where such can be used with convenience. *Beaumont Small.*

[1] The Druggists' Circular, August, 1890.
[2] Johns Hopkins Bulletin, April, 1890.
[3] Notes on New Remedies, 1892.
[4] British Medical Journal, July 11, 1891.
[5] British Medical Journal, January 17, 1891.
[6] Therapeutic Gazette, December, 1892.

PHENOCOLL. (Amido-acet-para-phenetidine.) During the past few years our knowledge of the chemistry of modern antipyretics has so far advanced that new synthetical remedies are now produced, the therapeutic properties of which have been carefully considered before-

hand. Such an one has been prepared by German manufacturers, and introduced under the name of phenocoll. It is said to be an antipyretic, possessed of all the favorable qualities of the older compounds, and devoid of any of their undesirable effects. Of the numerous antipyretics that have been discovered, only acetanilide, phenazone, and phenacetine have been received with any favor, and each one has its objectionable quality. To remove them has been the aim of the chemist, and numerous experiments have been made by rearranging the groups of molecules, or introducing new groups, with the hope of forming such a compound as phenocoll claims to be. Antipyrine and phenacetine appeared the most suitable for experimental work, and the endeavor has been, on the one hand to render the former less toxic, and on the other hand to increase the solubility of phenacetine and make its action more rapid. The comparative harmlessness of phenacetine is believed to be dependent, not alone upon its insolubility, but also upon the presence of the oxyethyl group. Hence it was suggested that the toxicity of antipyrine might be diminished by the introduction of this, or a similar group, into its composition. This, however, has not proved a success as yet. The experiments with phenacetine were more successful, and the subject under consideration is the result of the work in this direction. Very many experiments were made with a variety of groups of molecules, but generally when the solubility was increased the antipyretic action was sacrificed or some undesirable effect introduced. The object was at length attained by replacing in phenacetine one hydrogen atom of the acetyl group by the amido group NH_2. The preparation is effected by the interaction of phenetidine (vide phenacetine) and glycocoll or amido-acetic acid. The following equation expresses the reaction that occurs :

$$C_6H_4\ OC_2H_5\ NH_2 + CH_2\ NH_2\ CO_2H = C_6H_4\ OC_2H_5\ NH\ COCH_2\ NH_2 + H_2O.$$

Phenocoll, the base, forms in white acicular crystals which have a tendency to mat themselves together. It is readily soluble in alcohol and warm water, but only slightly in chloroform, ether, and cold water. Dilute caustic alkalies, or dilute acids when cold, have no power to split up the compound, but by prolonged boiling it is resolved into its constituents. The most important characteristic of this compound is its power of combining with acids and the formation of soluble salts.

The *hydrochloride of phenocoll* is the salt generally employed, but salts have also been formed with other acids. The *acetate* is soluble in two and a half parts of water, and is more suitable for subcutaneous use, besides being milder in taste than the hydrochloride. The *carbonate* is a bulky, almost tasteless powder, not very soluble in water, but readily dissolved by weak acids. The *salicylate* occurs in long needles, it has a sweetish and not disagreeable taste, and is supposed to add some of the therapeutic properties of salicylic acid to phenocoll.

Phenocoll hydrochloride is a white, minutely crystalline powder, with a bitter, saline, but not disagreeable, taste. It is soluble in cold water, about one part in sixteen, forming a neutral, stable solution. It is still more soluble in hot water and in alcohol. The following tests are given for its purity. Half a gramme should dissolve and form a clear solution in 15 c.c. of water ; the solution should not turn litmus paper blue. Solution of ferric chloride should produce in the solution only the faint yellow color of iron salts, but not a red coloration even upon heating. Heated to 60° C., and treated with a few drops of solution of sodium carbonate, the aqueous solution should not give off the odor of ammonia. With a few drops of solution of caustic soda, the phenocoll base should be thrown down as a white crystalline mass. Burnt on platinum it should not leave any residue.

The superiority claimed for it over other antipyretics, lies not only in its greater solubility and more rapid action, but also in its perfect harmlessness. Professor Kobert states that experiments have demonstrated that it does not produce any change in the character of the blood, and very large doses have been given to animals without any deleterious effects. The result of experiments by Dr. Isaac Ott, however, shows that in very large quantities it produces the same effects as phenacetine and similar compounds. He reports : 1, that upon frogs it produces a general paralysis, due to an action upon the cerebro-spinal axis ; 2, upon rabbits it produces a cyanotic condition of the ears, and reduces the force and frequency of the heart ; 3, it kills through an action upon the centre of respiration.

That it may exercise a toxic action when administered for its therapeutic action, is also evident from a case reported by Dr. Herzog, in which severe symptoms of dyspnœa, cyanosis, and heart-weakness were produced in an emaciated consumptive patient. When administered for medicinal purposes, it produces a rapid and marked diminution of temperature without any corresponding depression of the system. Fifteen grains are stated to be equal to twenty or thirty of antipyrine, or twelve or fifteen of phenacetine. As an antipyretic it is recommended to be given in doses of eight grains, frequently repeated, in some cases every hour, until a lowering of temperature is noticed ; or it may be given in fifteen-grain doses, repeated once or twice a day. As much as seventy-five grains have been required in some instances to maintain a condition of apyrexia. In rheumatic fever it reqnires to be given in the full doses of fifteen grains ; from the report of cases treated it promises to be a remedy of some value, the pain and swelling of the joints is relieved with the lowering of temperature, and in a few days the disease is apparently under control. In addition to its use in the many forms of febrile disease, it has been found to be of service in malarial fever. Dr. Peter Albertoni was the first to call attention to its anti-periodic action at a meeting of the Bologna Medical Society, December, 1891. He first corroborated the statements regarding its therapeutic effects in fever and its freedom from injurious action, and then with the co-operation of other physicians residing in malarious districts, employed it in malarial fevers of all types. It was used in thirty-four cases, with a permanent success in twenty-four, doubtful results in five, and failure in the other five. It was given in fifteen-grain doses, in powder, six or seven hours before the expected paroxysm Very recently Dr. F. Cervello, of Palermo, reports its use in eighteen cases of quotidian, tertian, and erratic ague, in which fifteen were cured. He states that it should be given in twenty- to twenty-five-grain doses, repeated twice or three times at intervals of two hours, in such a way that the last dose shall be taken about two hours before the beginning of the attack. He considers that it is superior to quinine in many cases, particularly in the malignant forms of malaria, on account of its rapid absorption and powerful antipyretic action.

The antipyretic action of the drug is noticed within an hour, and the lowest temperature is reached within two or three hours. The effect is rapidly overcome and the rise in temperature takes place rapidly. It is excreted by the kidneys, and within twenty-four hours of its administration no trace can be detected in the urine. During its employment, the urine has been noticed to acquire a dark color, but no albumin is present and the kidneys are not in any way injured. The sweating, that often occurs, is most severe in those troubled with night-sweats, and in these cases may be overcome by the simultaneous administration of $\frac{1}{100}$ or $\frac{1}{60}$ grain of atropine. The reaccess of fever in these cases is often accompanied by more or less shivering and chilliness.

The investigations and clinical reports upon the action of this new remedy have been chiefly made in Germany by Hertel, Jacobi, Herzog, and Cohnheim, but Drs. Cerna and Carter, of Philadelphia, have done some very thorough experimental work, to determine the comparative action of antipyrine, phenacetine, and phenocoll. They consider that in ordinary medicinal doses phenocoll exercises a slightly stimulant action upon the circulation, and when it causes a depressant action, it does so in excessive amounts only. The following are their conclusions regarding its action on the heart and circulation :

1. Phenocoll, in ordinary amounts, has practically no effect upon the circulation.

2. Large doses diminish the blood-pressure by influencing the heart.

3. Phenocoll reduces the pulse-rate by stimulating the cardio-inhibitory centres. It then increases the rapidity of the pulse by paralyzing said centres. The final diminution is of cardiac origin.

4. Upon the blood itself phenocoll has no action.

As to the relative action of the three antipyretics that were experimented with, they sum all as follows :

1. Antipyrine, phenacetine, and phenocoll all fail to produce any effect on the heat functions of the normal animal.

2. Antipyrine produces a decided fall of temperature in the first hour after its administration in the fevered animal. This reduction is due to a great increase in heat-dissipation, together with a fall in the heat-production.

3. Phenacetine, both in septic and albumose fevers, produces a very slight fall of temperature during the first and second hours after its ingestion by the stomach, but the greatest reduction occurs the third hour after its ingestion. The fall of temperature results chiefly from a decrease in heat-production, with a slight increase in the heat-dissipation. The increase in dissipation is not as great as with antipyrine. Probably the delayed action of the drug depends on its insolublity.

4. Phenocoll causes in fever a very decided fall in temperature, which occurs the first hour after the administration of the drug by the stomach. This reduction is the result of an enormous diminution of heat-production, without any alteration of heat-dissipation.

Phenocoll has not been much employed in this country, and reports of its use are very meagre. The reports which have appeared are generally in its favor, but a few are not so enthusiastic over its properties ; they have found its action very rapid and evanescent, and the sweating that often accompanies its action makes its effects much more uncomfortable than those of phenacetine. The drug requires to be more studied and its unfavorable effects carefully considered, before its exact position as a remedial agent is secured. *Beaumont Small.*

PHENOSALYL. This compound antiseptic has received some attention from the fact that it is the result of a series of experiments upon the various antiseptics by Dr. de Christmas, in the Pasteur Institute, Paris. This gentleman has given a great deal of attention to the combining of well-known antiseptics for the purpose of increasing their germicidal properties. He has shown that when certain antiseptics are associated together in one and the same solution, the microbicide power is greater than the sum of the solutions of each acting separately. Among the most efficient of these combinations he gives the following :

Benzoic acid	1 part.
Carbolic acid	8 parts.
Zinc chloride	1 part.

and

Carbolic acid	8 parts.
Benzoic acid	1 part.
Oxalic acid	1 part.

or

Salicylic acid	1 part.
Carbolic acid	9 parts.

A one to one hundred solution of these mixtures kills, it is claimed, the staphylococcus aureus in thirty seconds ; the bacillus anthracis, bacillus pyocyaneus, and the bacillus of Eberth in one minute.

A still more powerful mixture was prepared by combining

Carbolic acid	12 parts.
Salicylic acid	1½ part.
Peppermint oil	1 part.

More recently he has constructed the preparation to which he has given the name phenosalyl, and this he considers the most efficient antiseptic that he has formed, its action on the various bacteria being exceeded only by sublimate. It has the following composition :

Carbolic acid	90 parts.
Salicylic acid	10 parts.
Lactic acid	20 parts.
Menthol	1 part.

The three acids are heated up to the point of liquefaction, when the menthol is added. It is very soluble in glycerine, and in water to the extent of four per cent.
Beaumont Small.

PHENYLHYDRAZINE. This powerful reducing agent has been employed as a very delicate test for the presence of sugar in urine. It was discovered by Emil Fischer, and may be prepared by reducing diazo-benzine chloride by means of the action of hydrochloric acid and tin. Its chemical formula is C_6H_6NH.

The application of this substance as a test for sugar was introduced by Professor Fischer, but a modification of his method, proposed by Bond and Ultzman (*Medical News*, 1887, 146), is that which is followed for the detection of sugar in the urine. This is applied as follows : in fifteen cubic centimetres of urine in an eight-inch test-tube, dissolve by agitation one gramme of phenyl-hydrazine hydrochlorate and two grammes of sodic acetate. Gently raise to the boiling point, which is to be maintained for half a minute, then set aside for a period varying from a quarter of an hour to twenty-four hours, according to the amount of glucose suspected. The sediment is to be examined with a ×200 or ×300 lens. The phenylglucosazon will be recognized as sheaves, sprays, or stars of delicate yellow, needle-like crystals, very similar to tyrosin excepting in color, the latter always being white. The essential feature of the crystals is the delicate acicular form. The advantages claimed for this test are : 1. Normal urine does not respond to the test. 2. It will detect one-fortieth per cent. of diabetic sugar. 3. Other substances (save albumin, which must first be removed if in any amount) do not disturb its sensitiveness. 4. Alkaline or acid, cloudy or clear, urine may be used. 5. If typical crystals are found, the proof of the presence of sugar is absolute. 6. It requires no special skill to prepare and examine the specimen. When the phenylhydrazine is in excess, various-sized reddish and yellowish globules are present in the field, and these at times have short acicular offshots which have no diagnostic significance.

This is probably the most delicate and trustworthy test we possess for the qualitative examination for sugar, as no other known substance is capable of detecting less than one part in four thousand, which is possible by this reagent.

Phenyl-hydrazine enters into the formation of many antipyretic compounds, notably antipyrine and hydracetine (*q. v.*)

Phenyl-hydrazine levulinic acid, under the registered title of *antithermin*, has been used as an antipyretic in doses of five grains. It occurs in white crystals, insoluble in water, slightly soluble in alcohol. It is but little used, as its action is uncertain, and not so reliable nor so safe as that of antipyrine and other similar preparations.
Beaumont Small.

PHLORIDZIN. A glucoside obtained from the root-bark of the apple, pear, cherry, and other fruit-trees. Its chemical constitution is $C_{21}H_{24}O_{10}$, $2H_2O$. It forms in fine, colorless, silky needles, soluble only in one thousand parts of cold water, but freely soluble in boiling water. It is only slightly soluble in alcohol. It melts at a temperature of 222° F., but becomes solid again at 226° F., and melts a second time at 335° F. Phloridzin is very similar to salicin, and heated with potash it yields phloretic acid, which is homologous with salicylic and anisic acids.

It has been employed as an antipyretic in doses of fifteen to thirty grains, but is not now used.

Phloridzin is now utilized in physiological research, as it has been found to induce artificial diabetes. When given to the extent of eight grains per pound of body weight it causes an excretion of sugar which continues for twenty-four or thirty hours. It sometimes produces diarrhœa, but no other ill effect has been detected.

Beaumont Small.

PHOTOXYLIN. A nitro-cellulose, similar to collodion or pyroxylin, but prepared from wood-wool.

A three to five per cent. solution in equal parts of alcohol and ether is recommended to replace collodion in plastic surgery and other conditions in which such an application is suggested. The solution forms a thick liquid, which on evaporation leaves a firm, dense film, which is stronger than that of collodion.

Beaumont Small.

PICHI. The Chilian name of *Fabiana imbricata*, a member of the order Solanaceæ, indigenous to South America. It is very common in Chili and grows upon high, dry hills, and in appearance greatly resembles the "heather" in appearance. The broadly ovate, thick leaves, about a line long, are densely crowded upon the small branches, and whitened at their bases and edges by a profuse deposit of resinous matter. The branches bear a single large white flower in the second year. "The calyx is free, but closely investing the ovary, to which it adheres by the resinous exudation; it is short and open bell-shaped. The corolla is persistent and is borne on an orange-colored disk one-half inch long; it closely invests the ovary, and, slightly contracting above, it becomes funnel-shaped. Stamens five, unequal, included, the thread-shaped filaments inserted into the corolla at its constricted portion. Anthers short, two-celled, opening longitudinally. Pistil bicarpellary, the edges of the carpels turned in to meet a central column which bears the numerous pendulous ovules. Style slender, equalling the corolla and bearing a slightly two-lobed stigma. Fruit an oblong-ovoid, light brown, crustaceous capsule, two and a half lines long. Seeds about four, one-half a line long, flattened, oblong, brown, with a slight tubercular, roughened, crustaceous testa, the embryo curved, with fleshy albumin." "The resin is a striking peculiarity of the plant. It exists to some extent in the wood of the smaller branches, and is detected in the older wood. The bark abounds in the resin; it is ashy-gray, and finely roughened by minute, short, sharp, thickly-set longitudinal ridges, and minute gland-like protuberances, both of which exhibit, under the lens, a peculiar resinous structure."

Various analyses of the plant have been made, but without any very satisfactory results. An alkaloid, *fabianine*, has been described, but its identity is uncertain; the medicinal properties are more generally ascribed to a florescent glucosidal principle. It also contains resins and an essential oil, with an odor said to resemble vanilla.

Pichi was introduced as a remedy for the various disorders of the urinary apparatus, by Professor H. H. Rusby (*Therapeutic Gazette*, 1885, page 810). It has long had an extensive local reputation, and is freely used by the practitioners of Chili and other South American countries. It is considered to be of special value in vesical and renal troubles arising from the uric-acid diathesis, and is said to favor the expulsion of gravel and small calculi. It also acts as a sedative on the irritable mucous membrane, modifying the secretion and subduing the pain. Its use has been extended to all forms of acute and chronic inflammation of the urinary organs, and numerous reports of cases in which it has been employed tell of its beneficial action, not only in cystitis and vesical irritation due to simple causes, but also when these have arisen from gonorrhœal and prostatic disease. A special indication for its use is said to be the presence of pus in the urine. Dr. Reginald Harrison, after using the drug for four years in private and hospital practice, stated that he obtained considerable benefit from it, particularly under the following conditions; 1. In renal colic and the passing of calculi through the kidneys and along the ureters attended with hæmaturia; though not exercising any solvent power, it seems by its action on the tissues in some way to favor the escape of the stone, and thus to suppress the bleeding. 2. In the hæmorrhage which frequently accompanies cancer of the bladder. 3. The sedative action of the drug on the mucous membrane of the bladder has proved beneficial in many instances of irritability connected with an enlarged prostate.

In addition to its employment in urinary disorders, it is recommended for the relief of the headache, dyspepsia, and other symptoms arising from a condition of lithiasis, and has been used as an hepatic stimulant for jaundice and dropsy due to hepatic disease.

The drug is generally administered in the form of a decoction or fluid extract. The decoction is prepared by adding one ounce to twenty ounces of water, the whole to be given in four portions during the day. The dose of the fluid extract varies between ten minims and two drachms. The average dose is half to one drachm. The effects of the drug are usually experienced after a few doses have been given. The extract is not miscible with water, and the appearance of the mixture is made more pleasant by rendering it alkaline. Glycerine is recommended as the best vehicle for its administration; it is a fairly good solvent, and maintains the drug in suspension in fine particles. Salines should not be combined with it, as they cause the separation of the resin in dense curds. Fluid extracts of hyoscyamus, hydrangea, buchu, and other remedies may be combined when they are indicated. A solid extract has recently been prepared which allows of its administration in powder in capsules. The dose is from two to ten grains.

Beaumont Small.

PICRIC ACID. Has been utilized as a therapeutic agent in the treatment of inflammatory skin diseases and in malarial fevers.

The local application of a one to two per cent. aqueous solution has proved of decided value in erysipelas. It is to be applied from five to ten times a day and the solution allowed to dry upon the part. Its power of reducing the inflammation is supposed to be due to the fact that it penetrates the corneous cells of the skin, and by its astringent property acts as a proteetive to the Malpighian layer of cells; it also acts as a parisiticide upon the specific cause of the disease. It has also proved of service in eczema and erythema.

As an antiperiodic it is employed in the form of the *picrate of ammonium*. This salt is formed by saturating a solution of picric acid with carbonate of ammonium, or with ammonia. After carefully concentrating the solution, it is allowed to crystallize. It forms in yellow needles, very bitter, soluble in water and slightly soluble in alcohol. Like all alkaline salts of picric acid, it requires to be handled with care. When administered for any length of time, it possesses the disadvantage of causing a yellow discoloration of the skin and conjunctiva, and has been known to produce urticaria. As an antipyretic and antiperiodic it is regarded as inferior to quinine, but has the advantage of not causing any gastric disturbances, but rather of suppressing them when they exist. It does not produce the headache, giddiness, and other distressing symptoms that are often caused by quinine. It is indicated in patients suffering from the apyretic form of malaria who are free from cachexia. A Dr. Clarke states that he has treated malarial diseases in India entirely with this drug, to the exclusion of the alkaloids of cinchona. In intermittent fever and in malarial neuralgias and headaches the same success was observed. He gives it in doses of one-eighth to one and one-half grains, four or five times a day, in pill form, the average dose being a half grain. It is best given on the day of remission.

Beaumont Small.

PICROTOXIN. This neutral principle has attracted attention recently, on account of its reputed value as an antidote to opium poisoning, and as a respiratory and

cardiac stimulant in conditions of collapse and chloroform narcosis. The drug stimulates the origins of the inhibitory fibres of the vagus, the vascular and respiratory centres, and the motor areas of the medulla oblongata. By its use the respirations are rendered stronger and more deep, the heart contracts more forcibly, and the blood-pressure is increased by its action through the vaso-motor system. This action, Arpad Bókai (*Centralbl. f. klin. Med.*, Aug., 1889) pointed out, was opposed to that of opium, and rendered it a physiological antidote to poisoning by opium and other narcotics which produced death by paralysis of the respiratory and vascular centres. A number of experiments were performed, which proved its antidotal action. Later experiments of the same observer have to a certain extent modified his views. He finds that picrotoxin undoubtedly stimulates the respiratory centres and increases the blood-pressure and counteracts the toxic effects of small doses of opium; but when very large quantities have been taken it has less power to counteract the lethal action, as full doses of the antidote are liable to induce spasm of the respiratory muscles and hasten a fatal termination. He, however, found that the concomitant ingestion of paraldehyde would prevent this spasmodic action and allow the drug to exercise its effects as an antidote.

The dose that is recommended is one-tenth grain, to be repeated up to one-third grain during the day. The paraldehyde should be given in doses averaging forty-five or ninety minims daily.

Further experiments upon animals have demonstrated the efficacy of the drug to counteract the depression that accompanies the profound narcosis of chloroform, urethane, paraldehyde, and amyl hydrate, and suggests its value in all forms of collapse. *Beaumont Small.*

PIERREFONDS. A watering place in the Department of Oise, France.

Location.—Pierrefonds, a place having eighteen hundred inhabitants, is situated near the famous forest of Compiègne. It is pleasantly located in proximity to a small lake, backed by wooded mountain slopes. The springs supply cold sulphate of lime and chalybeate waters.

According to Dr. Vintras ("Mineral Waters of France"): "The sulphurous springs are collected in a reservoir constructed in the lake itself. This reservoir supplies the Thermal Establishment, which comprises twenty-one bath-rooms, eight douche-rooms, one ascending douche, and a large room for inhaling the sulphurous water in a state of pulverization. The *buvette* is placed in a little pavilion at the extremity of the park belonging to the company, and is supplied by a special spring. These waters are perfectly clear when they issue from the springs, but grow turbid on contact with the air, and become first bluish and semi-opaque, then white and milky, and ultimately deposit sulphur on the walls of the basins. Their smell is like that of addled eggs, and their flavor, though slightly resembling gall, leaves behind no disagreeable after-taste."

Analysis.—One thousand grammes of the sulphuretted water contains:

	Grammes.
Sulphuretted hydrogen, free	0.0022
Sulphide of calcium	0.0156
Sulphate of lime, Sulphate of soda	0.0260
Bicarbonate of lime, Bicarbonate of magnesia	0.2100
Chlorides of sodium and magnesium	0.0220
Silica and alumina, Salts of potash, Organic matter	0.0500
Carbonic acid and nitrogen	traces
Total	0.3258

Indications.—The Pierrefonds waters are employed for drinking and "pulverization." Vintras states that the treatment with pulverized water originated at Pierrefonds, and the credit of its conception is due to the distinguished Inspector, Dr. Sales-Girons. It is carried on in a special room, admirably arranged and fitted up for the purpose, during periods ordinarily of forty-five minutes each. Baths and douches are also used at Pierrefonds, but not on so large a scale.

The treatment at Pierrefonds is chiefly applicable to pharyngitis, laryngitis, and other diseases of the upper air-passages. Asthma, bronchitis, and even phthisis are said to be favorably influenced by a "course" of the water.

In regard to the chalybeate spring, the writer already quoted says that it is situated at a few paces from the sulphurous *buvette*, and covered by a little pavilion. The iron which it contains is in the form of bicarbonate and arseniate of iron, as has been shown by chemical analysis.

After affections of the respiratory organs, those which are most frequently met with at Pierrefonds are chlorosis, anæmia, amenorrhœa, and dysmenorrhœa (which are beneficially affected by the combined use of the two different waters), rheumatism, and certain diseases of the skin.

Accommodation.—While not a fashionable spa, Pierrefonds offers mild amusements to the visitor. The lodging-houses are neat and clean, but unpretentious. There are pleasant excursions in the immediate neighborhood, and shaded walks abound. The season lasts from June to September. Prices are moderate. The natives are exceedingly obliging. *Edmund C. Wendt.*

PIPERAZINE (Diethylene—Diamine. Ethlenimine). A synthetical compound primarily intended to replace spermine, but found to be a different body, both in chemical and in physiological characters. It is now utilized only as a solvent for uric-acid deposits in the place of lithia salts.

It is formed from the action of ammonia on ethylene bromide, which produces a mixture of compounds from which diethylene diamine is separated by fractional distillation at a temperature between 130° and 180° C. When separated by a patented process it is supplied to the profession under the name of piperazine. It is a solid which melts at 104° to 107° C., and boils at 145°. It forms in bright, lustrous tables. When exposed to the air it absorbs water and carbonic-acid gas, and becomes liquefied. It is very soluble in water, and forms a tasteless, alkaline solution without being in the least corrosive. An hydrochlorate is prepared which is also very soluble in water, and forms in silky, lustrous, lanceolate crystals. The following test is given for its detection in urine:

About 10 c.ctm. of urine are decomposed with a few drops of concentrated soda, and slightly warmed for a short time. After cooling, the liquid is filtered from the flocculent precipitate (phosphates, etc.), made decidedly, but not too acid, by a few drops of hydrochloric acid, and decomposed by potassium bismuth-iodide. First, a dirty-colored amorphous precipitate is formed, which contains no piperazine, but is produced by the nucleo-albumin which is a constituent of normal urine. The mixture is then warmed for a short time to about 40° to 50° C. (whereby the precipitate aggregates), rapidly cooled, and filtered. On energetically rubbing with a glass rod, the bismuth compound gradually crystallizes out and falls as a fine red powder.

The compound separated from such a dilute solution can be readily and certainly identified. It consists of characteristic and constant stellate groups of crystals of bismuth—piperazine.

Experiments with solution of piperazine upon uric acid and upon calculi formed of uric acid and uric acid with phosphate of lime, prove that it exerts a powerful solvent action. When placed in a one per cent. solution at a temperature of 90° F., the stones are rapidly acted upon, the sharp edges are removed, and the surface becomes smooth and slippery; within twenty-four hours the mineral portion is dissolved and a soft mucoid skeleton only remains. All forms of urinary deposits are said to be, more or less, acted upon. Compared with carbonate of lithium it dissolves twelve times as much uric acid. Tests have been made of the relative solubility of fragments of a stone in one per cent. solutions of piper-

azine, lithia carbonate, borax, and sodium carbonate. In the piperazine solution the fragment was dissolved in six hours, the lithia solution did not dissolve until after forty-eight hours, the borax dissolved only a very small portion in forty-eight hours, and the sodium solution had no effect whatever after the same period. In each case the residue was placed in the piperazine solution, when it entirely disappeared. A very important characteristic of the piperazine urate that is formed is its great solubility; even when an excess of uric acid is acted upon only the soluble salt is produced. This is seven times more soluble than the lithia salt. One part of the latter requires three hundred and sixty-eight parts of water for its solution, while one part of the piperazine urate is soluble in fifty parts of water.

The physiological action when administered in health is perfectly harmless. It does not disturb in the slightest degree the functions of the digestive, circulating, or respiratory organs. Even when introduced directly into the blood its effects are negative. After its administration and absorption it is not decomposed or acted upon in any way, but passes through the system and is excreted by the kidneys unchanged. Piperazine may be detected in the urine two hours after its administration, and it continues to be excreted for a prolonged period. The urine is not rendered alkaline, nor in any way altered by its prolonged use.

It is evident from these properties that piperazine is theoretically a very valuable drug for the treatment of all conditions in which uric acid is formed in excess. It has been very extensively used in Germany, and numerous cases are reported in which it was used with very marked success — in gout, in all its forms, in lithiasis, renal calculi, vesical calculi, and in many forms of rheumatism of a gouty character. In these conditions it is supposed to first saturate the uric acid that remains dissolved in the organism, and then to attack all deposits of uric acid. The soluble urate of piperazine that is formed is readily excreted with the urine. The piperazine that is not neutralized in the system comes in contact with calculi and deposits in the kidney and bladder and there exerts its specific properties. In gout it relieves the painful joints, improves the digestion, and counteracts all the ill effects of the uric-acid diathesis. The deposits about the joint are diminished and any further increase in size prevented; where these deposits have ulcerated through to the surface the local application of a solution of piperazine hastens resolution and healing of the part. In lithiasis it is reported to act instantly and to give permanent relief, the surfaces and sharp edges of the gravel are rendered smooth and the expulsion favored. In many cases the small calculi are passed within twenty-four hours, and the urine becomes clear and free from deposit in a few days. On account of its freedom from any irritating action on the mucous membrane, it may be made to act directly upon the deposits in the bladder, by injecting a one per cent. solution, which assists in the decomposition of the larger calculi that would otherwise require operative treatment.

The results of its use have not always been so favorable. Professor H. A. Hare reports having employed it in some cases of well-marked gout and in gouty rheumatism without any beneficial effects. He administered it internally and by hypodermic injection in the usual doses without relief. Sir William Roberts, in the "Croonian Lectures for 1892," on the treatment of the uric-acid diathesis, states that piperazine in blood-serum or synovia had not the slightest effect in adding to the solvent powers of these media on sodium biurate, nor the slightest effect in retarding its precipitation from serum and synovia artificially impregnated with uric acid. He concludes that if piperazine has any beneficial action in gout it is not due to its solvent powers on the material of gouty concretions. The drug, however, appears to be worthy of an extended trial. The numerous reports of its successful employment and its freedom from any ill effects are in its favor, and there is little doubt but that it will be extensively used and its position as a remedial agent more definitely established.

On account of its hygroscopic properties it must never be prescribed in powder or pill form. It is supplied in bottles containing five grammes, which is sufficient for five days' use. This is to be dissolved in a definite quantity of water, and one-fifth given each day in divided doses. The quantity employed by all observers has been one gramme daily, in solution, well diluted. The effects of the drug are rapidly manifested, but its use may be continued for a long time without producing any unfavorable symptoms. After the subsidence of the attacks a smaller dose of eight to fifteen grains may be given every third day, and continued for months. When administered hypodermically, fifteen minims of a ten per cent. solution may be used. The injections are to be made in the neighborhood of the affected joints. The drug is to be given internally at the same time. The effects of this method are reported to be very gratifying; the swelling and pain subside and the deposits are absorbed and greatly reduced in size. In some cases it is reported that deposits of gouty material in the pinnæ of the ears and in the eyelids were removed by two or three injections. The following solution is also prepared for its local application to the affected joints: Piperazine, 15 to 30 grains; alcohol, 5 drachms; water, 2½ ounces.

Dr. David D. Stewart (*The Therapeutic Gazette*, January, 1893) contributes a very valuable report of cases treated with satisfactory results.

Piperazine has recently been employed as a remedy for the treatment of epilepsy; the preliminary observations are reported to be favorable, but the results of its use in this disease are not yet known.

Beaumont Small.

PLOMBIÈRES. This spa has already received a brief notice in Vol. V. of the HANDBOOK. The place is sufficiently important, however, to deserve some additional attention. Plombières has been called, not without reason, "the Queen of Watering-places of the Vosges." It is charmingly situated, and its surroundings are so attractive that it is a favorite summer resort with many who have not been ordered there for a course of the waters. The little town has only about 2,000 inhabitants. It is situated in a narrow valley, with mountains rising steeply up on either side. The climate is invigorating, and, while the days in summer are often hot, the nights are invariably cool.

A special feature at Plombières is the long time (one-half to one and a half hours) during which patients remain in the water. Mr. Wolff ("The Watering-Places of the Vosges") says that only four springs out of the twenty-seven which are now in use at Plombières, are drunk at all. The first is the chalybeate, which is very mild, and is employed mainly as a table-water and as an adjunct to bathing in cases of anæmia and chlorosis. Another spring used for drinking, and also for bathing, the "Source Savonneuse," is mildly laxative. Besides these, the "Source des Dames" and the "Source du Crucifix" are employed for what little drinking there is. Apart from the chalybeate and the Savonneuse, the Plombières waters all belong to one category. Dr. Constantin James calls them alkaline; Dr. Bottentuit, "*arséniatées sodiques, sulfatées et silicatées sodiques;*" M. Jacquot, "*bicarbonatées sodiques silicatées;*" and Dr. Macpherson, "indifferent." The latter designation is most in keeping with their slight degree of mineralization.

The same author states that, "in addition to the baths, a very effective remedy in some cases applied at Plombières are the *étuves*, also called *étuves de l'Enfer*. These are hot vapor baths, for which the heat and vapor are supplied by the running springs. There are two such establishments, both of course underground, and both, at their hottest points, very hot indeed. But for people who cannot stand excessive heat, there is the convenient institution of *étuves en boîte*, which are taken in a closed box, with a hole left in the top for the head." Energetic massage is also much employed at this spa; so that the patient's time, what with drinking, bathing, walking, douching, massaging, and dieting, is quite fully occupied. Most of the visitors are women, al-

though it is by no means an exclusively "female watering-place."

The place is rich in mineral springs, but the proportion of solids in the waters is rather insignificant. Over twenty-five springs are used at Plombières, and the water of most of them is collected into a single conduit and conveyed to the different thermal establishments. Only three of the latter are perfectly modern and satisfactory, viz., the *Nouveaux Thermes*, the *Bain Romain*, and the *Bain Stanislas*. Although so slightly mineralized, the varying temperature of the baths (65° to 160° F.) admits of a certain amount of variety in treatment. The waters are easily borne when taken internally, and do not produce any constitutional disturbance.

ANALYSIS—One thousand parts of the water contain in parts:

	Source Vanquelin.	Source No. 1, Du Thalweg.	Source Des Dames.	Source Du Crucifix.	Source No. 5, Savonneuse.
Temperature.	158° F.	137° F.	124° F.	115° F.	68° F.
Carbonic acid (free)...	0.00638	0.00879	0.1287	0.00825	0.00309
Silicic acid.....	0.02155	0.07539	0.02731	0.00739	0.04589
Sulphate of soda	0.13564	0.07534	0.09274	0.10070	0.04685
Sulphate of ammonia, Arseniate of soda....	traces	traces	traces	traces	traces
Silicate of soda.....	0.12862	0.07343	0.05788	0.10611	0.04209
Silicate of lithia.....	traces	traces	traces	traces	traces
Silicate of alumina..					
Bicarbonate of soda ..	0.02288	0.01426	0.01133	0.02092	0.00818
Bicarbonate of potash.	0.01673	0.00125	0.00133	0.00234	traces
Bicarbonate of lime....	0.02778	0.04965	0.02868	0.03639	0.04451
Bicarbonate of magnesia	traces	notable traces	0.00670	traces	0.01253
Choride of sodium	0.01044	0.00794	0.00927	0.01005	0.00651
Fluoride of calcium, Oxide of iron and manganese	traces	traces	traces	traces	traces
Organic and azotyzed products.....	indications	indications	indications	indications	indications
Total.	0.37053	0.02295	0.25821	0.29823	0.19665

A course of Plombières is useful in many nervous states, especially those associated with hyperæsthesia, as well as in those depending upon lithæmia. Many symptomatic neuralgias and paretic conditions derive benefit from a course of treatment at Plombières. Stiff joints may be limbered up, lumbago cured, gouty manifestations alleviated, diseases of women improved. The place also has quite a reputation for the cure of sterility, though on what grounds does not specifically appear. The waters are also applicable to cases of gastralgia, dyspepsia, catarrhal conditions of the bowels, especially when accompanied by chronic diarrhœa. Some skin diseases, such as eczema and psoriasis, are likewise said to be greatly benefited by these waters. The chalybeate springs are, of course, useful in anæmia and chlorosis. In phthisis the place is said to be contraindicated.

Plombières is a decidedly international watering-place, although English and Americans form but a small contingent of the six thousand annual visitors of the spa. With reference to accommodation, Mr. Wolff is authority for the following: "The better hotels and villa-pensions seem intended for people altogether of the better classes. They are good, but dear. Of course, there are less pretentious ones, down to the lowest point of the scale. For the spa is much visited. The following are among the best: The Grands Hôtels, Hôtel de la Paix, Hôtel Stanislas, Villa Mocquard, Le Chalet Rose, and Maison Rossignol. There are as many as about a hundred private hotels, many of them with a regular table d'hôte." Altogether, it is quite true that Plombières should be better known in our country than is now the case, especially as it is more convenient of access than Wildbad, Gastein, Teplitz, and the other spas of that order, which Americans are wont to visit. *Edmund C. Wendt.*

POTT'S DISEASE. HISTORY.—This disease was not first accurately described by Percival Pott, as has been stated. A year before Pott wrote his classic paper ("Remarks on that Kind of Palsy Affecting the Lower Limbs," etc., London, J. Johnson, No. 72 St. Paul's Churchyard, 1779), Jean Pierre David gave a full account of the disease in a Prize Essay, *Dissertation sur les effets du mouvement et du repos dans les maladies chirurgicales*, the subject proposed by the Royal Academy of Surgery at Paris for the year 1778. This essay was translated and appeared among the "Surgical Tracts," by the late J. C. Justamond, collected and interspersed with occasional notes and observations by William Houlston, and printed in London for T. Cadell, in the Strand, in 1779. Here is M. David's description of a case which he saw at the hospital in 1776: "Having been violently beaten, at the age of thirteen, by his father, he felt, a few months after, a weakness in the spine, attended with pain and a difficulty in keeping the upright posture. He at first walked with great difficulty, and afterward could not walk without leaning upon a stick, with his body bent forward. These symptoms, which continued more than six months, were followed by a fever, accompanied with difficulty of breathing, and pain in the middle of the back without any very apparent swelling externally. These symptoms were relieved by bleeding and other remedies, and the patient seemed restored to his former state, but the difficulty of walking and of supporting himself increased by degrees, and at length a tumor was formed toward the lateral and posterior part of the last false ribs, the increase of which was very slow, and made no change in the color of the skin. This tumor, extending itself, gained the region of the loins, and more than six months after its appearance the skin became inflamed, grew thin, and by the assistance of maturating poultices applied to the tumor, a fistulous opening was made in it, from whence there issued, according to the patient's account, more than a quart of matter as white as milk. This discharge having continued very plentiful for three months without hopes of cure, the parents, tired with the length of the disease, took the resolution of sending the young lad to the hospital. When he came there he had a fistulous opening on the right side of the lumbar region, which furnished an ichorous and plentiful discharge; a slow, suppuratory fever accompanied, and every appearance seemed to show that death would soon terminate this disorder. A pledget of soft ointment only was placed upon the fistulous orifice, and the disease was left to nature. I frequently saw this patient, who, being better fed, and more attended to than at home, began to recover a little from the deplorable state to which he had been reduced. He particularly kept very quiet in his bed; and his spine was then incurvated with an evident projection outward, toward the last dorsal vertebra. Almost two months after he came into the hospital, the matter which oosed from the fistuluous opening grew thicker and less plentiful, the countenance appeared better, the pulse less frequent, and he began to give some hope of recovery. This hope was more confirmed six months after, for the patient began to feel some degree of strength in the spine. Two months after this last period the fistulous orifice was closed, and the patient began to walk with a stick; but he was crooked, and seemed to have lost much of his former height. From the accidents this patient had undergone, and the deformity the spine had contracted during the course of the disease, I imagined that some of the dorsal vertebræ had been affected with caries; that the remains of them, after being confounded together, and after having been in a state of granulation, had at length acquired a degree of solidity sufficient in some sort to supply the place of the bodies of these bones. I could not but consider rest as having been the chief promoter of this salutary end; the subsequent facts appear to have completely confirmed my conjectures on this point. First, the patient, who had been the subject of the preceding observation, and whom I had always kept within my notice, having been seized in 1769 with a peripneumony, of which he died, I was allowed to inspect the body, and my first care was to take notice of the disorders the spine had experienced three years before.

I found, as I suspected, several vertebræ, the bodies of which were confounded with each other; these were the ninth, tenth, and eleventh of the dorsal vertebræ, which had lost at least half of their longitudinal dimensions, while the spinal processes, which had not suffered the least alteration, formed the projection and a remarkable convexity outward."

There has, perhaps, never been drawn a more perfect picture of a case of Pott's disease; if there has, it was not drawn by Percival Pott.

David differentiated these cases from lateral curvature; he noted the manner in which the abscesses differed from other abscesses as to their contents, the course without treatment and after incision, and as affected by rest of the diseased spine, and his ideas of their proper treatment were the same as those held by orthopedic surgeons of the present day; and the principles of the treatment which he advocated were the same as now govern the management of this disease.

Pott's paper, published a year after David's, treated of the paraplegia accompanying some of these cases. He says: "The disease of which I mean to speak, is generally called a palsy, as it consists in a total or partial abolition of the power of using, and sometimes of even moving, the lower limbs, in consequence, as is generally supposed, of a curvature of some part of the spine." He condemned the use of "steel stays, the swing, the screw chair, and other pieces of machinery." In treatment, Pott, following Dr. Cameron and Mr. Jeffrys, of Worcester, "made an issue by an incision on one side of the projection, and gave strict charge to the mother to take care that the pea was kept in." At times he used a seton on each side of the projection, and at other times he made eschars with caustic, then inserted kidney beans, and sprinkled the bottoms of the sores every third or fourth day with powdered cantharides. Nowhere in Pott's paper is there evidence that he opened the spinal canal post mortem, or suspected the true pathology of the cause of the paralysis. His observations were solely confined to a consideration of the clinical phenomena during life, and of the superficial bony alteration after death. Pott's paper was written for the purpose of advocating a novel treatment by inducing superficial suppuration, and David's for the purpose of illustrating the value of rest in the treatment of these and other chronic bone and joint diseases; neither appears to have thought that in the description of the outward manifestations of the disease there was anything new to advance.

Paraplegia.—When the tubercular growths in the body of a vertebra have caused a perforation at the posterior surface, and a destruction of the periosteum of this surface, the tuberculous inflammation begins to spread in the epidural space. In this way partly tubercular granulations, partly tubercular abscesses, press the dura mater upon the cord. Reaction takes place in the dura, but a specific inflammation of this membrane does not yet occur; the process still remains a peri-pachymeningitis. It is only after the process has lasted for some time that the peri-pachymeningitis becomes a pachymeningitis; but even then the process is limited for a long time to the outer layers of the dura mater. If the patient lives long enough, the process finally passes through the dura, and then assumes the characteristics of a typical tuberculous inflammation of the cord. Thus this specific tuberculous myelitis never sets in until near the end of the disease, to which the patient succumbs.

Very soon after the invasion of the epidural space by the tubercular process, the cord begins to show functional disturbance. This may sooner or later pass on to complete paralysis. This has been shown to be due to the pressure of the new growth. The pressure interferes with the flow of lymph from the cord, and a stasis results. After the œdema has existed for some time the lymphatic fluid acts as a poison to the nerve elements of the cord. It first increases, and then decreases, and often open spaces are left in the neuroglia; a softening of the cord occurs, but at the same time an hypertrophy of the interstitial connective tissue, so that finally complete sclerosis results.

Paraplegia is by far the most frequently associated with disease of the first three or four dorsal vertebræ, occasionally with disease in the lower cervical bones, and rarely with disease in the lower dorsal and lumbar regions. It may come on before deformity or any other symptom has been noticed, or at any time during the course of the disease. It has no definite relation to the acuteness of the angle or the shortness of the radii of the curve, and it may be recovered from, while the deformity grows worse. The duration may be for a few weeks, or it may last for months or years; relapses occur in a certain number of cases. Loss of sensation, and of control of the bladder and rectum, is comparatively rare. Treatment is of no avail except as it is directed to the cure of the bone lesion, namely, immobilization and recumbency. Much has been claimed for iodide of potash administered in heroic doses, but it has not been demonstrated to be of the slightest benefit except in the children of syphilitics, and counter-irritation by blisters, issues, and the actual cautery are as useless as they are brutal. Treated by uninterrupted immobilization and recumbency nearly every case ultimately recovers.

Abscess.—The abscess of Pott's disease is not a true abscess in the sense of containing pus and the microbes of suppuration. The lining membrane of the cavity is made up of miliary tubercles embedded in fibrin, and the contents are the liquefied product from the degeneration of this new growth. In the fluid "pus" no germ elements are found except the tubercle bacillus, and only in a limited number can even this be demonstrated by microscopic examination or culture experiment. Nevertheless, inoculation in fit subjects always results in tuberculosis, and proves the nature of the process.

Fig. 522.—Lateral Deviation, with Rotation, in Pott's Disease; old case.

The treatment of these tubercular abscesses is less satisfactory than that of similar abscesses connected with tubercular osteitis elsewhere. They usually form first on the anterior surface of the spinal column, and before they

are demonstrable or accessible have formed numerous pockets and tortuous tracts. Complete evacuation by aspiration or incision is rarely possible, and unless accomplished renders the operation useless, and adds the risk of infecting the cavity with septic elements. This fact, and the knowledge that a very considerable number of these abscesses disappear without evacuation, if only the bone disease be effectually treated, has led the majority of orthopedic surgeons to a let-alone policy, which eventuates in reabsorption or spontaneous opening and evacuation. Simple aspiration is no longer practised. If an aspiration is attempted, it is conducted with full antiseptic precautions, and followed by the injection into the cavity of a mixture of sterilized iodoform in glycerine and water or olive-oil. If an incision be made, the contents of the cavity should be carefully and as thoroughly

Fig. 523.—Marked Lateral Curvature, with Rotation, in Pott's Disease; recent case; rear view.

as possible washed out with sterilized water, the iodoform mixture injected, and the cavity closed without drainage and with carefully adjusted compression. In a certain number of cases a more rapid cure is effected by such treatment.

Lateral deviation of the spine, either with or without rotation, is a frequent early symptom of Pott's disease. The rotation, affirmed by Bartow and denied by Lovett, unquestionably exists in some early cases, and is quite universally present in those cases where the lateral deviation has existed for some time. (Figs. 522, 523, 524.) Fig. 525 shows the profile as the patient bends forward, the parallel lines *a* and *b* (in the latter figure) drawn from the spinous processes indicating the extent of the lateral deviation.

Early Symptoms.—In cervical disease, before any deformity has taken place, and often while the restriction to passive motion is still uncertain, if the patient be placed first prone and then supine across the parent's knees, the head will not be allowed to dangle, no matter how long the position be maintained. In dorsal and lumbar disease, forward bending, when the patient sits on the table or floor with knees straight, will be more restricted than passive backward bending with the patient lying prone.

Differential Diagnosis.—We need only refer to scoliotic and rachitic curves. In scoliosis the curve does

Fig. 524.—Front View of Same Patient.

not become rigid until it has existed for some time, and the deformity has become quite severe, while in Pott's disease early rigidity is the diagnostic symptom. Rachitic curves only occur in infants, and rarely without other rachitic manifestations. The curve is never angular, but it may be fairly rigid.

Prognosis.—Dr. Samuel Ketch, from a study of seventy-five cases, found that the average time of treatment

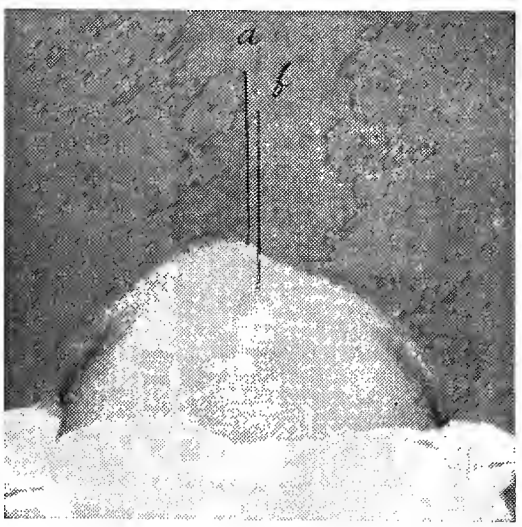


Fig. 525.—Same Patient as in Fig. 522, Bending Forward, showing Amount of Rotation.

in obtaining a cure was $26\frac{1}{28}$ months in the superior region, $64\frac{8}{28}$ months in the middle region, and $47\frac{11}{28}$ months in the inferior region.

TREATMENT.—The treatment of Pott's disease aims to immobilize, more or less perfectly, the area of disease, and to wholly remove the superincumbent weight by recumbency, or to partially remove it by some apparatus. When the plaster-jacket was first used it was believed to support, by its circumferential grasp, the chest, and by the jury-mast the head, by transferring their weight to the pelvis.

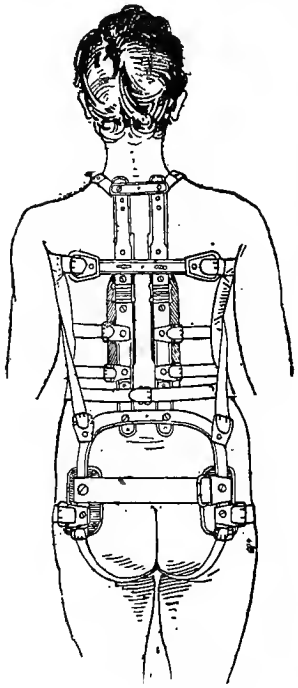


FIG. 526.—The Taylor Spinal Brace.

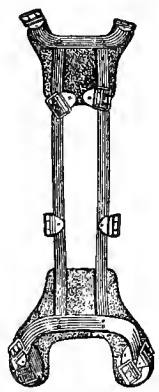


FIG. 527. — Modified Taylor Spinal Brace.

This it does not do, but it does by its leverage action take some of the superincumbent weight off the diseased vertebral bodies. In the same way do all braces act that prevent increase of deformity. In no way can the whole of the superincumbent weight be removed except by recumbency, and even then destructive pressure between the diseased surfaces from muscular spasm is not always avoided.

Immobilization of the diseased bones is conducted upon three different principles, namely: To correct the deformity in so far as is possible by partial suspension, practised at considerable intervals, and immobilization by plaster jacket during these intervals; secondly, to correct the deformity, in so far as is possible, by continuous antero-posterior leverage by means of a brace, which uses the transverse process of the vertebræ of the kyphosis as a fulcrum; thirdly, to immobilize, by the longest possible lever which uses the whole width of the back as a fulcrum, without any attempt at correction of the deformity. A fourth plan is that used by Blanchard, of Chicago, who attempts a rapid correction of the deformity by longitudinal traction and lateral pressure from weights, while the patient is in prone recumbency, followed by the application of a "shell-back" brace, moulded over a plaster-cast of the back to a comparatively accurate fit.

The plaster-jacket has already, in the earlier part of this work, received full consideration, and the wood and paper corsets, acting upon the same principle, will be fully described under Scoliosis.

The principle of the Taylor antero-posterior spinal brace has already been set forth in the earlier part of this work. The brace shown in Fig. 526 is the latest form of the brace as used by Dr. Taylor. Properly fitted, it is, in the writer's opinion, the most effective of the spinal braces. It is, however, an expensive brace, and not readily measured for and obtained in such shape as to be readily fitted and satisfactorily worn. An inexpensive modification is shown in Fig. 527. In cases where the deformity is not too great it will be found a most satisfactory apparatus.

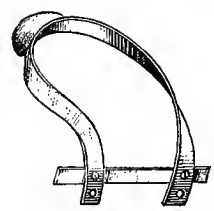


FIG. 530. — Chin-piece to Whitman's Brace.

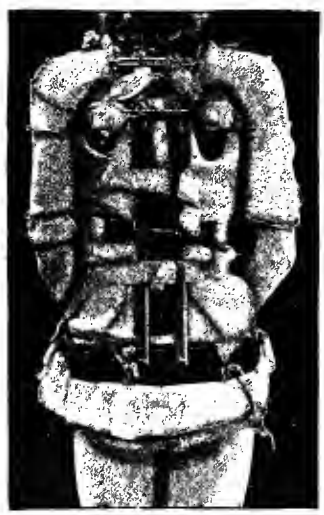


FIG. 531.—Whitman's Brace.

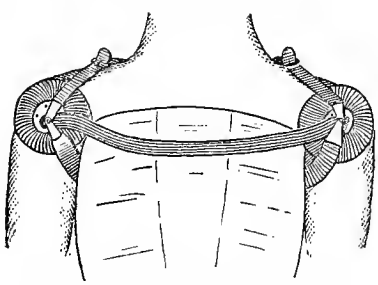


FIG. 528.—Whitman's Brace; front view.

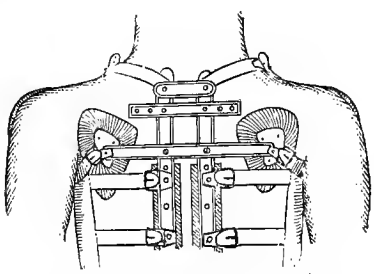


FIG. 529.—Whitman's Brace: rear view.

An effective brace for disease in the mid-dorsal region is that of Whitman, shown in Figs. 528, 529, 530, 531, 532 and 533. It prevents forward drooping of the head and perfectly supports the shoulders.

Of the braces that immobilize by a long leverage action upon the entire back without any attempt to correct the deformity, the Thomas cuirass forms the best example. This is shown in Fig. 534. It consists of an irregular oblong frame of flat bar-iron, shaped to fit the contour of the spine, and reaching from the base of the neck to the level of the greater trochanters. This is padded on the side next the patient with felt, and the whole covered with leather.

Fig. 532.—Whitman's Brace ; side view.

Fig. 533.—Whitman's Brace, with Chin-piece Applied.

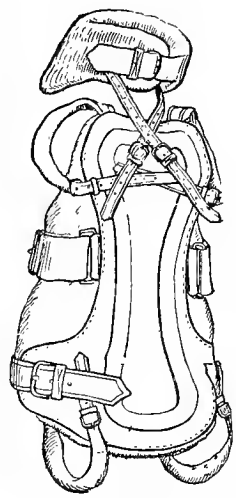


Fig. 534.—The Thomas Spinal Cuirass, with Collar.

A brace somewhat similar in its design and action is that of Wallace Blanchard, shown in Fig. 535. This is

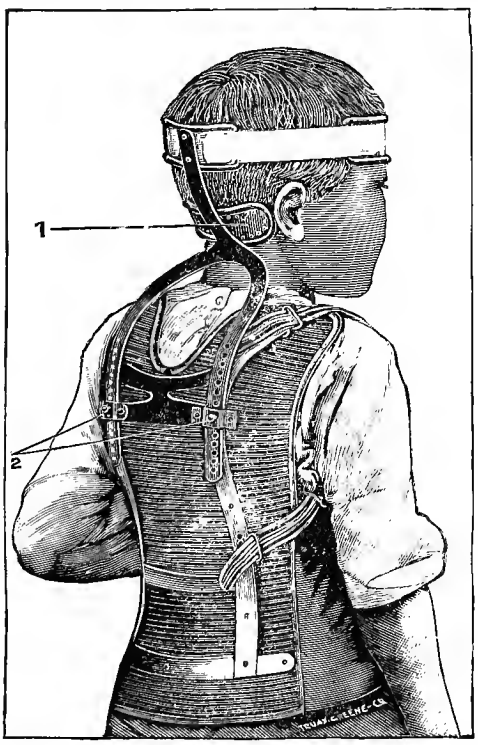


Fig. 535.—Blanchard's Brace.

made to fit accurately over a plaster-cast of the spine, taken when the deformity has been corected in so far

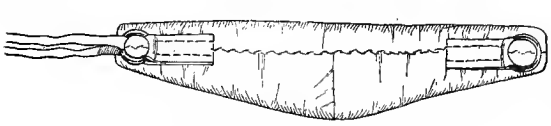


Fig. 536.—The Thomas Collar.

as is possible by longitudinal traction and lateral pressure.

For cervical caries a simple and effective device is the Thomas collar, shown in Figs. 536, 537, 538. It is made

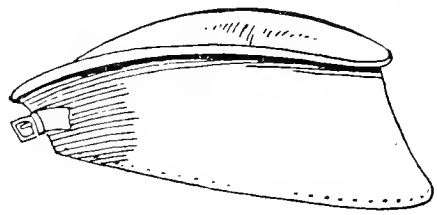


Fig. 537.—The Thomas Collar.

from thin sheet-iron, zinc, or tin, wrapped in felt, and the whole covered with basil leather. It fits the neck snugly,

Fig. 538.—The Thomas Collar Applied,

but not to strangulation, and so completely fills the space between chin and sternum that no motion is permitted.

John Ridlon.

POTT'S PARALYSIS IN CHILDREN. FREQUENCY.—The ratio of cases of spinal caries in which paralysis is a complication to the whole number of cases, varies greatly with the clinic of the one making the estimate.

	Cases of spinal caries.	Paralyzed.	Per cent.
Gibney [1]	295	62	21 0
Taylor and Lovett [2]	445	59	13.0
Mohr [3]	72	5	7 0
Drachman [4]	166	22	13.6
Sayre [5]	109	38	35 0
Total	1,087	186	17.0

SYMPTOMATOLOGY. *Prodromal period.*—There may or may not be a prodromal period characterized by sensory disturbance. This may be pain, varying much in degree; it may be girdle-like, or there may be persistent neuralgias at any spot of the abdomen or legs. Possible also are paræsthesiæ, as tinglings or sensations of heat or cold, hyperæsthesia and anæsthesia; anæsthesia occurs usually in spots.

PARALYSIS OF MOTION.—The paralysis which is characteristic of the affection varies from a slight weakness of a few muscles, not to be noted without close observation, to a complete loss of power of most of the muscles of the body, so that the patient lies prostrate. Though usually a paraplegia, the paralysis may be a monoplegia or a hemiplegia, or it may involve all parts of the body supplied by spinal nerves; any form, too, may develop after a time into a paraplegia. There may be a brachial paraplegia, and later this may extend and involve the legs. In severe cases the abdominal and respiratory muscles may be affected. The legs are very often affected unequally. Of 58 cases reported by Gibney,[1] 24 (40.6 per cent.) had complete paralysis of the affected parts, and of these 4 had also incomplete cervical paraplegia. Of 59 cases analyzed by Taylor and Lovett,[2] 32 (54.2 per cent.) had complete paralysis, and 3 had paralysis of the arms. Of 83 cases in children under sixteen, tabulated by the writer, 27 (32.5 per cent.) had absolutely no power of motion in the legs, and of these, 12 had also to a greater or less extent paresis of the arms.

PARALYSIS OF SENSATION.—"Some impairment of sensation is found in all Pott's paralysis, but it is usually so slight as only to be recognized by the most delicate tests and for a short time" (Bradford [6]).

Very frequently, however, sensation in the paralyzed parts is decidedly dull, usually some time after the muscular weakness is noted, and there may be almost complete anæsthesia of all the body below the site of compression. This is significant, of course, of a very extensive transverse myelitis. Hemianæsthesia, or areas of anæsthesia, are sometimes found, and there may be, though usually there is not, pain of a constant heavy aching character all over the paralyzed limbs. There may be also paræsthesia and hyperæsthesia, all of these sensory symptoms being due to compression or myelitis of the posterior columns. Generally tactile sense disappears first, then the sense of temperature, and last the sense of pain (Erb).[7] Michaud [8] quotes a case in which there was paralysis of sensation and not of motion, and there are several cases in which the sensation was found dull before muscular weakness was noted. Taylor and Lovett [2] found, out of 59 cases, 15 (25.4 per cent.) with incomplete sensory paralysis. Of the writer's 83 cases, some degree of sensory paralysis was noted in 30 (36 per cent.).

SPASMS AND CONTRACTURES.—In the prodromal period there may be twitchings of various muscles, due to irritation of the anterior nerve-roots, but as a rule, at first the paralyzed muscles are completely relaxed, quiet, and soft; the joints are also relaxed and do not oppose passive motion. In the later stages, with the advent of secondary degeneration in the cord, the flaccid muscles may become tense and rigid; usually at first the rigid legs are extended and the feet held in slight equinovarus, but later a change comes on slowly or suddenly, sometimes while the patient is asleep; the thighs become flexed on the pelvis and adducted, the legs flexed on the thighs, and the feet frequently take the position of calcaneo-valgus. If the limbs are extended again they will often flex in a jerk without any apparent cause. In some cases there is present what has been called "clasp-knife" rigidity (for example, if, when the knee is flexed, the leg is gradually straightened, it moves smoothly and easily till full extension is nearly reached, and then it suddenly becomes rigidly extended, and considerable force is required to bend the knee again). At first abnormal positions can be readily passively corrected, but later contractions set in and the legs become fixed in the position adopted. Of the writer's 83 cases, 12 (14.4 per cent.) were observed to have rigid muscles.

BLADDER AND RECTUM.—In severe cases the bladder or the rectum or both may be affected. Usually at first there is difficulty in micturition, shown as slowness in starting the stream, but later there is true incontinence. The anal sphincter also may be paralyzed, but unless there is diarrhœa, the paralysis may not be noted. The involuntary evacuations may be conscious or unconscious. Incontinence may result apparently from downward extension in the cord some months after symptoms of complete paraplegia have existed, and this incontinence may last for years, and yet the patient finally improve and obtain entire control over the bladder again. In other cases, the resulting cystitis is an important factor in causing death. Taylor and Lovett,[2] in 59 cases, find 8 with paralysis of bladder or rectum, and in the writer's 83 cases 34 made some complaint of weakness of sphincters.

REFLEXES.—The condition of the deep reflexes is of diagnostic value. They are regularly exaggerated, unless the seat of the lesion be the lumbar enlargement, in which case they are absent. The slightest tap on the patellar tendon, the lightest pressure on the sole of the foot, even a tap on the bone or fascia, or belly of muscle, will in many cases call forth a vigorous contraction of all the muscles of the leg, and sometimes be followed by a similar contraction of the muscles of the other leg. Even the evacuation of the bladder or rectum is said sometimes to be sufficient to cause a clonus of the limbs. The cutaneous reflexes are sometimes exaggerated, even so much that pinching the skin will cause a violent reflex clonus; again they are not to be found, and still again they are unaltered.

TROPHIC AND VASO-MOTOR CHANGES.—Trophic changes are said to be uncommon, unless the cervical or lumbar enlargement is involved; but if the paralysis has existed any considerable time one frequently finds a notable degree of atrophy of the legs, together with some coldness, occasional lividity, and generally a dry, inelastic, scaly skin. There may be localized œdemas and sweatings, and rarely lesions of the joints secondary to lesions of the cord. Roser [9] has seen three cases of spontaneous dislocation of the hip, brought about by the reflex motions of Pott's paralysis; the luxation was behind, gradual, and painless. In severe cases bedsores are frequent. Of 83 cases noted, 16 (19.5 per cent.) showed some wasting of the paralyzed parts.

MEDULLARY SYMPTOMS.—When the upper cervical cord is compressed, Charcot has noted paralytic myosis and spastic mydriasis, from paralysis or irritation of the corresponding paths in the cervical medulla. Respiratory and gastric disturbances, persistent hiccough, and difficult swallowing or vomiting, as well as retardation of the pulse, have been met, and are attributed to implication of the vagus, spinal accessory, or phrenic.

TIME IN POTT'S DISEASE AT WHICH PARALYSIS APPEARS.—The paralysis may come on as a diagnostic symptom of Pott's disease before the latter has been otherwise made manifest, or it may come on when spinal disease has existed for years, and to all appearances the destructive process has subsided. Taylor and Lovett [2] say paralysis occurs on an average about two years after the beginning of the disease. Gibney [1] sets the average time at three years. The writer has found in 75 children that paralysis came on within a year from the be-

ginning of the disease in 32, in one to two years in 12, in two to three years in 11, in three to four years in 9, in four to ten years in 6, and in over ten years in 5.

Duration of Increase of Paralysis.—From the first note of weakness to the maximum of paralysis attained, there may be less than a day, and there may be several months, but, perhaps oftenest a few weeks. In 44 of the 83 cases studied, this time was noted, with a result as follows: under one month, 19 cases; one to two months, 12; two to three months, 4; over three months, 9.

Duration of Paralysis.—The duration of the attack may be a few weeks or it may be a lifetime; usually it varies from a few months to a few years. Pott [10] put the time at from two months to two years. Gibney [1] in 13 cases found a duration ranging from four weeks to twenty-two months. Taylor and Lovett [2] give as the average duration twelve months, but when paralysis comes on while the patient is under treatment, an average duration of only seven months.

In 66 cases in children in whom the duration is known, the paralysis lasted less than a year in 40, from one to two years in 13, two to three years in 6, and more than three years in 7.

Recurrences.—A few cases have more than one attack, and three and even four attacks have been noted. Taylor and Lovett [2] find in 59 cases recurrences in 6. The intervals between these recurrences vary from a few weeks to some years. Gibney [1] in 58 cases found 8 recurrences, and the writer in 74 children found also 8 with a history of more than one attack.

Terminations.—There are three terminations: recovery, death, and permanent paralysis. 1. Recovery is usually gradual, and frequently lasts months. After a period of absolutely no change in the patient's symptoms, it is found that a few motions can be executed by the paralyzed parts at times; then there is a permanent increase of power in those parts, the sensibility improves, and generally becomes normal before entire power over the muscles is established, control of the bladder is regained and, last of all, usually months after the patient believes himself well, the tendon reflexes become normal.

2. Death may result from progressive myelitis with its attendant cystitis, bedsores, diarrhœa, pyæmic fever, and exhaustion, or the patient may yield to tuberculosis, or be cut off by some intercurrent disease. Gibney [1] in 13 deaths found 6 from myelitis, 2 from tuberculosis, and 5 from other diseases. Taylor and Lovett,[2] in 5 deaths, had 1 from tuberculosis and 4 from intercurrent affections. The writer's cases in children furnish 12 deaths with known causes, distributed as follows: Tubercular meningitis, 2; amyloid, 1; phthisis, 1; exhaustion, 1; after operation, 1; other causes, 6.

3. Permanent paralysis may be slight in amount, simply noticed as a weakness, or it may be a paralysis with contractures, and the patient get about, if at all, with great difficulty. In the last case, however, the general health may be excellent and the condition without danger to life.

Prognosis.—In a broad way the prognosis of Pott's paralysis is good, *i.e.*, it tends to recover entirely. Taylor and Lovett,[2] in 47 cases whose results are known, find 39 recoveries (83 per cent.). Gibney [1] finds in 58 cases 29 recoveries (50 per cent.) In 62 cases in children under sixteen, the writer has found recoveries in 49 (79 per cent.). In making the prognosis in any particular case, certain factors enter which may be considered in detail:

1. *Treatment of the Patient before the Paralysis.*—If the patient has been under treatment the prognosis is somewhat better. Taylor and Lovett [2] give 100 per cent. of recoveries, but the writer has noted 15 such cases with only 10 recoveries (67 per cent.).

2. *Duration of the Paralysis.*—The maximum time with recovery in the writer's cases is four years, and of the 7 cases in which paralysis lasted more than three years, only 3 recovered. In the 24 cases whose paralysis lasted less than six months, 14 (58.4 per cent.) recovered; 16 recovered in from six months to a year, 10 in from one to two years, and 6 in from two to three years. A patient's chance of recovery, therefore, steadily grows during the first year, being considerably greater in the second six months than in the first; it is nearly as good during the second year as during the last half of the first; but the prognosis grows rapidly worse during the third year, and after three years there is comparatively little hope.

3. *Time from Beginning of Spinal Disease to Beginning of Paralysis.*—Of the 32 cases whose paralysis began within a year, 20 (62.5 per cent.) recovered, while of the 43 whose paralysis began more than a year after the spinal disease, 31 (72 per cent.) recovered. In other words, if the process is acute and advancing rapidly enough to bring on a paralysis early, the prognosis is worse than if slower changes compress the cord at a later stage.

4. *Age of Patient.*—Of 22 cases under five years when the paralysis began, 17 (77.3 per cent.) recovered; between five and ten years, 20 of the 36 cases recovered (55.5 per cent.); and between ten and fifteen years about the same percentage of recovery is found. Neglecting other factors, therefore, the prognosis grows better with the youth of the patient.

5. *Severity of the Paralysis.*—In the writer's cases, of those with simple paresis of the affected muscles, 75 per cent. recovered and 15 per cent. died, while in those with complete paralysis of affected parts, 41 per cent. recovered and 30 per cent. died. Fifty per cent. of those with marked sensory, vesical, or rectal affection got well, and twenty per cent. died. Obviously, then, the lighter the paralysis the better the prognosis; but with complete paralysis, the addition of sensory or vesical palsy does not make the chance of recovery materially less.

6. *Location of Lesion.*—Cases other than cervical or dorsal are too few to form a basis for estimate. In 74 children the percentage of recovery in paralysis of cervical origin is 53, while in that of dorsal origin it is 66.

7. *Rigidity or Contractures of Limbs.*—Of 12 cases in which rigidity was prominent, 5 recovered.

8. *Marked Wasting of Limbs.*—Of 16 cases with atrophied limbs, 8 recovered.

9. *Character of Spinal Deformity.*—The kyphosis, as was noted by Pott, is apparently not of great importance in prognosis, but a large gradual curve claims the largest per cent. of recoveries.

10. *Sex.*—As to the liability to paralysis in Pott's disease, it is interesting to note that of the 74 children studied, 34 were males and 40 females. The per cent. of recoveries is about the same in each.

11. *Part of the Body Involved.*—When there is more than a paraplegia present, the prognosis is made correspondingly worse, the per cent. of recovery being in the writer's cases 36, as compared with 62 in children with simple paraplegia.

12. *Recurrences.*—The cases studied give no reason for thinking the prognosis in a second attack any worse than for a first attack.

13. *Intercurrent Diseases.*—The writer has seen two cases of intercurrent typhoid fever; in one, as the fever progressed, the paralysis grew more severe till the patient became powerless, and then lightened with convalescence. The other, a fairly severe case of paralysis, was quite unaffected by the fever. In one case of amyloid disease, which died paretic, there was marked improvement in the paralysis during the two months immediately preceding death.

14. *Proportion of Deaths.*—Taylor and Lovett [2] find 5 deaths in 59 cases, Gibney [1] 13 in 58 cases, and the writer 12 in 86 cases. The mortality of the entire number of cases is 15 per cent.

General Summary of the Prognosis of Paralysis:

1. There is not a symptom characteristic of the paralysis that is of fatal import. Recovery has taken place even from threatening asphyxia.

2. There is hardly a condition of the paralysis so severe as to deny the possibility of recovery. Recovery has occurred from paralysis of arms and legs, anæsthesia, and incontinence.

3. The three most important elements in prognosis in the order of their importance are, (*a*) the duration of the paralysis; (*b*) the completeness of the paralysis of the affected muscles; (*c*) the age of the patient.

TREATMENT.—All authorities agree that the back should be put at rest; therefore confinement in bed or a spinal support, either jacket or brace, must be the first measure adopted. In certain cases this enforced rest, perhaps aided by extension and counter-extension, is sufficient for prompt cure. Relief in a few days or weeks has been given by opening an abscess connected with the spine, and operation is to be recommended if an abscess is present. Subsequent treatment is expectant; the number of drugs given, outside of tonics, is large, and no one is especially useful. After drugs, electricity is recommended, but some orthopedic surgeons are confident that its use has done harm. The cautery [12] and suspension [13] have both been thought to do good in some cases. With reference to all the methods of treatment beyond rest, it is to be noted that as the paralysis tends to a cure, which sometimes comes suddenly and unexpectedly, a careful estimate of the relative value of different remedies is difficult, if not impossible. Some cases, however, do not get well, and even grow worse very rapidly, and for them there has been since 1882 [3] a last resource in resection of the vertebral laminæ at the site of the lesion and relief of pressure. The mortality of the operation is large, but there have been some remarkable successes, and it is distinctly valuable as a last hope. *John H. Huddleston.*

[1] London Lancet, 1878, v., 259.
[2] New York Medical Record, 1886, xxix., 699.
[3] Boston Medical and Surgical Journal, 1889, 405.
[4] Schmidt's Jahrbuch, 171, s., 62.
[5] Trans. Am. Med. Ass., 1879, xxx., 657.
[6] Bradford and Lovett: Treatise on Orthopædic Surgery.
[7] Erb: Ziemssen's Cyclopædia, vol. xiii.
[8] Michaud: Sur la meningite et la myélite dans le mal vertébral. Paris, 1871.
[9] Centralblatt für Chirurgie, 1885, xii., 569.
[10] Pott: Remarks on that Kind of Palsy affecting the Lower Limbs, etc. London, 1779.
[11] New York Medical Record, 1885, xxviii., 452.
[12] New York Medical Journal, 1878, xxvii., 140.
[13] Am. Jour. of the Med. Sci., 1889, n.s., xcvii., 439.

POUGUES. An important thermal station in the Department of Nièvre, France.

LOCATION.—Pongues, or as it is often called, Pougues-les-Eaux, is a small place of about fifteen hundred inhabitants, prettily situated in the valley of the Loire, eight miles from the city of Nevers. Bradshaw ("Mineral Waters, Climatic Health-Resorts," etc.) says that "the situation of Pougues, in a large and airy valley, on the right bank of the Loire, is beautiful, and the impression is never forgotten. The excursions and minor walks are very numerous. The garden and beautiful old park, beginning immediately behind the bathing establishment, are very tastefully laid out, and offer walks of every description. The small lake affords boating. This picturesque part of France has no end of excursions of historical interest, among which we mention Garchizy and its Byzantine church of the twelfth century; Ussy, with the Castle of Bordes; the iron and steel works of Germigny; Castle Villemenant and the valley of Nifont; Poiseux and the fountain of the fairies; Saint Aubin and the wild gorge of the Douée; Premery; the forest of the Bertrange; Champroux; la Charité and the forges of Fourchambault, etc.; all being surrounded by hills covered with magnificent forests. The town of Nevers, with its historical associations and monuments, is equally interesting." The climate is agreeably equable. The season lasts from May to October.

The waters of Pougues are effervescent, cold, calcareo-bicarbonated, and chalybeate.

There are two springs, the *Source Saint-Léger* and *Source Bert.*

According to Dr. Vintras ("Mineral Waters of France") the first, "which has been the longest known, supplies a very comfortable hydro-mineral establishment, to which it furnishes more than eleven thousand gallons of water per day. The second has been lately discovered, and is exclusively used for drinking. It is weaker than the *Saint-Léger*, and is rather an excellent table-water than a medicinal agent. The water of both springs is exported in very large quantities. The establishment is composed of a main building with two wings, one reserved for ladies, the other for gentlemen. It contains twenty-six baths, very complete douche arrangements, and everything necessary for hydrotherapeutical treatment."

ACCESS.—Five hours from Paris, on the Paris, Lyons & Mediterranean Railroad.

ANALYSIS.—According to Prevot, one thousand grammes of the *Source Saint-Léger* contain:

	Grammes.
Carbonic acid, free	0.6091
" of the bicarbonates	1.0098
" of the carbonates	1.6033
Hydrochloric acid	0.1275
Sulphuric acid	0.1450
Silica	0.0150
Peroxide of iron	0.0146
Lime	0.7000
Magnesia	0.1150
Potash	0.0450
Soda	0.6290
	4.4133

INDICATIONS.—The waters of this spa are used with benefit in cases of atonic and neurotic dyspepsia, gastralgia, lithæmia, gouty manifestations, gravel, diabetes, Bright's disease, and genito-urinary disorders, as well as the various morbid conditions depending chiefly on anæmia. In many forms of diseases of women they are said to be highly efficacious, a circumstance probably entirely due to their tonic properties.

The method of treatment at Pougues is chiefly by drinking the waters in moderate quantities, the baths, massage, etc., being merely used as accessories to the internal use of the springs.

ACCOMMODATION.—The hotels are comfortable and clean. The *Hôtel Splendide* is the best known establishment. *Edmund C. Wendt.*

PRESTE (LA). A spa in the Department of the Pyrénées Orientales, France.

LOCATION.—The little village of La Preste is picturesquely built on a small plateau not far from Amélie-les-Bains and Perpignan. The springs supply a hot sodio-sulphuretted water, used both internally and for baths. Some recent improvements have brought the thermal establishment up to modern requirements, and all the different douches, springs, etc., are now administered. The climate is pleasant and the surroundings agreeable. Vegetation is luxuriant.

ACCESS.—By the South of France Railroad to Perpignan. Thence in four and a half hours by carriage to the spa.

ANALYSIS.—The numerous hot springs seem to have a common origin and composition. The *Grande Source*, or *Source d'Apollon*, is alone employed. According to Anglada one thousand grammes of the water contain:

	Grammes.
Carbonate of soda	0.0397
" potash	traces
" lime and magnesia	0.0011
Sulphide of sodium	0.0127
Sulphate of soda	0.0206
" lime	0.0007
Chloride of sodium	0.0014
Silicic acid	0.0421
Barégine or glairine	0.0103
Loss	0.0051
	0.1337

Dr. Vintras ("Mineral Waters of France") says that the *Grande Source* rises within the establishment which it supplies, and furnishes forty-four thousand gallons per day of clear, colorless water, with a slightly sulphurous smell and an alkaline flavor. It deposits white filaments of *glairine* in the reservoirs. Its temperature is 113° F.

INDICATIONS.—The author above mentioned speaks as follows on this point: "It results from this analysis that the waters of La Preste are of a mixed character. They are sodio-sulphuretted and sodio-bicarbonated, and contain an excess of alkaline principles. They are employed for drinking, and for baths and douches. They are easily absorbed by the stomach, increase the appetite, and exercise a remarkable action upon the urinary passages, increasing considerably the secretion of the kidneys, and diminishing the over-acidity of the urine. They are also especially valuable to patients suffering from uric and phosphatic gravel, vesical catarrh, vesical irritability or spasm, and chronic cystitis. In these last cases they are superior to the strong sodio-bicarbonated waters. They facilitate the expulsion of renal calculi; they exercise also a beneficial action in chronic affections of the liver. In addition to the above, the waters of La Preste will be found beneficial in the cases for which ordinary sulphurous waters are prescribed, such as, for example, bronchitis and chronic laryngitis, idiopathic or spasmodic asthma, phthisis in the first stage, and certain affections of the skin."

The waters of this spa are now exported in large quantities, and are said to keep well.

ACCOMMODATION.—The thermal establishment is comfortable, the hotels are only moderately good, and the lodging-houses decidedly inferior. La Preste is much frequented, especially by Spaniards. The season extends from June to October. *Edmund C. Wendt.*

PROGRESSIVE MUSCULAR ATROPHIES. Our knowledge of the progressive muscular atrophies has begun to clear, but the entire subject is still involved in a dense mist of obscurity. While it may be well, for clinical purposes, to retain the classification proposed in the original article of the HANDBOOK, it seems to be pretty well established that all the different forms of the disease of muscular origin are mere varieties of a single genus, in fact, that they constitute esseutially the same disease. This is shown not alone by the numerous transitions from one form to the other, and by the fact that in many cases it depends merely upon the personal bias of the observer whether the case shall be included under one class or another, but by the further fact that the anatomical changes in the muscles are essentially the same in all the different varieties. It is well to remember in this connection that, according to Lewin, who has made a number of very thorough and interesting examinations of the muscles, the microscope furnishes no thoroughly reliable differential data between myopathic progressive muscular atrophy and pseudo-hypertrophy, on the one hand, and the muscular atrophies of undoubted nervous origin, on the other hand. Lewin's investigations have led him to believe that progressive muscular atrophy is a diffuse process, affecting the entire muscular system. The nuclear proliferation, which is such a prominent part of the process, is the initial stage of the disease, and is probably the expression of a reaction of the muscular tissue to some irritant. The latter may possibly consist of some substance circulating in the blood, or it may be due to the loss of an inhibitory influence on the part of the trophic centres. Erb is inclined to favor the latter opinion. He believes that myopathies are spinal in origin and due to a dynamic disorder of the trophic cells of the anterior horns of the spinal cord. He also believes that our present microscopical technique is unable to reveal these changes. The arguments which he adduces in favor of this theory are—the very prominent influence of heredity in the production of the disease, the localization of the atrophy in muscles which correspond to definite spinal centres, the frequent coincidence with idiocy, epilepsy, etc.

The arguments adduced are, however, insufficient to sustain this theory. There is no reason why heredity should not play a part in the etiology of diseases of the muscular system. The latter possesses a relative autonomy for embryological reasons, and is accordingly able to transmit its vices by heredity. Furthermore Babinski and Onanoff have shown that the distribution of muscular atrophy is related to the development of the muscles rather than to localization in spinal centres. The coincidence of muscular atrophy with nervous diseases of various kinds is also not a proof of the nervous origin of the former. Vices of evolution, due to hereditary taint, may affect various systems, and it is for this reason that progressive muscular atrophy may be associated with anatomical and dynamic changes in the nervous system as well as in other organs of the body.

Struempell propounds a very remarkable theory, which is based upon the clinical history and post-mortem findings in a single case. In this case there was an absence of degeneration reaction and of fibrillary twitchings in the affected muscles, so that despite the fact that the localization of the disease pointed very strongly to its spinal origin, Struempell was inclined to place it among the progressive muscular dystrophies. At the autopsy, however, extensive changes (atrophy) were found in the motor cells of the anterior horns of the spinal cord, and to a less extent in the peripheral nerves. The muscles presented simple (non-degenerative) atrophy. According to this writer the entire process begins in the muscles, and extends subsequently to the nerve-fibres and cells. After the muscular fibres belonging to a "neuron" (nerve unit, consisting of a nerve-cell and its fibre) have undergone simple atrophy, the entire neuron will be destroyed. This theory seems to us to be entirely disproved by the fact that the spinal cord is rarely affected, and that, furthermore, the lesion in the muscles is rarely due to simple atrophy.

Further light has been shed upon the condition known as the peroneal or leg type of progressive neurotic muscular atrophy, according to Hoffmann. This writer now proposes the term progressive neural muscular atrophy. The disease does not always begin in the lower extremities, but sometimes starts in the upper limbs, or it develops in both at approximately the same time.

In two cases Hoffmann detected abnormal electrical reactions of the facial nerve, the mimetic facial muscles, and the tongue, although the function of these parts appeared to be entirely normal. In a very carefully observed case Dubreuilh found old changes in the nerves. These changes diminished in intensity from the periphery toward the centre, and were barely indicated in the anterior cervical and lumbar nerve-roots; there was slight proliferation of the neuroglia in the columns of Goll, involving the entire posterior column in the lower dorsal cord. The gray substance of the spinal cord was normal. The changes were most pronounced in the nerves and muscles of the hands and feet. Hoffmann thinks it probable that the changes in the nerve are degenerative in character rather than inflammatory.

Our knowledge of the subject is still too meagre to warrant any positive satisfactory conclusions concerning the pathology of these conditions. But it seem to us that the constant drift of the new data—clinical and anatomo-pathological—which have been acquired within the last ten years, tends toward the view that the entire group of progressive muscular atrophies belongs to a single class of developmental anomalies, due to inherited embryological changes. The differences in the clinical history and pathology of the various forms included in this group depend upon whether the degenerative or nutritive changes affect primarily the muscles, the peripheral nerves, or the motor cells in the anterior horns of the spinal cord. Such a theory, if substantiated, would shed light upon much that is obscure in the relations of the different affections included under the head of the progressive muscular atrophies. *Leopold Putzel.*

PROLAPSUS UTERI. ANATOMY.—Under this heading it is proposed to consider certain points in the pelvic anatomy which have especial bearing on the subject of prolapsus uteri.

The bony and ligamentous framework of the pelvis fails to give complete support to the pelvic and abdominal viscera. A large outlet is required for the passage of the child; and through this same outlet the viscera tend to fall. The structures which close in this opening and

support the superincumbent weight must be strong, elastic, and dilatable.

The greater part of the uterus projects into the pelvic cavity and is freely movable. It must be classed among the viscera tending to fall through the outlet; and is, therefore, in part, at least, restrained by the same force as that opposed to the rest of the abdominal mass. In other words, the occurrence of a prolapse of the uterus involves the giving way not only of the structures whose especial function is the support of the uterus, but also of those which support the viscera above.

Looked at from this broad point of view, the term prolapsus uteri becomes too narrow in its meaning, and Hart and Barbour's expression, "Sacro-pubic hernia," is more apt.

The supporting diaphragm which covers in the pelvic outlet has been termed the "pelvic floor." Its structure is as complex as its varied functions would seem to demand, and many of the details are yet in need of investigation. In a general way, however, enough is known of both structure and mechanism to be of material aid in explaining the phenomena of prolapse, and indicating the line of treatment to be followed.

In describing this structure, for our purpose it will be convenient to start with the recto-vesical fascia. This is a diaphragm of fascia, concave above, attached to the pelvic wall along a line running from the lower border of the pubes across the obturator fascia to the iliac spine; thence across to become continuous with the lower part of the fascia of the pyriformis.

This diaphragm is perforated by the rectum and va-

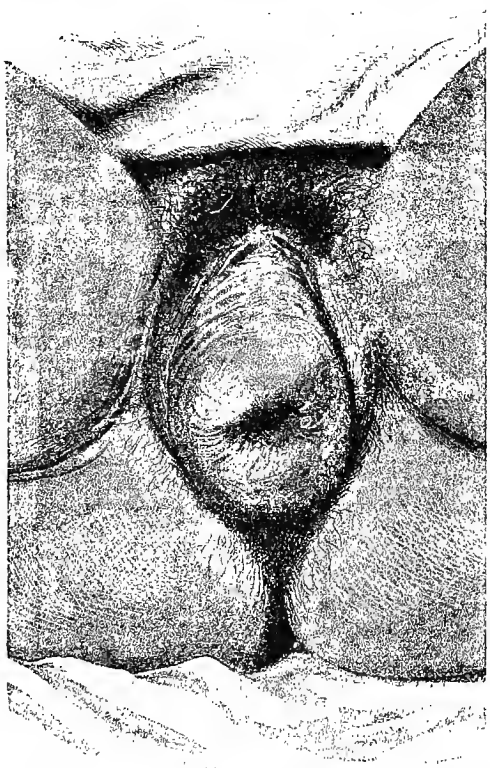


FIG. 539.—From a Photograph of Extensive Prolapse, with Hypertrophy of Cervix and Cystocele (Pozzi).

gina; and fibres are sent from the fascia to invest and strengthen the walls of these two canals. Portions of this fascia are especially strong and contain involuntary muscle-fibre. Most marked are the two bands running from the base of the bladder to the pubes—the anterior true ligament of the bladder. Less marked are the lateral ligament of the bladder and the ligament of the rectum.

Just beneath this concave sheet of fascia, and in close relation with it, comes another of muscle, the levator ani. The fibres take their origin along a line just beneath that of the recto-vesical fascia as far as the spine of the ischium. The fibres from the pubes pass down and back, separating for the urethra and vagina, part meeting in the median line, part mingling with the fibres of the ex-

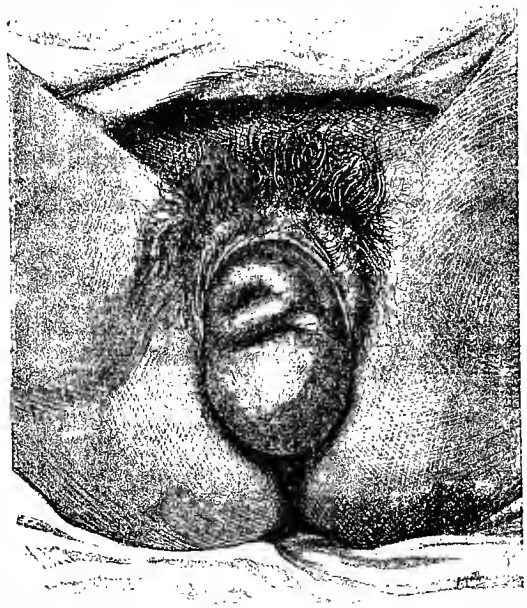


FIG. 540.—Extensive Prolapse, with Hypertrophy of Cervix and Rectocele (Pozzi).

ternal sphincter in the perineal body. The lateral fibres from the obturator fascia and spine of ischium converge as they descend upon the side of the rectum; while others meet in a median aponeurosis between the rectum and coccyx; the most posterior of all are inserted along the lateral margin of the lower part of the coccyx.

The whole muscle thus forms a diaphragm pierced by the vagina and rectum, and with the overlying fascia forms a concave floor upon which the abdominal and pelvic viscera can find support. Moreover the contraction of the levator ani will tend to lessen the concavity of this floor, and so raise the abdominal and pelvic viscera. It will also draw the lower end of the rectum up and forward; and, owing to the oblique direction in which the axis of the vagina is crossed by the fibres they will constrict this canal.

Before going further with the description of the supporting structure it will be well to consider a few points regarding the direction and relations of the three canals —urethra, vagina, and rectum. The urethra lies close to the subpubic ligament. The vagina has the lower part of its anterior wall in close relation with the urethra, and is bound firmly to it. The vaginal canal (which, it should always be borne in mind, is a mere transverse mucous slit in the pelvic floor) runs back and up at an angle of about sixty degrees to the horizon in the upright subject. In the upper part of its course it is in close relation with the rectum; but at a point about one and a half inch from the lower end the rectum turns suddenly back at right angles, so that its external orifice, the anus, is one and a half inch from the vaginal orifice. The tissues filling up this space between the two canals form the perineal body.

The thick, powerful, external sphincter ani, which has one origin at the coccyx, after passing about the anus, terminates in this perineal body, its fibres frequently decussating with those of the levator ani, bulbo-cavernosus, and transversus perinei muscles. The levator ani has already been described. The transversus perinei muscle

Prolapsus Uteri.

arises on either side from the tuberosity of the ischium, and meets its fellow in the perineum. The bulbo-cavernosi, which have little interest in this connection, come on their way along either side of the vulva, and meet again in the perineal body.

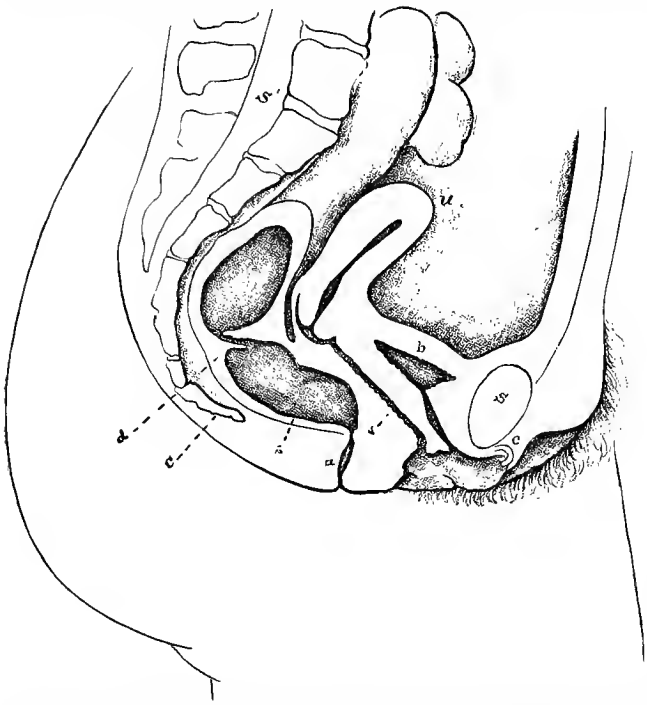


FIG. 541.—Sagittal Section, Median Line (Diagram). Shows relation of peritoneum to pelvic viscera, and the average position of the pelvic organs. *S*, Symphysis pubis; *S'*, sacrum; *c*, coccyx; *a*, anal canal; *r*, on perineal body, points to rectum; *v*, vagina; *e*, clitoris; *b*, bladder, when collapsed; *u*, uterus; *d*, valves of rectum (Ranney, modified from Foster).

The pubic triangle anterior to the transversus-perinei is closed in by a complicated fascia, the detailed description of which is unnecessary here. The important points are that although much weakened by the extensive longitudinal opening of the vulva it offers considerable support to the structures above; and its posterior fibres are fused with the substance of the perineal body. The deeper layer is in close relation to the under surface of the levator ani.

The perineal body, besides containing the structures mentioned, has a large amount of elastic fibrous tissue. It thus forms an important structure, a kind of *point d'appui* for all the muscles and fasciæ which bridge the pelvic outlet. From its position it supports the lower end of the anterior wall of the rectum, as well as the lower part of the posterior vaginal wall; while the anterior vaginal wall must receive support, as it is really above and resting upon the posterior.

There remains to be mentioned a considerable space back of the vagina, roofed in by the levator ani, and between the rectum and obturator fascia. This is the ischio-rectal fossa, and is filled with fat. Behind and somewhat below it is bounded by the inferior border of the glutæus maximus; the integument and superficial fascia on either side of the anus form the floor. This fat, resting on the structures named, gives some support to the pelvic diaphragm, and in its turn is helped (in the upright posture) by the pressure of the gluteal masses; while the region anterior to the perineum is supported by the crowding in of the large labia majora by the thighs.

To summarize briefly, then, we have a diaphragm of fascia and muscle supported to some extent anteriorly by deep perineal fascia, resting posteriorly on the ischio-rectal fat; while the bridge of muscles and fasciæ which meet in the perineal body forms with the integument the lower layer of the pelvic floor. The whole receives additional support from the fat of the buttocks, thighs, and labia.

The integrity of this floor is impaired by its perforation in two places: 1, by the rectum; 2, by the vagina.

Above the perineal body, for a variable distance, the vagina and rectum are in contact, though loosely bound together. As a rule the upper one-fifth of the vagina is free—the peritoneum of Douglas's pouch intervening. The anterior wall, which is shorter, is firmly attached to the urethra, but loosely to the base of the bladder. The upper end of the vagina is firmly attached to the cervix uteri. The axis of the uterus is forward, and nearly at right angles with the vagina. Posteriorly it has no attachment to the rectum; anteriorly it is loosely attached to the bladder, to about the level of the internal os. The bladder is loosely attached to the pubes, being separated from it by a mass of fat.

We now come to one of the most important of the intrinsic uterine supports—the sacro-uterine ligaments. From either side of the cervix a band of musculo-fibrous structure runs back, and out, and up, to be inserted upon the second bone of the sacrum. The fibres of this

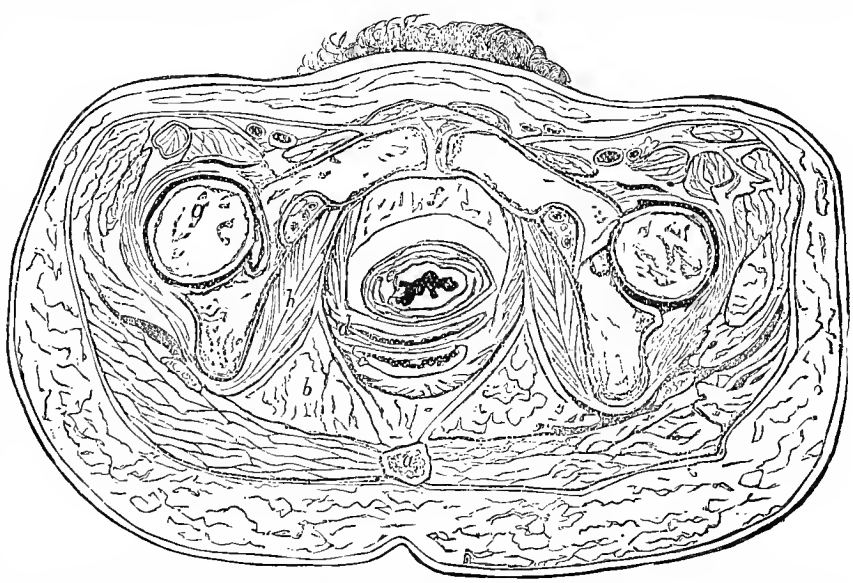


FIG. 542.—Transverse Section at Plane of Hip-joints (Ruedinger). *a*, Coccyx; *b*, ischio-rectal fossa, bounded by glutæus, obturator internus, and pelvic fascia; *c*, rectum; *d*, vagina; *e*, bladder; *f*, retro-pubic fat; *g*, hip-joint.

ligament are intimately united to the anterior wall of the vagina. In this way is formed a supporting beam for the uterus running from sacrum to pubes (Ranney).

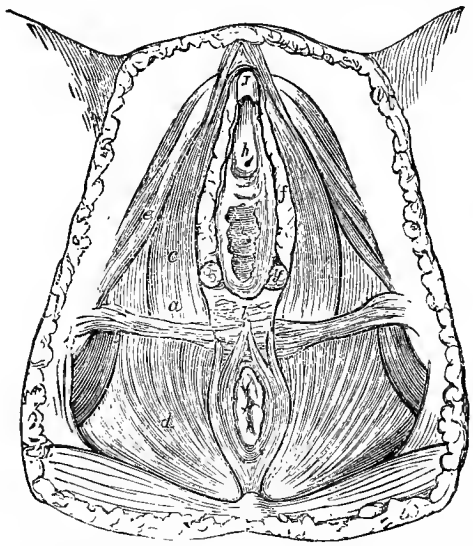


FIG. 543.—Dissection of Perineal Region (Savage). *a*, Just above transversus perinei; *b*, perineal body, junction of superficial perineal muscles; *c*, bulbo-cavernosus; *d*, on levator ani, in ischio-rectal fossa; *e*, erector clitoridis; *f*, bulb of vagina; *g*, Bartholinian gland; *h*, vestibule; *J*, glans clitoridis.

It now remains to speak of the broad and the round ligaments, and the pelvic peritoneum. The relations of the latter to the normal pelvic organs are too well known to be considered here in detail. It is important to note, however, that the peritoneum is exceedingly elastic, and

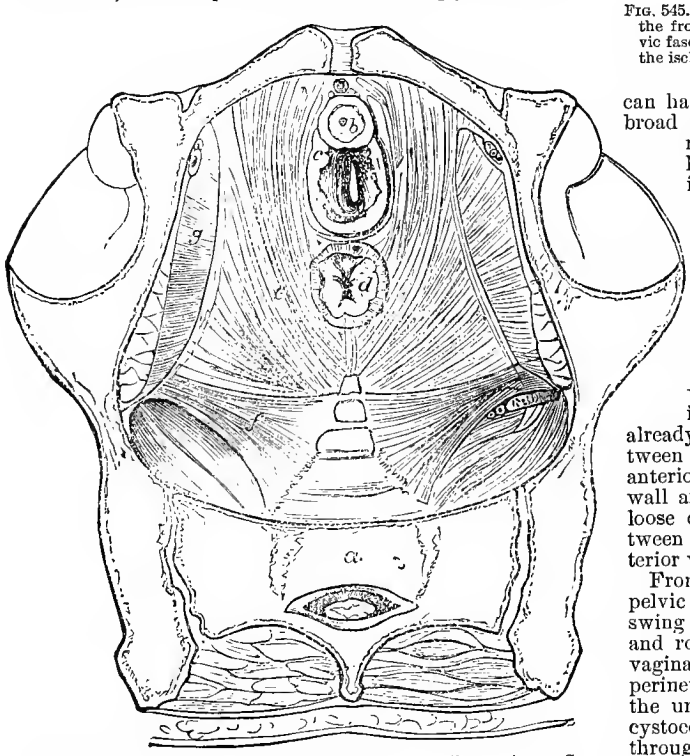


FIG. 544.—Dissection of Pelvic Floor from Above. (Savage.) *a*, Sacrum; *b*, urethra; *c*, vagina; *d*, rectum; *e*, levator ani; *f*, coccygeus; *g*, obturator internus.

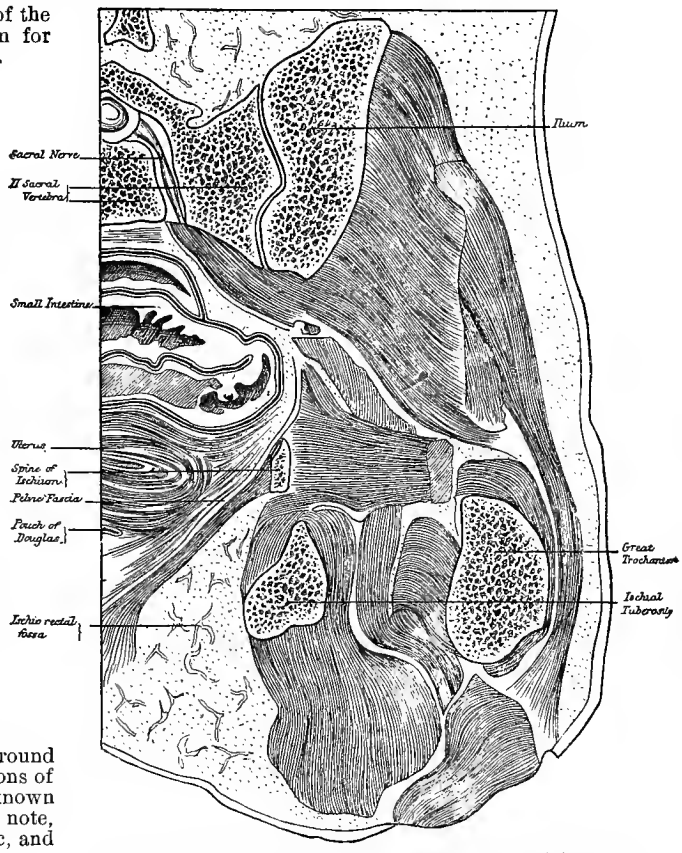


FIG. 545.—Coronal Section of Left Half of Pelvis. (Barbour.) (Seen from the front. The uterus was retroverted.) Shows the relation of pelvic fascia to levator ani which lies just below, and is seen rising from the ischial spine, also the cushion afforded by ischio-rectal fat.

can have very little power as an organ of support. The broad ligaments derive their strength chiefly from the muscular and connective tissue and vessels which lie between the layers of the peritoneum connecting the side of the uterus with the pelvic fascia. Their function is usually that of guy-rope rather than support. In extreme degrees of prolapse, however, they furnish considerable resistance. The round ligaments, in like manner, have practically nothing to do with the support of the normal uterus; and prolapse must be considerable before they are called upon to bear any strain.

The firm or loose nature of the connective tissue which binds together all the pelvic structures has importance in the mechanism of prolapse. As already stated, there is comparatively firm union between pubes and urethra; between urethra and lower anterior vaginal wall; and between the lower vaginal wall and rectum through the perineal body. There is loose connection between pubes and the bladder; between bladder, vagina, and uterus; and between posterior vaginal wall and rectum.

From this it follows that pressure from above upon the pelvic floor anterior to the broad ligament will tend to swing the structures anterior to the vaginal fissure down and round the pubes as an axis. So that the anterior vaginal wall would slide over the posterior wall and perineum, and protrude from the vulva, carrying with it the urethra and posterior wall of the bladder, causing cystocele. The pressure posterior to the broad ligament, through Douglas's pouch, would roll the upper part of the posterior vaginal wall forward and down. At the same time the uterus would descend, its axis following

that of the pelvic cavity. A rectocele is of comparatively rare occurrence, the posterior wall usually freeing itself from the rectum and prolapsing without it. Winkle speaks of one hundred and eight cases of pro-

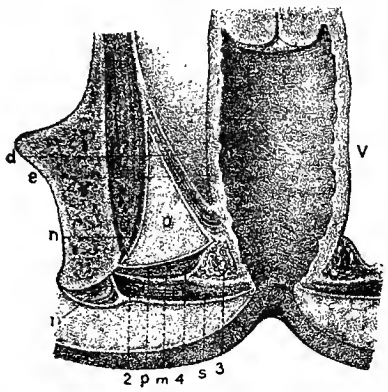


Fig. 546.—Perpendicular Antero-Posterior Section of Pelvis through the Vagina. (Savage.) *P*, body of pubic bone; *V*, vagina; *d*, recto-vesical fascia and the obturato-coccygeus muscle; *e*, inferior fascia of the same; *p*, posterior aponeurosis of the perineal septum; *m*, anterior aponeurosis; *s*, under layer of superficial perineal fascia; 1, sheath of deep layer of superficial fascia for the crus clitoridis and its erector muscle; 2, superficial transverse perineal muscle; 3, bulb of vagina; 4, lower muscular fibres of perineal septum.

lapse of the uterus, of which fifty-four were associated with cystocele; rectocele was found, however, in only thirty-three cases.

The peritoneum usually becomes displaced with the uterus, and occupies relatively the same position that it did with the uterus normally situated in the abdomen. This relation of the peritoneum to the prolapsed organ should be carefully studied.

From the foregoing it is evident that a prolapsus is complicated. No one structure is always primarily at fault; and it is as great folly to assign all cases to want of support in the perineal body, as to laxness of the recto-

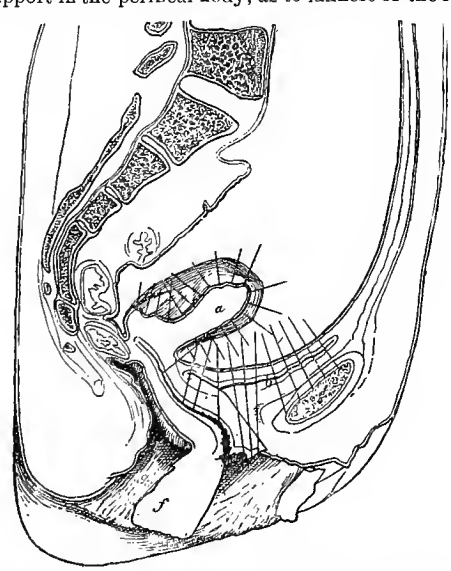


Fig. 547.—Diagram to illustrate effect of intra-abdominal pressure on the segments of the pelvic floor. (Hart.) *a*, Uterus pathologically anteflexed; *b*, bladder; *c*, rctro-pubic fat; *d*, labium majus; *e*, symphysis; *f*, perineal body; *g*, rectum.

Note tendency of pressure to displace downward all that portion of the pelvic floor in front of the anterior rectal wall.

vesical fascia, or utero-sacral ligament. All the supporting elements work together, so that failure of one throws undue strain upon the rest; and while ligaments and fasciæ and perineal body are important, we must not lose sight of muscular tonicity, abundance and quality of fatty tissue, and firmness of connective tissue.

Etiology.—Many points in the etiology have necessarily been considered in the anatomy.

The causes of prolapsus uteri, aside from the deformed pelvis, may be classed under two general heads: 1. Where the support is insufficient to bear even the normal uterus and viscera.

2. Where there is abnormal strain upon the pelvic floor and uterine support.

1. Under the first head, the injury to the pelvic floor during parturition is of prime importance. The ligaments and fasciæ have all been stretched; there is often rupture of the fibres of the pelvic fascia and levator ani. The perineal body is frequently torn transversely, laterally, or in the median line.

Where there has not been actual rupture there may be incomplete involution, leaving everything stretched, lax, yielding.

When there has been rupture it is easy to understand the natural sequence. With the integrity of the perineal body gone, many of the important structures in the

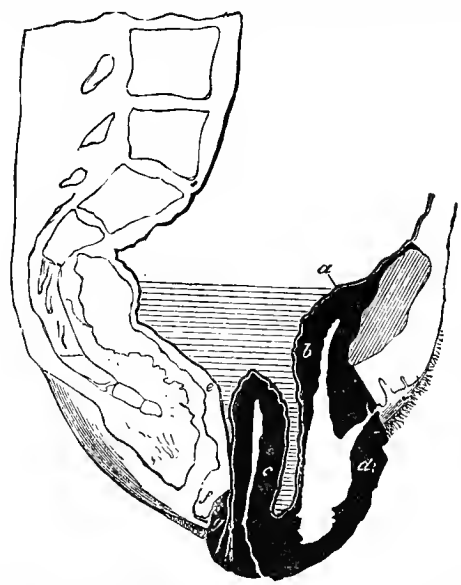


Fig. 548.—Diagram showing the result of intra-abdominal pressure causing prolapsus with cystocele, and illustrating the hernial nature of prolapsus uteri. *a*, Peritoneum; *b*, bladder; *c*, uterus; *d*, anterior vaginal wall; *e*, anterior rectal wall; *f*, perineum; *g*, posterior vaginal wall. (After Schütz.)

pelvic floor have lost their central point of support, or rather fixation. While if the laceration is such as to split the perineal body from before back, the posterior vaginal wall loses its support, and with the anterior rectal wall, tends to roll out through the elongated and probably gaping vulva. At the same time the anterior vaginal wall and the bladder, which naturally rest upon the posterior vaginal wall, lose part of their support, and tend to fall out also. These conditions, as is well known, are favorable to sub-involution of the vagina, and a prolapse of the lax and heavy vaginal walls is still easier. Under these conditions there is constant traction on the uterus by structures which should naturally tend rather to support it, or at least not to drag upon it.

Aside from the laceration and lax condition due to parturition, there may be incomplete support owing to loss of fat, or to want of tone in the muscular and ligamentous elements due to debility from any cause, such as disease, want of nourishment, and old age. Masturbation is also credited with bringing about a want of tone in the muscular and fibrous structures. Pessaries which stretch the vaginal walls play some part in impairing the support.

2. Under the second head (of abnormal strain upon the pelvic floor and uterine support) come all uterine tumors and others which are free enough to descend and bear upon the pelvic floor. The large sub-involuted uterus may be important, though it must be remembered that the sub-involution of the uterus is usually associated with a similar condition of the other pelvic structures which have been altered during pregnancy; hence the supports are lax and yielding at the same time, while the vagina is heavy and large and tends to prolapse.

Ascitic fluid may also aggravate any tendency to prolapse, though it is doubtful whether alone it would be of importance.

Hypertrophy of the cervix has sometimes been classed with prolapsus uteri. It may cause a prolapse by the increased weight; but it frequently exists in a marked degree, the cervix even protruding from the vulva, without causing any dislocation of the uterine body. Hence it should be classed under a special heading.

Tumors of the vaginal wall may cause enough dragging to dislocate the uterus.

Prolapse has been known to follow a blow on the abdomen, or a sudden severe strain, even in the virgin; and the frequent straining from chronic cough, constipation, stricture of the rectum, and strangury from any cause may be a serious factor in bringing about or greatly increasing prolapsus. It has long been well known that tight lacing is a frequent cause of this condition, and it becomes far more serious when there is constipation, cough, etc., in addition; the firm resistance of the abdominal wall throwing all the brunt upon the pelvic diaphragm. The age at which prolapse is found coincides nearly with that of the child-bearing period, as would be expected; though it may occur at any age and in a virgin. Munro reports a case in a child three years of age. Cases of congenital prolapse have been spoken of, but are not described with sufficient detail.

Out of 184 cases collected by Wanbey, there were only 6 occurring in women who had not had children. Winkle thinks that most cases of prolapse occur between the twenty-fifth and thirty-fifth years of life.

A deformed (kyphotic or spondylitic) pelvis may be the initial cause of prolapse. In this case the uterus does not find space sufficient for its accommodation. Veit reports the case of a girl, fourteen years of age, who had a kyphotic pelvis and prolapse of the uterus.

Diagnosis and Symptoms.—The diagnosis of prolapsus uteri is usually an exceedingly easy matter. All uncomplicated forms where there is prolapse to any extent, are self-evident. The cases which present difficulty are those where the degree of dislocation is slight; and these derive their importance from the fact that the symptoms may be wholly disproportionate to the apparent trouble, and the relief proportionately great from prompt and well-directed treatment.

Subjective symptoms which are in any sense pathognomonic do not exist, since the symptoms of this affection in its milder form are common to many other pelvic troubles. The displaced organ, by dragging on its support, by pressure on sacral nerves or rectum, and dragging on the bladder, and by interfering with the pelvic circulation owing to the twisting or pressure of the broad ligament vessels, will cause many symptoms which will call attention to the pelvis without indicating the exact nature of the trouble.

The commoner symptoms are pain (often dragging) in the loin, groin, and lower back; pain in the hip or thigh, constipation, painful defecation, frequent micturition, hæmorrhoids. As a result of passive congestion there may be leucorrhœa, dysmenorrhœa, menorrhagia, and metrorrhagia. Where the prolapse is excessive with protrusion of the cervix, or even of the whole organ, the constant irritation from exposure, rubbing, and dribbling of urine (a common feature of this condition) will cause ulceration of the mucous membrane, and hence pain and discharge.

It is evident then that the diagnosis must rest upon vaginal examination. As a rule, in the early stages the uterus retroverts as it descends; but this is not necessarily the case, and it is important not to be misled by this into overlooking the cases where there is a retrocession of the uterus toward the hollow of the sacrum, while it still maintains the normal angle with relation to the axis of the vagina. These cases are probably due to a relaxation of the anterior support, while the utero-sacral ligaments remain normal; and our experience would indicate that this condition is relatively more common in nulliparæ.

Since the uterus is normally so mobile, and since there is so much difference in individuals, it is practically impossible to define a limit which shall determine where prolapsus begins. In the slight cases the relief given by tentative treatment will be the criterion.

The condition most likely to be confused with prolapse of the uterus is hypertrophy of the cervix, particularly the forms where the intermediate or supra-vaginal portions are involved. Here the bimanual examination, and if necessary the passage of a sound, will show whether the fundus is still in the normal position.

The differentiation between prolapsus uteri and vaginal tumors, or fibroids and polypi extruding from the external os, will be easy if pains are taken to find the cervix and determine the position of the canal.

For practical purposes, however, the diagnosis of the existence of prolapse is the least important part of the examination. It is of much greater importance to determine the associated conditions, viz., the position and condition of ovaries and tubes, the presence and character of adhesions, the condition of the perineal body, the probable relations of the peritoneum, and the existence of true rectocele and cystocele. A sound in the bladder, and sound or finger in the rectum, will show whether the mucous membrane of these organs has prolapsed with the vagina.

Treatment.—To speak of treatment without first considering the prophylaxis of prolapsus uteri, is to ignore a most important factor in its production, namely, the improper management of cases during and after confinement.

All tears of the perineum occurring during labor should be carefully repaired, and the posterior vaginal wall inspected for any laceration which may extend along its surface. If such is found it should also be repaired.

The rectum should be empty by the second day; the bladder should never be allowed to remain full for any length of time after the first day; and the position of the patient should be changed from time to time. Rest in bed is of great importance so long as the uterus is large and heavy; and until involution is well established any laxity of the vaginal walls should be treated by the use of astringent injections and tampons. Large tears of the cervix should be operated upon as soon as possible after convalescence.

Treatment of prolapsus may be divided into palliative and surgical.

Slight degrees of prolapse can often be relieved, and sometimes cured, by the use of tampons or pessaries, but they should not be used soon unless the vulvar opening is intact, and then only when the uterus is moderately small and easily placed in its normal position. Ring pessaries and air pessaries are of very doubtful utility, because of the tendency they have to stretch the vagina and eventually make the condition worse than it was before their use. The stem and cup pessary with bulb and perineal band, may be indicated in very exceptional cases, but their clumsiness and filthiness will exclude their use in almost every instance. Hodge's pessary will often be found useful. Gehrung's pessary for cystocele is very difficult to adjust and should never be employed by anyone who does not thoroughly understand its application. Schultze's sled runner pessary may also be given a trial.

Brandt's method of pelvic massage has found some very warm advocates, and is of undoubted use in cases of prolapse where the supports below are moderately intact, where the uterus is small, and where the trouble probably arises from loss of tone in the uterine ligaments, with a lax and atrophied condition of the pelvic cellular tissue; also in cases complicated by adhesions.

The surgical treatment offers such a good chance of recovery, and is attended with so little danger, that it is to be insisted upon in the majority of cases.

The surgical treatment of these cases can, in a broad sense, be divided into four parts:

1. Operations intended to diminish the size of the uterus, and to close to a greater or less extent the vulvar opening.
2. Alexander's operation.
3. Operation for the ventral fixation of the organ.
4. Extirpation of the uterus.

Under the first heading must be mentioned amputation of the cervix, curetting and packing the uterus, the use of electricity, and later some plastic operation upon the perineum and vagina.

Alexander's operation is one of great use in properly selected cases. It should never be undertaken when the uterus is heavy or when the prolapse is complicated by any form of pelvic tumor, or by adhesions. The support from below must be good, and for this reason operations on the cervix and perineum should precede Alexander's operation. If these rules are observed satisfactory results will follow, and Alexander's operation will be found a most useful adjunct to operations on the uterus, perineum, and vagina.

Ventral fixation is a method of treatment having much the same limitations as Alexander's operation, and possesses no advantage over it provided the round ligaments can be found, except in certain cases where there are adhesions which might be safely broken up through the open abdomen, but which would be unsafe to tear by means of bimanual manipulation.

If the abdomen is opened for the removal of some pelvic growth complicating prolapse, then ventral fixation may be attempted or else some method of shortening the round ligaments within the abdomen, as by folding them on themselves or uniting them in front of the uterus.

Vaginal and abdominal hysterectomy have been undertaken for the cure of prolapsus. The technique is the same as when the operation is performed for fibroids, or malignant disease; and as yet a sufficient number of cases have not been collected to warrant an opinion regarding its utility. This much, however, may be said, that in some few cases herniæ have developed into the vagina, which naturally made the condition of the patient more pitiful than before the operation.

Resort to operative measures should never make the surgeon unmindful of the importance of general and local tonic treatment. Good general health and muscular tonicity, with a healthy condition of vaginal mucous membrane and endometrium, will increase the power of the supports and diminish their burden, thus making the results of operative treatment more satisfactory and enduring.

George Haven.
George A. Craigin.

PROPHYLAXIS, GENERAL PRINCIPLES OF. Medicine as an art finds its highest point of development and practicability in the prevention of disease. The process of prophylaxis has been from the empirical to the rational, though, as a completed science, it still remains far short of a perfect system. Its principles, like all great truths that affect the welfare, progress, and destiny of mankind, have long been foreshadowed in beliefs, superstitions, and vague conceptions, and instinct has often served as a guide where reason failed to discover. Indeed the notion that disease is avoidable and preventable, may be said to be primitive, if not innate in the human mind, being manifested in some form or other among all nations and races during all times. The ancients possessed it, and from the very earliest dawn of medicine until now, the search after absolute and specific preventives of disease has always occupied a large share of the attention of those engaged in the practice of the art. The Egyptians, the Greeks, and the Romans recognized the great importance of sanitation and hygiene as prophylactics, and inculcated rules for the preservation of health and the prevention of disease. Moses, the lawgiver, laid down a sanitary code, with severe penalties attached for infringement, and gave special direction for the disinfection of persons, places, and things, so thorough and effective in use that even this advanced age can find but little room for improvement. Among the Orientals the amulet is the most ancient form of disease preventive. Thus a dried toad worn next to the skin was held to be a protection against the plague, and coral worn by infants was supposed to preserve them from all the diseases incident to teething. Many of the precious gems were held to shield their possessors from the effects of poisons, or even to betray their presence by change of color when brought near them. The diamond and amethyst were reputed to guard against drunkenness. So lately as 1808 the Shah of Persia thought that he could not send a more acceptable present to Bonaparte than a few of the precious bezoar stones, which that great man, however, did not appreciate at their Oriental value, for, it is said, he contemptuously threw them all into the fire. Pope Adrian used an amulet composed of dried toad, arsenic, pearl, coral, emerald, tormentil, hyacinth, and tragacanth. Serapion recommends the gem hyacinth as an excellent amulet to protect the body during thunderstorms. The ancients made use of the *lapis lazuli* as an amulet, and Schröder describes it as an admirable charm for driving away fright from children. In the time of Queen Elizabeth, of England, we find Lord Chancellor Hatton, writing to Sir Thomas Smith, saying, "I am likewise bold to recommend my most humble duty to our dear Mistress (The Queen) by this letter and ring, which hath the virtue to expel infectious airs and . . . I trust, Sir, when the virtue is known, it shall not be refused for the value." In heathen countries the images and symbols of one or other of their gods were worn as amulets. When Christianity became triumphant the representation of its Founder on the Cross, and passages from Scripture, were used to ward off disease, or even the Evil One. Celsus says in the preface of his work, "De Re Medica," "Diseases are to be attributed to the wrath of the immortal gods, and from them relief is to be sought." These instances of superstition and credulity might be multiplied indefinitely. They are, however, sufficient to illustrate the general prevalence of the ideas and methods employed to prevent disease. Man, in every country and at all times, actuated by the first law of nature, shrinks from pain and gives faith and credence to the mysterious and incredible, if it only promise to shield him against danger or calamity. Not only is this true in respect to ancient and mediæval times, but even at this day we find peoples and communities, judged as intelligent in ordinary matters of life, resorting to, and relying upon, the protecting influences of little bags of sulphur, garlic, or camphor, hung from the neck, which they deem capable of warding off contagious disease. In contradistinction to these primitive and irrational conceptions modern prophylaxis undertakes to possess an actual knowledge of the real causes, and as an art seeks, through rational measures, to combat and destroy them. Its cardinal principle is knowledge of, and avoidance of, causes. Guided by these, its purposes are carried out by two methods in the attempt to prevent the occurrence of disease. The first of these undertakes to conform to the general rules of sanitation and hygiene, and thus bring the body into a vigorous condition of health; and the second aims to afford protection by investigating, understanding, and removing the predisposing conditions and causes of disease. From this conception it is evident that a completely developed system of preventive methods is possible, through an actual and exhaustive knowledge of the several and various elements of physiology, hygiene, and etiology. In the light of developments made possible through the achievements of the germ theory and cell doctrine of diseases, a science of prophylaxis has been rendered feasible and possible. In order to understand its principles and methods it will be necessary that a brief examination be made into those circumstances and influences which are ordinarily presumed to favor or retard the origin, development, and the distribution of disease. Many of the older conceptions of morbid phenomena have been entirely revolutionized by the advent of microscopy and bacteriology, and in no department is this change more marked and radical than in that of etiology.

In former times the latter was chiefly an *x*, which each speculator defined as he pleased, and a number of them did not fail to avail themselves of some of the most fanciful and wildest of guesses. We now know that many of these are false, and are furthermore enabled to form exact notions of the nature, origin, habitat, and *rôle* of the causes of disease, and to fully estimate their importance individually. Not only are our data concerning the exciting or proximate causes more ample and precise, but our knowledge of the predisposing conditions of disease and their power to produce susceptibility in the organism has been considerably extended in recent times.

It is now proper to take a cursory survey of these several factors of etiology and attempt to discover their nature and *rôle*, and assign to each its proper value in this connection.

The predisposing conditions of disease are found to exist in, and emanate from, internal and external human environment. All zymotic phenomena, while not originating in peculiar environment, so far as we now know, yet are its inevitable outcome. This is true to the extent that there must always be a pathogenicity upon the part of the germ, and a susceptibility upon the part of the individual attacked, or else there is no disease and the organism escapes. If either of these co-operants be absent or inoperant there is failure to originate morbid phenomena, and the germs are not reproduced. Hence, should there be anything in the media to hinder the conjunction and co-operation of both of these necessary factors, disease does not occur. Prophylaxis as a science undertakes to discover and understand these necessary conditions, and by modifying or avoiding them seeks to prevent their products—disease. In order to accomplish this, its procedures and methods partake of two general divisions. The first is to prevent liability or susceptibility on the part of the organism ; the second, to remove or destroy pathogenicity upon the part of the germ, and to render all circumstances and conditions which favor or foster its presence and perpetuation hostile. The first division of these methods is largely hygienic, sanatory, and preparative in character, while the second is aggressive and purposes to seek out and destroy the germs. In the latter we have the method of disinfection and antisepsis illustrated. Experiments show that when animals are well fed and cared for, and brought up to a high state of nutrition, they may withstand inoculation of viruses which under ordinary circumstances would destroy them ; and that the under-fed or half-starved are highly susceptible and quickly succumb. From experiments of this kind it has been found that susceptibility is invariably present in a directly inverse ratio to the standard of nutrition of the animal. In the light of these facts it is seen that the metabolic processes of the organism through which the functions of respiration, circulation, digestion, and assimilation are maintained, are highly essential to a competent degree of vital resistance. Hence we are led to believe from this standpoint that the prevention of disease will largely depend upon the attention paid to those methods which are connected with the nutrition and vigor of the organism in general, and the body-cells in particular. In this connection food, habitation, clothing, exercise, and ventilation stand paramount to all others. In their absence the organism cannot exercise its highest forces of protection, being deprived of the physical basis of energy, and the organism becomes susceptible and liable to invasion. Our success in combating morbid agencies will largely depend upon the degree of prominence given these details and the efficiency with which they are executed. They constitute the fundamental principles and ultimate grounds upon which to erect the edifice of a rational prophylaxis. They indicate the cardinal fact that disease agents do not possess the power of unconditionally deranging the health, but that there are certain conditions necessary for this, and that it is only when the organism is sufficiently predisposed to be susceptible that the germs can enter and set up disease. In further substantiation of this point, the luminous and far-reaching theory of Metschnikoff enables us to both appreciate and understand its importance. It furnishes us with a clear conception of the final details of the mechanism of the cells, whereby they resist and destroy the micro-organisms of disease. In another direction the equally important investigations in regard to the *rôle* and influence of the fluids of the body, such as the blood, glandular products, and intercellular-tissue juices show how the organism employs these as a means to resist disease ; and it has also been shown that the blood-serum not only exercises important properties as a germicide, but also furnishes, when of proper quality, the means for the subsistence and functions of the phagocytic cells.

Thus far we have viewed briefly those agents and agencies internal in the organism whereby it protects itself and maintains its integrity. It is now proper that we direct attention to a few of those conditions which tend to so alter and modify these as to render the system liable to disorder. The factors of race, age, sex, temperament, idiosyncrasy, heredity, and habit of body are all recognized as elements in the etiology of disease. Under present circumstances of our knowledge, prophylaxis has no means through which it can obviate or avoid the results of these causes, and it at best can only expect to modify their effects. No precautionary measures with which we are now acquainted are capable of entirely combating the influences emanating from these, and they must, from the nature of the case, be largely considered as inevitable in character. In the second division of predisposing conditions, such as follow from influences of climate, soil, habitation, occupation, class, and season, we do find them susceptible of modification and control, and we can so act as to ameliorate or completely counteract their deleterious effects to a large degree. It is with the latter that prophylaxis is chiefly occupied, and finds its field of usefulness. Without dwelling *seriatim* upon each of the above agencies, it may be said in a general way that climate, class, occupation, and food constitute the leading and most important predisposing causes of disease. Man, like all living organisms, is powerfully affected by the nature of his environment. Under certain circumstances the conditions of the latter are highly propitious and lessen the struggle for existence ; on the other hand, they may be antagonistic and render life precarious and hard. Again, in one respect, at least, the importance of heredity cannot be over-estimated. That is, we must distinctly understand that those predisposing conditions which exist by virtue of temperament or idiosyncrasy, also those typical proclivities called diathesis, however influential as factors controlling morbid processes in individuals, receive their force and character from heredity, and may be said to be merely effects of hereditary predisposition specialized in certain sets of individuals ; but heredity means much more than mere temperament, idiosyncrasy, and diathesis, for it not only includes all these, but also implies a morbid predisposition which has arisen in the ancestors before, and has been transmitted to the offspring and has become intensified by descent, or modified by sex, age, or accessory circumstances. We may not know what these intricate and occult conditions are, but we see them manifested as results concerning which there can be no doubt. In such disorders as gout, rheumatism, diabetes, scrofula, cancer, neuralgia, rickets, syphilis, epilepsy, chorea, and a number of others, the hereditary factor is frequently present and exercises a powerful influence. In respect to climate, the effects are potent. In the warmer or tropical countries of the earth the duration of life is shorter, and the morbidity and mortality greater than they are among those who live in temperate regions. In the colder regions these extremes are again met with, and disease is more frequent and deaths more numerous as the result of pulmonary and bronchial disorders. Thus within certain limits the dangers from warm and tropical climates are equal to those resulting from cold and dampness. In warm regions germs and their products, in the form of paludal fevers, are indigenous. Humidity and warmth, together with the large quantities of decaying vegetable substances incident to the tropics, afford a favorable culture medium for the perpetuation and existence of germs, and

the inhabitants are a ready prey. The association of pneumonia, bronchitis, rheumatism, and asthma with a bleak and wet climate is too invariable to permit our doubting their reality as causes. Sydenham attributed to the atmosphere an "epidemic constitution." Moist weather, be it hot or cold, is always found conducive to the spread of contagion. From this we can regard it as certain that there exists a connection between infectious disease and the atmospherical conditions. Statistics show that cholera, diarrhœa, and the exanthemata are always aggravated by damp weather. A warm, dry climate, on the contrary, tends to check or lessen the spread or progress of morbid agents of every kind. The ailments most usually associated with climate are those commonly regarded as inflammatory, and the exact value of its influence in prophylaxis has not been worked out except in a very general way. In respect to occupations as predisposing to disease, the fact of such predisposition is well known and admitted. The indications for prevention are plain and need not be dwelt upon here. The same is true of the influences arising from class. Poverty is a potent factor in undermining the organism through the want of food, clothing, and suitable habitation. Statistics show that the upper classes have a longevity twenty-five per cent. greater than the lower class, and fifteen per cent. greater than the middle artisan classes. In the matter of susceptibility to disease, Korosi, of Buda-Pesth, found that cholera, small-pox, measles, and typhoid fever were far more prevalent among the poor. Zymotic diseases as a whole were sixty per cent. more frequent among those living in basements than among those living in higher domiciles. In regard to other statistics of this class, those of Dublin show that in the first class of society, including independent people and professors, the mortality was 22.5 per 1,000. In the second, or middle class, it was 25.4 per 1,000. For the third class, composed of shopkeepers, workmen, and others, it was 26.1 per 1,000; while for the fourth class, occupants of jails, poorhouses, and those in the lower walks, it was 37.5 per 1,000. Influences emanating from city and suburban life show marked contrasts in producing liability to disease. The influences of city life tend toward degeneration and are highly conducive to disordered innervation leading to increased predisposition to disease. Its crowds, its dust, the deprivation of light and sunshine, filth, bad odors, bad water, and want of out-door exercise are potent causes of debility. This is true in so far that it is well-nigh impossible to find a fourth generation of pure bred Londoners or Parisians, their progeny dying out in early life, partly from physical and moral decline and partly from inability to continue the struggle for existence. The pure Londoner of the third generation can seldom be found in the workshop, for his physical condition is too poor to stand the strain, and he is, as a rule, short, narrow-chested, scrofulous, and with deformed jaws, and a small head. In the struggle for existence such men are at a disadvantage and succumb as the early prey of disease agencies. From what has already been stated in regard to the predisposing or debilitating influences of disease, their nature, kinds, and means of operation, the indications for their modification or removal are evident. The purpose of prophylaxis in this direction will be to produce a high state of bodily health through the means of hygienic and sanatory methods, and to remove or destroy those circumstances of environment, in so far as such a thing is possible. The preservation of health-giving conditions of any and all kinds is the great prophylactic principle. To augment and fortify the reserve forces which are manifested in the form of vital resistance to disease agents is the chief object. In combating the presence and maintenance of germs without the body, we have the second department of prophylaxis, which embraces the methods of antisepsis and disinfection. The purpose of these is to destroy the pathogenic agency of infectious material and thereby prevent the spread of disease. It may be stated that a disinfectant for one disease is a disinfectant for all, and what is capable of acting as a germicide for one, is capable of acting in others. Any agent, therefore, which in certain proportions acts as a germicide, in a smaller quantity may act as an antiseptic. An antiseptic is any substance capable of preventing or retarding the growth of the bacteria of putrefaction. It follows from this that all germicides are antiseptics, though all antiseptics are not germicides. The purpose of germicides is the absolute destruction of infectious agencies; on the other hand, antiseptics may be employed to prevent and arrest putrefaction, and thereby destroy the media upon which infectious agents may lodge and propagate. Collections of putrefying matter should be disinfected and removed, not because they promote and invite the presence of every form of bacterial disease, but because the effluvia and noxious odors arising from them are possible sources of debilitating influences, and in this way they operate directly upon the economy and render it more liable to the invasion of disease. The apartments of the sick should be freely ventilated. In most instances the uppermost room of the house is the best location for the care of a contagious disease. Here the patient will obtain freest access to air and light, and be less liable to be visited and seen by those who may be liable to contract the disease. When the malady subsides all bedding, carpets, hangings, furniture, and clothing should be submitted, as the nature of the article demands, to thorough processes of disinfection as hereafter described. For the disinfection of rooms and apartments chemical substances are used of a gaseous and liquid form. One of the best for this purpose will be found in chlorine. It decomposes hydrogen and ammonium sulphides at once, and is more certain than any other gas. Chloride of lime moistened with water or with dilute sulphuric acid, and placed in a shallow vessel, will furnish it from a ready source. It will destroy organic matter in the air. Another, cheaper, more efficient, and convenient disinfectant for apartments will be found in sulphur dioxide. To be efficient it must be used in large quantities. Ten pounds of sulphur moistened with alcohol, ignited in a closed room, should be allowed to burn for six hours to disinfect a space ten feet by fifteen feet by seven or eight feet. Fortunately for personal prophylaxis and disinfection, the actual seats of the germs in the body are known. In each particular disease there is always some particular part, tissue, or organ which is chiefly occupied by them. In employing disinfectants it is proper that we always begin with a direct special attention to these parts. In the exanthemata it is the skin and mucous membranes that constitute the leading centres for the production or propagation of the infectious agents, and they should receive the most attention. In diphtheria the same methods will apply, while in cholera, typhoid fever, dysentery, and diarrhœa, it is the discharges from the bowels and kidneys that demand the most scrupulous care, since it is by these avenues that they are reproduced and act as the vehicle for contagion. For personal disinfection of the skin and fauces, Labarraque's solution diluted with twenty parts of water, is useful and efficient. Oily disinfectant inunctions for the skin by means of carbolized sweet oil, vaseline, or camphorated oil are good, and furnish the best means of preventing the detachment of epithelia and pus; they should be employed from the very commencement of small-pox and scarlet fever. The throat in these diseases should also be washed freely with Condy's fluid, a weak solution of sulphurous acid and water, or Labarraque's solution. All discharges from the nose, lungs, and throat should be received upon rags and immediately burned, or, if upon towels or handkerchiefs, these should be at once plunged into a solution of chloride of lime. The body in these disorders may be also bathed or sponged with one per cent. solution of chloride of lime, weak carbolic-acid solution, or a 1 to 10,000 solution of the corrosive chloride of mercury. In those instances where the stools are the subject of apprehension, they may be disinfected with a solution of corrosive chloride of mercury, one half-ounce of the salt to a gallon of water, and clothing that is suspected should be treated by placing it in boiling water to which has been added two ounces of chloride of lime for each gallon. For the disinfection of apartments, clothing, bedding, carpets, hangings, closets,

sewers, and other places of contagion, there are other means at command. Among the most effective, convenient, and reliable of these may be mentioned moist and dry heat, and chloride of lime in solution. In addition to these we possess other agents of lower powers of disinfection which will be found suitable for ordinary antiseptic and deodorant purposes. These are boiling water, dry heat of a temperature of 180° F., sulphur dioxide, carbolic acid, sulphate of copper in solution, chloride of zinc, and sulphate of iron in solution. In regard to the first of the former list, heat, it is scarcely necessary to say that fire, complete combustion, is an effective method of destroying disease agents. In buildings of little value and in the case of articles of clothing and furnishings which have been infected with dangerous contagia, such as small-pox, cholera, or diphtheria, it is always the best and safest plan to destroy them by fire whenever the circumstances will allow. Heat, for general purposes of disinfection, is the most effective of all methods. It is employed in several ways both as dry and moist heat. Drs. Parsons and Klein have made numerous and elaborate experiments both in regard to the degree and the form of the heat, and in regard to the duration of the exposure. These tests show that dry heat is the best form and most readily adapted for the ordinary purposes of disinfection to which it is applied. This kind of heat can be supplied by means of a common laundry drying closet or a baker's oven, either of which affords a sufficiently powerful heat to destroy all contagious matter. The chief objection to dry heat is that it penetrates bulky and badly conducting materials very slowly, and the time usually allotted for the destruction of germs is far too brief for the complete destruction of all of them. If the drying closet be used care should be taken to let the articles remain exposed for at least four hours, and the temperature should not be below 200° or 250° F., the latter being far better. Ordinary fabrics such as linen, wool, silk, and cotton will bear a temperature of 200° F., without danger of being scorched. White woollens are always soonest affected, and should be carefully watched. To avoid bad effects the temperature should be observed carefully and never permitted to exceed 250° F. in any case. Dry heat is generally applicable to all classes of goods that can be boiled, and is said to be materially aided in its penetration by the addition of a certain amount of moisture, though the latter does not directly assist in the destruction of the contagia. Koch, from experiments, found that bacteria in general, free from spores—and no human disease with which we are acquainted possesses them—cannot resist a temperature of 212° F. for many minutes, and that if it be continued for an hour and a half they almost all invariably perish. Steam is considered to be the best form in which moist heat may be employed. Its complete penetration for five minutes is found to accomplish thorough disinfection. Koch, Parsons, Klein, and others are all agreed in their preference for it, because it is more rapid, certain, and reliable than any other agency. A pressure of twenty-five pounds, if continued for five minutes, will always insure complete penetration and the death of the bacteria. The results of the employment of boiling water are not shown by experience to be completely satisfactory. However, if the boiling process be kept up sufficiently long, say for several hours, and a little carbolic acid or chloride of lime or zinc be added to the water, the results can be relied on to a certain degree. If in any case there should be any doubt, when the disease is of a fatal character, the articles should, when such a step is practicable, be submitted to dry heat in an oven or drying closet, and the highest temperature compatible with the safety of the fabrics should be used. As a rule in these cases, the finest fabrics, such as linens, cottons, and woollens, may be treated to a temperature of 225° F. for an hour without apprehension.

With regard to the mode by which chemical disinfectants act and exert their influence as such, there are a number of speculations and solutions offered. Some are thought to act by oxidation, others by their properties of coagulating albumin, and still others in a manner quite unknown or but little understood. A number of the chemicals employed as disinfectants are known to evolve oxygen freely, and are presumed in this way to hasten the disintegrating of the noxious matters. Chlorine, nitrous fumes, and ferric compounds are supposed to disinfect by this process.

Bichloride of mercury in solution is the most powerful and reliable disinfectant known to science. Experiences show that it is a deadly poison to all the lower forms of life, which it kills almost instantly when employed in the proper proportions. In the proportion of one part to five hundred parts of water it destroys the vitality of bacteria in ten seconds; in the strength of one to two thousand, in one and one-third minute; and in that of one to twenty thousand, in from fifteen to twenty minutes. Thus it will be seen that time is an element always to be considered when the solutions are used in ordinary proportions. The fact that bichloride of mercury combines with albumin leads to the belief that it interferes somewhat with the process of destruction, and this is always to be remembered when it is employed. It cannot be used in connection with lead, tin, or copper, owing to its corroding properties, and for this reason it is not suitable for disinfecting vaults, sewers, or privies, where metal pipes are a part of the fixtures. The following solution is recommended by Sternberg as capable of destroying completely all the germs associated with infectious disease, viz.: bichloride of mercury, four ounces; sulphate of copper, one pound; water, one gallon. Dr. Parsons recommends the following solution as suitable for clothing, excreta, etc.: bichloride of mercury, half an ounce; hydrochloric acid, one ounce; aniline blue, five grains; water, five gallons. Mix. This is the standard solution No. 1, of the Public Health Association, and has been tested thoroughly as to efficacy. It should always be labelled "Poison."

Chlorine gas is another powerful oxidizing agent, and is extremely irritating to the air-passages when inhaled. It decomposes ammonia compounds and sulphuretted hydrogen, and affects all substances arising from putrefactive changes. It bleaches organic matters and destroys odors, either by withdrawing hydrogen or by direct oxidation. It is a pale, yellowish-green gas at ordinary temperatures, about two and a half times as heavy as the atmosphere. Chlorine gas is usually generated by means of chloride of lime, moistened with water or dilute sulphuric acid. There are several popular disinfectants which contain this gas in sufficient proportions to be of service in disinfection. Among these may be mentioned Platt's chlorides, Labarraque's solution, and Javelle water. Chloride of lime is frequently used without the addition of water or dilute sulphuric acid, being scattered over the surface of apartments or the earth, and in gutters, vaults, and privies, and the moisture in the air liberates the gas as free chlorine. Bromine and iodine gas are used for purposes of a similar character, but their expensiveness renders them impracticable for common use. In this connection it may be added that fumigation should always be regarded in the light of an accessory process, and that when infection is actually present, it should invariably be supplemented by the other and more efficient processes of baking with dry heat, steaming, and washing, as the exigencies of the case may require. A failure to do this and make the process complete will, through leaving a single article or place overlooked, create a new centre for infection, and the work will have been futile. All wood-work, walls, floors, and furniture must be rubbed down and washed with a solution of bichloride of mercury, an ounce to the gallon of water, and the hangings, bedding, and clothing submerged, or rinsed in a weak solution of chloride of lime. For purposes of fumigation the most available, inexpensive, and reliable antiseptic for apartments is sulphur dioxide (SO_2). This is the most ancient of all scientific agencies used for the purpose of preventing the spread of disease and destroying the lesser forms of life. The Greeks and Romans were acquainted with the preservative properties of this gas, and used it as an antifermentative in wine. Guyton de Morveau, who

first studied its action, was of the opinion that it would completely destroy miasms. Koch asserts that anthrax bacilli are destroyed in a one per cent. solution in thirty minutes, and Sternberg says, "In the proportion of one to two thousand, in an aqueous solution, SO_2 kills micrococci in two hours." The experiments of Baxter led him to the conclusion that "it is the most powerful volatile disinfectant known." Notwithstanding these high words of commendation I am inclined to the opinion that this gas can be too much relied upon as a disinfectant, and that the proper course lies in either supplementing its employment by other means, or in using it in a more concentrated form than has been the practice heretofore. For the disinfection of rooms recently vacated by diseased persons, five pounds of sulphur should be burned for each thousand cubic feet of air-space. The sulphur is best ignited by pouring over it three ounces of alcohol and applying a lighted match. Care should be taken to get the heat from the burning sulphur to generate a certain amount of vapor, since it is in this form that the gas exerts its powers as an antiseptic for decaying matters. To accomplish this the sulphur may be placed in a tin vessel and the latter then placed in another shallow vessel containing water, so that the heat will come in contact with the water. The apartments during the entire period of fumigation should be kept completely closed, and opened about twenty hours afterward and thoroughly ventilated. Before using this substance, however, it is necessary to have all carpets taken up, the wall-paper removed and burned, and all other hangings loosened up so that every part may become exposed and the gas reach every nook and corner. The chemical action of sulphur dioxide is supposed to be one of deoxidization and the resultant acid coagulation of albuminous substances. It is two and a quarter times as heavy as air, and has a peculiar pungent and disagreeable odor, which is perceived when a sulphur match is ignited. Sulphurous acid and sulphur dioxide are both destroyed by chlorine and permanganate of potassium, and should never be used in conjunction. The great solubility of sulphurous acid renders it one of the most valuable substances to sterilize liquids. Dr. Edson, of the New York Board of Health, says that sulphur dioxide is the most practicable and reliable means for the destruction of the contagia of exanthemata and diphtheria.

Another important and valuable antiseptic, though not a disinfectant, is found in carbolic acid. Its chief advantage is that it is a liquid and slightly volatile, and can, therefore, be sprinkled in apartments and upon substances, and thus penetrate every crevice and be of service. It requires about twenty-five parts of water for thorough solution, and in this proportion is a very powerful and thorough antiseptic. It coagulates albumin when of this strength, and enters readily into union with organic substances whenever brought into contact with them. Dr. Sansom has shown that a mixture of carbolic acid and glycerine is a delicate and effective application for diseases of the skin of a contagious nature. The chief property of this acid and of the compounds associated with it is the power of destroying vegetable and animal micro-organisms, and preventing the putrefactive and fermentative changes associated with their presence. Vaporizers for carbolic-acid fumes have been improvised by the means of hot metal plates upon which the acid is gradually dropped. Carbolic acid conceals all odors, though it will not destroy hydrogen sulphide, as is the case with chlorine, and it lessens the rapidity of putrefying matter suspended in the air; though it will not stop these changes entirely, it arrests the growth of fungi in fecal matter, and in stronger proportions will completely wither them. A mixture of one part of carbolic acid and nine parts of vinegar and a little gum camphor, is a simple and pleasant deodorant for apartments.

In addition to the foregoing measures of hygiene, sanatation, disinfection, and antisepsis as preventives of disease, there has arisen in recent years another distinct department of preventive methods as the result of investigations into the nature and mechanism of immunity or the refractory condition. This subject has been thoroughly discussed in another part of this volume, and needs no further treatment in this place. Whenever the alleged facts in regard to this doctrine of immunity shall have been thoroughly established, prophylaxis will, in making application of them as auxiliaries, have made a decided advance and have added to the fast-increasing amount of accessories. *J. Wellington Byers.*

PYOCTANIN (METHYL-VIOLET). Introduced in 1890, by Professor J. Stilling, as a powerful antiseptic for surgical purposes. He claimed that it possessed bacteriacidal properties equal to those of any other substance in use, and at the same time was perfectly harmless to the tissues. He had instituted a series of experiments, and found that 1 to 4,000 solutions prevented putrefaction up to the sixth day. Weaker solutions were found to prevent the growth of pathogenic bacteria. He experimented with a great number of the aniline dyes, and found that certain auramines proved to be the next best. These have been named yellow-pyoctanin. Upon animals he found that, when dropped into the eye, a 1 to 1,000 solution stains the conjunctiva, sclerotic, and iris, but not the cornea if uninjured. In the human eye it often causes a dilatation of the pupil without any paralysis of accommodation. When the surface of the eye is scratched, or if it is inflamed and injured, the part is immediately dyed, the degree depending upon the strength of the solution. The more recent the corneitis, the longer the stain lasts. If the action of the application is beneficial the coloration will be noticed to gradually fade; should it not do so, it is evident that there is no power of repair. When granulations exist they are readily and deeply stained. He never found any irritation to follow its use, even when the powder itself was dusted on the conjunctiva. The drug is perfectly harmless, Professor Stilling having injected large quantities subcutaneously and into the peritoneal cavity without producing any toxic action. He also filled large wounds with the powder without any unfavorable sign. After the injection of large quantities the abdominal organs and the tissues are stained, but the blood and the blood-vessels retain their normal appearance. Rabbits have also been made to eat the dye with their food.

In one of his papers, Dr. Stilling summarizes its qualities as follows: 1. Pyoctanin is an antiseptic surpassing all others. The bacteriological researches have shown blue pyoctanin to be about three times as strongly antiseptic against anthrax bacilli as sublimate is, and to be quite as efficacious as sublimate toward the staphylococcus aureus. 2. It is an absolutely non-toxic substance. 3. In consequence of this non-toxicity it is a matter of indifference in many cases of wounds, etc., whether somewhat weaker or stronger solutions, or even the pure drug, be used. 4. It does not coagulate albumin—a negative quality of high value physiologically, which pertains to no one of the antiseptics heretofore known. 5. It possesses an extremely high degree of diffusibility, permeates the interior of the eye like atropine, and acts similarly in other tissues.

Therapeutically, he obtained the greatest success in ophthalmic practice with a 1 to 1,000 solution, or by slightly dusting the part with a two per cent. powder. In conjunctivitis he considers that twenty-four hours will usually suffice to effect a cure. He also had good results with it in blepharitis, eczema of the lids, keratitis parenchymatosa, iritis serosa, choroiditis, and in one case of sympathetic ophthalmia. In blennorrœhal and gonorrhœal ophthalmia he obtained the best results by pencilling the parts several times a day until the membrane was quite blue. In granular lids a daily application of the pencil generally effected a cure more rapidly than when nitrate of silver or sulphate of copper was used. Pyoctanin was also used with success as a dressing in wounds, ulcers, and in acute suppuration. The following are the preparations advised for use: Pure methyl-violet, to be used as a powder for large wounds and ulcers. Large pencils, for small wounds, burns, etc.; for purulent cases the blue pencil is better than the yellow, on account of its greater antiseptic property. Small pencils, for ap-

plication to the eye in cases of corneal ulcer, etc. Powders, of one to one thousand strength for mild cases of conjunctivitis, for more severe cases a two per cent. powder is prepared; these can also be used as a snuff in affections of the nasal mucous membrane. Ointments, varying in strength from two per cent. to one part in ten; solutions, from one-tenth to one per cent.; the one to one thousand to be used for ordinary cases of conjunctivitis, keratitis, etc.; in non-purulent cases the yellow dye is used, on account of its greater cooling properties; the solutions should be filtered and kept in dark-glass bottles and changed every eight days. Gauze and medicated cotton dressings may also be obtained.

Since its introduction the drug has been very extensively used, with varying success. With some it has produced all the good effects that were expected of it, with others it has failed entirely, and in many instances has given rise to troublesome and painful irritation of the eyes. The unsightly stain it produces and the danger of destroying the linen, render it objectionable to many. The antiseptic properties of the drug have also been called into question. Liebreich considers that it is unsuitable for practice, as it is a mixture of different aniline compounds, and cannot have any definite character. Other investigators have failed to destroy the pus cocci with a 1 to 1,000 solution in twelve hours, and found that it was only with great difficulty diffusible in the tissues. Many of the failures are no doubt due to the inferior quality of the drug, and the irritation may often be produced by impurities present, but the very great difference of opinion that exists, and the numerous cases of successes and failures that are reported, envelop the subject in a great deal of uncertainty.

As an antiseptic it has been applied to a great variety of diseases, but has acquired a notoriety during the past year as a means of treating malignant disease. In January, 1891, Professor von Mosetig reported a number of cases treated by injections of pyoctanin, with very favorable results. For some time he had used the different forms of aniline as an injection, with the purpose of staining the nuclei of the cells and thus checking their growth, but the constitutional symptoms produced had always been a hindrance to the treatment. When Professor Stilling introduced methyl-violet he at once began to use it for this purpose. The germ-destroying power of the agent, in connection with its diffusibility in healthy and diseased tissues, made it a very promising agent, especially as it was also harmless and devoid of any injurious effect on the human economy. The first case was a woman, sixty-six years of age, with a large tumor of the lower jaw which prevented her from swallowing and caused great suffering. After thirty-five injections of six grammes of a 1 to 500, and afterward of a 1 to 300, solution, the tumor was so much reduced without ulceration that the patient could eat without discomfort. In the case of a man fifty-eight years of age, with a cystosarcoma of the chest-wall measuring thirteen centimetres in width by eighteen in length, after twelve injections of six grammes of a 1 to 300 solution, the measurements were reduced to ten by twelve centimetres. In two cases of adeno-carcinoma of the neck, the same treatment proved so effectual that the patients considered themselves cured. Another case was that of a woman, sixty years of age, with papilloma of the bladder; for which twenty grammes of a 1 to 1,000 solution was injected into the bladder every second day. After the injections there was notable improvement, the hæmaturia had ceased, and there was little or no pain. Professor Mosetig also cited a case of a man sixty years of age, with an enormous sarcoma of the pelvis; colotomy had been performed. After sixteen injections of six grammes of a 1 to 500 solution into different parts of the mass, it had shrunk to one-half its former size, and the patient was greatly relieved and able to walk about for a few hours daily.

Following Professor Mosetig's announcement came a number of cases treated by other surgeons with similar favorable results, and during the past year it has been employed very extensively both in Europe and on this side of the Atlantic. The results of the treatment have varied to an extreme degree, some surgeons claiming very remarkable cures, while others have failed to observe any signs of benefit, and look upon it as a perfectly useless procedure. The greater number of those who look with favor upon the treatment, including its author, do not claim that it is a curative agent for cancerous diseases, but simply that during its use the progress of the growth is checked, the local condition improved, and a temporary relief obtained. In a few cases a decided retrograde change has been observed, but permanent cures have not been very clearly demonstrated. The following directions are given for its employment: Under proper antiseptic precautions the part is to be carefully curetted until all the diseased tissue that is accessible is removed. When there is no ulceration of the surface, the curetting is omitted. After the curetting, a tampon of iodoform gauze is placed in the wound and allowed to remain for forty-eight hours. The surface is then washed and carefully dried and the injections made into the tissue, to the depth of the needle if necessary, according to the extent of the tissue involved. Other injections are made into the surrounding tissues, as many as fifteen punctures being made at one sitting. It is advised to begin with the deeper injections, in order to avoid a discoloration of the tissues on the surface in the early stages. After completing the injections, pure pyoctanin powder is introduced into the cavity, or, gauze or cotton, medicated, may be used. The tampon is left in position until the second day, when it is removed and the parts thoroughly washed and the injections repeated. The introduction of the solution exerts an analgesic action, and also checks the profuse hæmorrhage that is frequently present. When a favorable result is obtained the tissue is said to develop a more healthy granulating surface, the infiltration and tension subside, and the patient experiences relief from pain and discomfort.

Intra-pulmonary injections have been used for the treatment of pulmonary tuberculosis. The liquid employed was a 1 to 500 solution, of which eight to sixteen minims were injected. The injections are reported to have been well borne, but when the liquid penetrated to the bronchi, a violent attack of coughing was provoked. Therapeutically, it is said to have produced a lessening of the hectic condition and reduced the number of bacilli in the sputa. *Beaumont Small.*

PYRIDINE (C_5H_5N). A liquid body obtained from bone oil by treatment with sulphuric acid and subsequent fractional distillation to separate the anilines and other compounds. It may also be obtained by the dry distillation of bone, coal, etc., and as a decomposition product of various alkaloids. It is also present in tobacco smoke.

It is a colorless liquid, with a peculiar empyreumatic odor and pungent taste. It is very hygroscopic and mixes freely with water, alcohol, and oils. Its specific gravity at 32° F. is 0.9858. Pyridine resembles alkaloids in its property of forming salts with acids. It is distinguished from aniline bases by its power of resisting the action of oxidizing agents. Two drachms of a ten per cent. aqueous solution, to which three drops of volumetric permanganate solution have been added, should maintain the red color for at least one hour. Pure pyridine should not be altered by exposure to light.

Pyridine has been used as a cardiac stimulant in doses of three or four drops, three times a day. It increases the strength of the cardiac contractions, raises the blood-pressure, and diminishes the number of pulsations. It is recommended for use in the conditions in which digitalis is indicated, but must be used with caution, as its action is powerful, and vomiting, vertigo, and syncope have followed its use in individuals with much debility. It has proved of more service when inhaled for the relief of asthma, cardiac distress, angina pectoris, and in the dyspnœa of phthisis and laryngeal affections. Its action is prompt, and in many instances permanent relief is obtained. The ease that follows the inhalation of tobacco-smoke in asthma, is supposed to be due to the presence of pyridine. Germain Sée has studied its action in various forms of asthma and recommends it particularly when the disease

is of a nervous origin. One drachm is placed in a saucer in a closed room, at a temperature of 68° to 77° F. In about an hour evaporation will have taken place, and the patient should then inhale the impregnated atmosphere for fifteen or twenty minutes, which may be repeated two or three times a day. The drug may also be inhaled by placing ten or fifteen drops on a handkerchief.

It has been used as a local application in diphtheria, a ten per cent. solution being employed. An aqueous solution of one part to three hundred has also been recommended as an injection in gonorrhœa. The drug has not, however, established itself as a remedy of much value, and is rarely employed in this country. It must not be confounded with pyrodine, which is a preparation of hydracetine. *Beaumont Small.*

QUARANTINE. The term quarantine has lost its ancient significance in late years. Formerly held to apply to a period of time, it has now come to represent a method, rather than detention for a given number of days. The term is from the Italian *quarantana*, or forty days, that being the period which was established first by the Venetians several centuries ago.

The original quarantine establishment, although so long preceding the bacteriological period of medicine, was based on the principle of exclusion. To-day the same principle obtains, except that we now have a definite germ which we exclude. Formerly disease was supposed to be conveyed by the persons themselves, or in some unknown manner. The germ theory, which has now been accepted by scientific men the world over, rests, in brief, on certain well-known facts deduced from observation of the characteristics of epidemic and contagious diseases. It has long been known that cholera, yellow fever, and plague traversed the same route as commerce; that they went no faster than man could travel; that they spread precisely in those places where man went. This proved the germ to be a material thing, capable of being transported. It was further seen that after it effected a lodgment it spread in some manner, so that it was capable of self-multiplication. This proved the existence of a living organism. That it followed the rule of living organisms was further demonstrated by the fact that each of these diseases produced only after its kind; thus the seed or germ of *plague* being sowed in a place, *plague* only resulted, and no other disease as a direct consequence of that importation. It naturally followed, then, that the practical world was ready to accept the germ theory in its entirety as applied to contagious and infective diseases. It is on this theory that the modern quarantine system is based, that is, on the exclusion of germs. But modern quarantine goes further. Not only are the germs excluded, but they are *destroyed* by systematic application of germicides or anti-bacillary agents.

From the earliest times the practice of quarantine has prevailed as a personal right (*jus personæ*), and, by extension, as a national right (*jus gentium*). The right of a man to protect himself against the encroachments of an enemy naturally extends itself to that of protection of whole communities, political divisions, and countries, and is practically undisputed.

When we come to consider the details by which quarantine is carried out we find the greatest diversity of practice. *Regulations* of quarantine, even in those countries which are most lax in their practical administration, are extremely stringent, sometimes seeming to be in inverse ratio to their efficiency. Thus, in one of the South American Republics, three or four years ago, quarantine regulations which prevented passengers from any infected ship being landed on the shore were broken to allow a high officer with his suite to land from a ship having on board cholera patients, and on which several persons had died of cholera on the voyage. The rapid extension of the disease into the city and its environs, along the different lines of travel radiating from the port, soon followed, and the history of this epidemic remains to-day as a standing monument to the laxity of what seems on paper a very stringent and rigid quarantine. We come now to the practical details.

(*a*) By Sea.—When a ship arrives at a place designated on the chart as a quarantine anchorage of a certain port, she is boarded by the health officer or his authorized deputy; inquiries are made of the officers and the ship's surgeon, if there be one, as to the health of the crew, and the passengers if any; the nature of the cargo, from whence obtained; the length of the voyage, and the present sanitary condition of the vessel. These inquiries are made, not for the purpose of absolving the quarantine officer from making a careful inspection and satisfying himself as to the actual condition of the vessel, but for the purpose of placing the ship's officers on their honor in making their replies, and rendering them liable to the penalties of the law for making false statements. This safeguard is universal. After these inquiries have been made, the next duty of the quarantine officer is to call for the passenger list and crew list of the vessel. The health officer should have a sufficient number of enlisted men to be stationed at the gangway of the main deck of the ship; the passengers of the first and second cabins are then called upon the deck and formed in line. The officer takes his station at a convenient passageway, and the passengers, being called by name as they pass before him in review, are inspected and counted. If the count should fall short of the number on the passenger list assigned respectively to the first and second cabins, inquiries are made as to what has become of the missing passengers; or, if the ship's officers insist, a recount is then made. The reason for this is too obvious to require explanation. The passengers having thus been reviewed, the immigrants are next called on deck, and the enlisted men of the health officer again stand at the gangway to prevent passage or "doubling up" of the line on the reviewing officer. They are then formed in line and passed in front of the reviewing officer and counted. It must be apparent that the calling of names is an unnecessary performance, except that the exact number shall be accounted for, as borne on the passenger list.

This list should bear the visa of the United States Consul at the port of departure, in order to prevent the changing of the list or its manufacture en route, as it would be easy for the ship's officers, having lost a number of passengers, or a number of its crew, to substitute a new list for the one prepared before leaving the port of departure. Having made a careful inspection of the immigrants, the health officer next makes a tour of the ship. He should visit the state-rooms, closets, cubbies, and all such places on board the ship, and especially the quarters assigned to the steerage and immigrants, who should be required to remain on deck during this inspection. If any are ill the surgeon is interrogated as to the clinical history of the case; the patients are then examined by the health officers, and, in the event of there being contagious sickness, arrangements are at once made for their removal from the ship; and, in fact, the removal of all passengers should be immediately contemplated. This inspection need not require much time, and indeed up to this point the ship will have been detained only a short time. If, however, contagious disease be on board, the removal of all persons on the ship should be immediately made, the ship disinfected by approved methods, and allowed to join the commerce fleet at the earliest possible moment. The arbitrary detention of the ship for a given number of days is contrary to modern principles of sanitation. The well persons on board the ship should be removed to comfortable quarters on shore, and detained only long enough to fully complete the period of incubation from the time of leaving the port of departure, or of immediate personal contact with the sick. Thus, for instance, a ship leaving a port of Europe infected with cholera and arriving in this country ten days thereafter, may be reasonably presumed to have passed the incubation period, and the passengers of said ship should be set free without other detention than is required to ascertain if they are at the time healthy.

New merchandise, and the clothing actually worn on the bodies of such persons, need not be detained for disinfection, but all soiled linen and baggage packed in an infected port should be subjected to proper disinfection

before being delivered to the passenger or his agent. The same rules may be applied to immigrants, with this exception, that the immigrants themselves, being usually in cramped and crowded quarters, are more likely to have their personal clothing infected by contact with the sick than are the cabin passengers, who have more freedom and more exposure to air-currents.

No general rule can be well laid down for the treatment of cargoes of vessels without taking a general list of all goods and merchandise composing the cargo. Some cargoes are extremely liable to convey infection, while with others it is almost impossible, and there is no circumstance which can bring out in more bold relief the wisdom or folly of the inspecting officer than the orders given in regard to the disposition of the cargoes and different articles of merchandise. New goods packed in a manufactory and baled, shipped by ordinary channels of trades, are little likely to convey infection in any case; nor does the writer know of a single instance where an epidemic has been traced to the importation of new merchandise. Personal baggage and effects, soiled clothing, old rags, and the like are, however, subject to very different conditions. Persian rugs and articles of that kind, which investigation shows may be many years old, and in some cases handed down as family heirlooms, and finally sold to the trade—it may be after the death of the family by plague or cholera,—require disinfection by steaming; and soiled rags should either be steamed or delivered to the rag manufacturer on his giving bond that the bales will be opened at the paper mill or elsewhere, and dumped in a vat containing disinfecting solution, before being exposed to sorting by the operators.

The establishment of the quarantine comprises suitable barracks for the detention of the well; disinfecting chambers for the steaming of certain classes of baggage, and provision for the aëration of others liable to be damaged by steam or sulphur fumigation. Latrines constructed on scientific principles, and hospitals for those sick or injured, and an isolation hospital, or a series of isolation tents, for those affected by contagious diseases, and warehouses for the proper handling of baggage; an abundant supply of pure water; proper arrangements for lighting, heating apparatus, suitable quarters for commandant, mess-rooms, kitchen, lavatory, and laundry, and, at large quarantines, provisions for electric lighting;—all these should be provided. In addition, there should be separate quarters for the guard, and outside of these a wharf where supplies can be received, immigrants received and discharged, and communication be had with the marine patrol. The details of the force for the administration of the quarantine need not be detailed here, but they comprise briefly: Proper crews for sanitary service; waiters, male and female; nurses, male and female, for the sick; sufficient force for the supply of food; medical officers, and such others as the importance of the quarantine and the number of persons to be passed through seem to require. The marine patrol is necessary for the guarding of the ships detained in quarantine refuge undergoing disinfection, for the arrest of any persons attempting to board a ship without due authority, for the prevention of any communication between the ships and the quarantine on the one hand, or the shore on the other. This patrol must be more or less extensive, according to the area of the quarantine anchorage and its distance from the shore. If it be very near the shore, the patrol must be maintained with great vigilance to prevent communication. A quarantine in which the ships are not kept properly guarded, will be futile.

It has before been stated that the ship should be restored to the commerce fleet as early as possible; to accomplish this it is necessary that the disinfection of the ship be begun as soon as the passengers shall have been discharged from it, and maintained without intermission until the inspecting officer pronounces the ship fairly clean and no longer liable to convey infection if allowed to go to her dock in the city. It is obvious, in this connection, that there must necessarily be a variation in the regulations governing different ports; at ports where the ships are discharged in lighters, and where they do not require to enter the dock, the liability to convey infection is extremely limited, and the regulations may be conducted with less stringency than at ports where the vessel goes directly to her dock. However, there must be constantly borne in mind the maxim of marine hygiene, that the highest rule should be "a clean ship sailing from a clean port."

In some quarters it has been stated, and is sought to be constantly kept before the public, that quarantine is antagonistic to hygienic measures, and that reliance upon quarantine necessarily breeds indifference as to municipal hygiene and municipal sanitation; in fact, the contrary is the case, for modern quarantine is but the practical application of hygienic law.

(*b*) By Land.—Land quarantines, while operated on the same principle, are extremely difficult of management, requiring not only faithfulness and honesty on the part of the inspector, but patriotism as well. The inspector should be indoctrinated with the necessity resting upon him for vigilance far greater than that which rests upon the marine inspector, because the dangers of communication are greatly increased.

The inspection of railway trains and vehicles is confined to an examination of passengers on the train. They should be required to pass out at one end of each car, commencing at the baggage car; the inspector should require every person on the car to pass out of the rear end of the car, he having at the time an assistant on the platform while he takes his station on the ground where the passengers disembark. Each passenger then passes in review before him, and, when the car is empty, may re-enter at the other end. Persons who are feeble from disease or otherwise may be passed to one side and placed under guard, while the remainder of the passengers are reviewed by the inspector. He then turns his attention to the passengers who are detained, and examines them with a view of determining the nature of their illness; and if they are found with contagious disease, they are detained and placed in an isolation hospital provided for the purpose. It is usual in America, in a place in which an epidemic has been delared to exist, to furnish out-going passengers with certificates that their baggage has been disinfected under proper inspection. A failure to have such certificates should require that the baggage be detained and passed through the process of steaming, or other disinfection, at the discretion of the health officer. Sleeping-cars should be prohibited from entering an infected city or place; but as a matter of detail, it has been permitted repeatedly, in times of epidemic, for through passenger trains to pass directly through such places without stopping, which, in such cases, prevents their being infected, as infection is not carried by the air-currents. It is only when the air becomes stagnant and thoroughly infected by being confined, that it becomes dangerous.

The much abused *cordon sanitaire* is a line of guards extending across a given country for the purpose of preventing overland travel, except after authorized inspection. It is certain to fail in cases where the guards are unfaithful or where they are liable to be bribed. It has for this reason fallen into great discredit in some countries. In the United States, however, an instance of bribery has never yet been demonstrated, and the *cordon sanitaire*, as maintained in Texas and Florida, and in other places by the government, three of them under the writer's own direction, have been entirely successful in preventing the spread of the disease beyond the established line.

The Quarantine Laws of the United States.—The quarantine laws of the United States are of two kinds, State and National. State laws vary in many particulars, those of the seaboard States being entirely different from those in the interior; but the National laws follow a uniform and definite course. The first quarantine act was passed February 1, 1799, and is embodied in the present revision of the Revised Statutes, Section 4792.

Its general provisions are, that all officers of the

United States shall lay State and local quarantines wherever practicable, and in such manner as they shall be directed by the President of the United States, or the officers over them. Further, in regard to the regulation of vessels entering ports, the collector of customs of such port is directed to withhold entry until such time as a permit of the health officer shall first have been obtained.

Provision is made for the erection of suitable warehouses for the storing of goods from infected ports; and also for the unloading of cargoes of vessels. And, it further provides for the removal of certain public officers and the courts in the event of an epidemic breaking out in a given place. This law was passed under the stress of the great epidemic of yellow fever which had previously prevailed in Philadelphia and New York; and it may be said, in passing, that nearly every law on the United States Statute books bears a relation to some previous epidemic.

The next law, and that most relied on at present, is the law of April 29, 1878, framed by Surgeon-General John M. Woodworth, which prohibits the introduction of any vessel or vehicle from any infected ports; passengers, goods, and merchandise from infected ports; and places the execution of the act on the supervising Surgeon-General of the Marine Hospital service, subject to the approval of the President of the United States. It was for the first time provided in this act that representatives of the United States in foreign countries should give immediate notification of the existence of any contagious disease in any of said countries, in order that proper information might be had in this country. The act of 1878, however, did not provide any penalty which could be enforced against persons violating any of its provisions; consequently, in the act establishing eight quarantine stations, framed by the writer, approved August 1, 1888, a proper penalty for persons violating the quarantine was provided, and eight quarantine stations to be operated by the United States were established by the said act, viz., Delaware Breakwater, Cape Charles, Sapelo Sound, Tortugas Keys, San Francisco, Cal., San Diego, Cal., Port Townsend, Wash., and Chandeleur Island.

The powers of the Government over quarantine matters were further promulgated by the Inter-State Quarantine Act of March 28, 1890, also framed by the writer, whereby, whenever the President becomes satisfied of the existence of contagious disease in any State, and that there is danger of its spreading to another State, he may cause the supervising Surgeon-General of the Marine Hospital service to frame such regulations, subject to the approval of the Secretary of the Treasury and the President, as in his judgment are necessary to prevent the spread of the disease from one State to another. With the passage of this law it was believed that the powers of the Government were fully expressed on the Statute books, and that all necessary action could at any time be taken. As the Constitution of the United States gives Congress the exclusive right of legislation in all matters relating to commerce, commerce can thus be stripped of its power to convey contagious diseases by suitable regulations, and in the exercise of these laws there was no invasion of the rights of the State, but simply the exercise of a power wholly within the jurisdiction of the Government. A construction, however, was placed upon the act of 1890, which rendered it nugatory and of little effect. And in February, 1893, Congress enacted a law embodying the substance of former laws, and imposing new duties on the Marine Hospital Service, whereby complete surveillance is maintained over ships carrying immigrants from foreign ports. Under this act medical officers of the United States are detailed whenever there is need, to serve in foreign ports of departure and certify the condition of ships bound for ports in the United States. *John B. Hamilton.*

RABIES. Since the appearance of this work there has been uninterrupted effort, upon the part of many able investigators, to satisfactorily prove the position which inoculation with the modified virus of rabies is to occupy in the treatment of this most frightful disease.

The opinion which was held at the time of issue of the former article was cautiously expressed as follows: ". . . There are strong reasons for the hope that it [preventive inoculation] may prove to be a safe and sure preventive of the rabic disease."

The laboratories then in use for this purpose have furnished additional knowledge concerning the efficacy of inoculation against the bites of rabic wolves and other savage animals, the result of actual experimental research under the most trying and persistent conditions of absolute control. These labors have been made public in the Bulletins of the Pasteur Institute, and have been of so convincing a character that additional institutes have been erected in various countries for the treatment of patients with rabies in the manner laid down by the illustrious originator of protective inoculation; and this treatment is to-day regarded as the only successful method of preventing the appearance of that dread malady. Such an institute has been in constant operation for some years in the city of New York, from which also reports and bulletins are issued from time to time. The last of these to reach the profession is contained in the *New York Therapeutic Review* for January, 1893, in which a record of eighty-three cases is published.*

The patients in the New York Pasteur Institute are divided into classes as proposed by Pasteur, consisting:

1st. Of those patients who had been bitten by an animal in whom the existence of rabies was clearly proved by experimentation (injection beneath the dura mater of a fluid containing minute portions of the suspected animal's nervous system), and by the typical course of the disease to its fatal termination in the inoculated animal.

2d. Those who had been bitten by animals recognized by competent clinical authority to be suffering from genuine rabies; and

* NEW YORK PASTEUR INSTITUTE. STATISTICS OF THE PREVENTIVE TREATMENT AGAINST HYDROPHOBIA FROM MARCH 1, 1892, TO NOVEMBER 30, 1892.

	A			B			C		
Bites inflicted on the head and on the face: simple	..	....	4	..	1	2	..	....	1
Bites inflicted on the head and on the face: multiple	4	....	..	..	1	..	..	1	..
Cauterizations: efficacious	..	....	..	..	....	..	..	....	..
Cauterizations: non-efficacious	2	....	..	..	....	..	1	....	..
No cauterization	2	....	..	2	....	..	..	....	..
Bites inflicted on the hands: simple	..	16	21	..	11	30	..	4	5
Bites inflicted on the hands: multiple	..	5		..	19		..	1	
Cauterizations: efficacious	1	....	..	1	....	..	..	....	..
Cauterizations: non-efficacious	4	....	..	15	....	..	1	....	..
No cauterization	16	....	..	14	....	..	4	....	..
Bites inflicted on the limbs and on the body: simple	..	3	5	..	3	6	..	....	..
Bites inflicted on the limbs and on the body: multiple	..	2		..	3		..	4	4
Cauterizations: efficacious	..	....	..	1	....	..	1	....	..
Cauterizations: non-efficacious	3	....	..	2	....	..	1	....	..
No cauterization	2	....	..	3	....	..	2	....	..
Clothes torn	2	....	..	3	....	..	..	....	..
Bites inflicted on bare parts	1	....	..	1	....	..	1	....	..
Bites inflicted on different parts of the body	..	...	5	..	....	..	..	....	..
Cauterizations: efficacious	1	....	..	..	....	..	..	....	..
Cauterizations: non-efficacious	1	....	..	..	....	..	..	....	..
No cauterization	3	....	..	..	....	..	..	....	..
Clothes torn	..	....	..	..	....	..	..	....	..
Bites inflicted on bare parts	4	....	..	..	....	..	..	....	..
Amounts	..	....	35	..	....	38	..	....	10
		A			B			C	
General total					83				

The column A refers to persons bitten by animals in which hydrophobia has been evidenced by experimentation or by the death of some other persons or animals bitten by them; column B to persons who have been wounded by animals having been recognized mad by the clinical or veterinary examination, and column C to cases in which hydrophobia could only be suspected, as the animals had disappeared or were killed instantly and their bodies thrown away.

These eighty-three persons treated, came from—

2 Alabama.	1 Mississippi.	1 Pennsylvania.
11 Connecticut.	2 Missouri.	1 South Carolina.
2 Iowa.	30 New Jersey.	3 Tennessee.
4 Maryland.	4 New York.	2 Texas.
3 Massachusetts.	1 North Carolina.	14 Virginia.
1 Michigan.	1 Ohio.	

No death has been reported from among these persons.

3d. Those in whom the existence of the disease could only be suspected, owing to the fact that the animal from which the bite was received had either disappeared or had been immediately killed, and the carcass destroyed or rendered unfit for study.

Of the patients mentioned in the table (which accompanies the report and which we have reproduced on the preceding page), eighty-three in number, it is rather interesting to note that fifty-five, or the large majority of the entire number, were residents of three States, viz., New Jersey (30), Virginia (14), and Connecticut (11), while the rest of the patients, twenty-eight in number, were residents of fourteen States. These include a wide range of territory, comprising Alabama, Ohio, Michigan, Texas, South Carolina, etc., so that the effects of locality or surroundings may be justly disregarded. The report covers a period of nine months, from March 1 to November 30, 1892, and concludes with the statement: "No death has been reported from among these persons."

From this report it would seem that the preventive treatment of rabies by inoculation of the attenuated virus, according to the method of M. Pasteur, may be considered thoroughly successful, and that it constitutes at present the only rational and safe mode of treatment which has thus far been discovered. This boon is now being made available to sufferers from rabies in almost all parts of the civilized world, by the establishment of institutes similar to that of M. Pasteur in Paris.

Albert N. Blodgett.

RAMSGATE. One of the most popular of the English seaside resorts. The place is prettily situated on the Kentish coast, the cliffs and remarkably fine sandy beach being its special features. The climate is decidedly bracing, although the town itself is said to be warmer than Margate. The sanitary condition of Ramsgate is good, the death-rate being about nineteen per thousand.

According to Black ("Watering Places in the British Isles"): "Few places can boast such perfect bathing accommodation, both in the open air and at the baths, which are elegantly fitted up with luxurious seats in the reading, waiting, and refreshment rooms. There are machines under the east cliff, and baths there in front of the harbor and at west cliff—these last being the best. The sands are pre-eminently good, though there is little privacy. Otherwise they are excellent, and stretch right away to Broadstairs. Dumpton Bay, midway on the road thither, about three-quarters of a mile from Ramsgate, would be an especially beautiful and retired spot, were it not for the proximity of the favorite foot-path to Broadstairs, on which account ladies have frequently to turn back here, owing to the recklessness of bathers."

The Ramsgate season extends from June to October, and during its height the resort is often uncomfortably crowded. Tally-ho coaches run to Canterbury during the summer months, and there are many facilities for interesting excursions. The place is a favorite one for Londoners, though it is not particularly exclusive.

Edmund C. Wendt.

RECTUM, ULCERATION AND STRICTURE OF. In reading again what was written on this subject a few years ago, when this work first appeared, the necessity for revision and addition becomes very apparent. It has appeared to the writer that our present knowledge may perhaps best be stated in the form of several separate and distinct propositions.

I. *In all cases of non-malignant ulceration and stricture, the symptoms due to the ulceration must be distinguished from those due to contraction, in order intelligently to select the proper treatment.*

Although ulceration is usually the cause of non-malignant stricture, and is generally associated with it, there may be much ulceration and very little contraction, or there may be great stenosis with a comparatively small area of ulceration. In the one case the patient will suffer chiefly from the muco-purulent discharge, pain, and tenesmus; spending days and nights upon the water-closet, and losing flesh and strength from exhaustion, pain, and loss of sleep. In the other case, the muco-purulent discharge may be trifling and the calls to stool but little more frequent than natural, while the patient is in imminent danger of death from chronic or subacute intestinal obstruction. It is manifest that in the former case the mere enlargement of the canal would do little to relieve the patient's sufferings; while in the latter the relief of the contraction would restore the sufferer to comparative health.

Take, for example, a case recently sent me by Dr. Richardson, of New York. The patient was a young married negress, who during her whole life had never had a passage of fæces larger in diameter than her little finger, and for some months had scarce been able, with laxatives and straining, to have any at all. There had never been any blood, pus, or mucus in the stools. Examination showed a tight, falciform, congenital narrowing of the rectum at the usual site of this deformity, about two and a half inches from the anus, with little or no ulceration above it. The whole large bowel was loaded with fecal matter. The treatment in such a case is plain, and the woman was cured, or perhaps it would be more correct to say relieved and rendered perfectly comfortable, by dividing the stricture and subsequently using bougies, a treatment which, it is manifest, would have been of little use had there been any great amount of ulceration above the contraction. This brings us directly to the second proposition.

II. *Proctotomy and dilatation by bougies have a very limited range of utility, being applicable only to cases of non-malignant stricture, where the obstruction is of greater importance than the ulceration.*

Here let me say that proctotomy and the use of bougies are never indicated in cancerous stricture. Cancer of the rectum is not a thing either to be cut into or to be stretched open. Either remove it, do colotomy, or let it alone. Either course may be good surgery, but incising it, stretching it, or cauterizing it is meddlesome surgery, and attended by the same result as meddlesome midwifery. Under the head of cauterizing may be included electrolysis, which to accomplish anything must be either destructive cauterization, or gradual and simply mechanical dilatation.

If we limit thus the operation of proctotomy to non-malignant strictures, there are many cases where great benefit may be derived from it. I have even effected by it, in conjunction with subsequent dilatation, what may fairly be considered a radical cure; but unfortunately such results are few and far between, and are confined to cases of limited disease without much attendant ulceration and destruction of mucous membrane. In more severe cases of old stricture and ulceration, where the amount of disease rendered extirpation out of the question, and the treatment evidently lay between proctotomy with dilatation and colotomy, I have also in a few cases rendered the patient more comfortable by the former means than he would have been by the latter. But these cases have not been frequent enough to prevent my advocating as the safer course colotomy. Proctotomy may do good, colotomy certainly will. The former, in such disease as is here referred to, is a dangerous operation — much more dangerous than colotomy. In neither case will the patient have any control over his evacuations, though in one they will take place from the groin and in the other from the anus. One must be followed by the use of bougies as long as life lasts, the other needs no after-treatment.

The patient's condition in life is an element in choosing the treatment. Proctotomy and dilatation in hospital and dispensary practice are failures. The patients submit to an operation and expect to be cured, not realizing that proctotomy is but the first step in the treatment, which is really that by perpetual subsequent dilatation. This they have neither the time nor the patience to go on with. Better in these cases to do a colotomy at once than to add one more to the incisions already made. The best result I ever obtained from division and subsequent dila-

tation was in an old stricture of thirty years' duration, reaching above the limit of digital examination. The patient was a wealthy man, and willing to give any amount of time to the pursuit of health. The division of the stricture nearly cost him his life, but, recovering from that, he began the intelligent use of bougies upon himself, and at the end of a year used the largest instruments with ease, had one daily evacuation, and was only troubled by an involuntary escape of muco-purulent matter from the anus. Such a result is a manifest impossibility in a laboring man in hospital practice.

III. *In the severe forms of non-malignant ulceration and stricture, which are incurable by local applications, the proper treatment is either extirpation or colotomy.*

Here we must consider ulceration and stricture separately, as well as combined. Ulceration, either with or without stricture, may call for colotomy or extirpation, and stricture, with little ulceration or much, may do the same.

Colotomy for non-malignant ulceration, irrespective of stricture, we owe to Bryant, and it is one of the great advances in modern surgery. Following the general tendency of the day, I have also practised and advocated resection in a certain class of cases of non-malignant ulceration, exactly as would be done for malignant disease.

The rule of practice may be plainly stated. There are many cases of non-malignant ulceration of the rectum which are incurable, either by local applications or by constitutional treatment, and which in the end destroy life by exhaustion, loss of sleep, pain, and tenesmus. When the ulceration is limited in extent and can be reached by any incision, either dorsal or perineal, the ulcerated bowel should be excised, and the healthy gut above the disease sutured in the healthy gut below. If the disease be too extensive for such an operation, or if its exact limits cannot be determined beforehand, a colotomy should be performed.

Exactly the same rule may safely be followed in cases of non-malignant stricture. If the disease cannot well be kept in abeyance by incision and subsequent dilatation, it should either be excised or a colotomy should be done; and which, must depend upon the extent of the disease and the surgeon's individual practice and preferences.

It follows from this that a surgeon may do a colotomy in a case of combined ulceration and stricture for the ulceration alone, where the stricture could easily be overcome by dilatation. Mere stenosis is much easier to overcome by local treatment than is ulceration.

Given a case of extensive non-malignant stricture, say venereal or dysenteric, where the whole area of the disease covers only two or three inches of the bowel, the surgeon will be governed in his choice between extirpation with circular suture and colotomy by his individual preferences, always bearing in mind, however, that colotomy is an operation with almost no mortality, and that the same cannot be said of extirpation in any of its forms.

IV. *In non-malignant disease either extirpation or colotomy may restore the patient to perfect health and usefulness.*

In this article so far, I have spoken of colotomy as an accepted surgical measure of which the utility was fully recognized. I shall do so to the end. To anyone who denies the propriety of colotomy in certain cases, the whole article will be unintelligible and unacceptable. It is with me always a last resort, exactly like the amputation of a limb. To cut off a leg is to acknowledge the inability to cure the leg. To cut off the rectum from the function of defecation is to acknowledge the inability to cure the rectum. But to amputate a leg is still good surgery, often the best and only surgery, and to cut off the rectum from the rest of the alimentary canal is often the same. In disease of the knee-joint the surgeon may sometimes resect and sometimes amputate. In stricture and ulceration of the rectum we may do the same. It is often a question whether a leg after resection of the knee-joint is any better than a good healthy stump in the thigh, and it is often a question whether a rectum which has been operated upon by excision is any better than an artificial anus in the groin. It is long since anybody has contended that a man who had lost a leg by amputation had better be dead, and yet the time has not come when we do not hear that a man who has lost his rectum and whose descending colon ends in the left groin, is not better dead than alive. With those who hold such views this article can have no weight.

They tell me that over on Blackwell's Island there are a number of paupers who have submitted to lumbar colotomy, whose condition is very pitiable. To this I can only answer that I never do lumbar colotomy, and that none of the many patients upon whom I have done the inguinal operation is at all anxious to die. My cases are all about me, and I keep in communication with them as long as I can. Are any of them perfectly happy? Are they as well off as they would be if they never had had incurable disease of the rectum? No. But are they better off than they were when operated upon; and has a condition tending toward the grave been changed into one of comparatively slight discomfort? Yes. No patient of mine has ever reproached me for doing a colotomy upon him, though I have had a patient complain bitterly to me that, in spite of the operation, there was still a little muco-purulent discharge from the anus, and that there was a slight erosion of the mucous membrane at the artificial opening. In the same letter he has told me that he had gone back to his daily labor as a house carpenter after years of invalidism, and had gained forty pounds in flesh.

I have no desire to make the state of a patient with an artificial anus appear more comfortable than it is, and I have no prejudice in favor of colotomy over any other method of treatment that will prolong life and relieve suffering. I had as lief extirpate the rectum as to do colotomy, and could I do any good, I had as lief paint it with nitrate of silver as do either. I can only say that upon this one point there is a popular prejudice which is to be overcome by practical experience, and which will be overcome by any considerable experience with the results of colotomy. I should probably be as slow as anyone to recommend a surgical operation which I thought was to cover me with reproach, and I do not do colotomy with the idea that my patients will in the future execrate me. It is advised, advocated, and recommended as a thing which will improve the condition of, and be satisfactory to, the patient, and in all my cases the result has justified the recommendation.

In choosing between extirpation and colotomy in any particular case, it must also be remembered that the difference in the condition of the patient after the two operations is not as great as at first sight it might seem. Extirpation often leaves a useless rectum and anus after great risk and long convalescence; and there is not much to choose between an artificial anus with no sphincteric power in the perineal or sacral region, such as often results from extirpation, and the same condition in the left groin after inguinal colotomy. For the latter we never claim any sphincteric control, while for the former it is often claimed with only the slightest foundation. It is indeed quite the rule to see in the reports of cases of extirpation, that the patient has good sphincteric control, though sometimes the words "except in case of diarrhœa" are added as a saving clause; and yet as I write I am trying to remember a single case of real sphincteric power after extirpation of the lower part of the rectum, either in my own practice or in that of others, which has come under my observation. It must be very rare. We all know how common is the disabling of these slender muscular bands after operations for not very extensive fistulæ, and how commonly we see incontinence associated with even slight stricture and ulceration within the rectal pouch. What then is to be expected after such extensive cutting and cicatrization as is involved in the operation of extirpation?

A study of the physiological anatomy of the function of defecation, leads one to smile when he reads in a journal that a patient has "sphincteric control except in case of diarrhœa." It is much like saying that a man has good use of his legs except when he tries to

walk. And yet what is meant is this:—After complete removal of the sphincters and several inches of the rectum, a patient will often have sufficient warning of the approaching act of defecation, when the passages are solid and normal, to allow him time to prepare himself for it by seeking the closet, a warning of from a couple of minutes to half an hour. The warning is simply the normal involuntary peristalsis of the large bowel forcing its contents toward the anus, which is felt in every man as the premonition of an approaching evacuation. The difference between a man with perfect sphincters and one without, is that the former can *prevent* a passage even when the rectum strongly demands relief, and even in case of diarrhœa. I don't know that I have ever seen a case of extirpation of even a small part of the sphincters where this power remained.

It is the same with the colotomy patients. They have the premonition and have time to prepare themselves, but of actual sphincteric power, there is none. The advantages of an outlet to the alimentary canal without sphincteric power in the perineal or sacral region, over one in the groin, may not be great enough to compensate for the risks of an extirpation over that of colotomy; and yet I would not be understood as advocating either operation in preference to the other. Where the disease, be it stricture or ulceration, can be extirpated without too great risks, and too great destruction of the parts—in other words, where it is comparatively limited in extent and freely movable on surrounding tissues—extirpation is to be chosen. Where the extent of the ulceration is not positively known, or the removal of the stricture involves a more or less extensive removal of the pelvic contents, colotomy is preferable. Both operations will invariably give great relief and may restore the patient to perfect health. In the more extensive cases, even after colotomy, there may still be some discharge of bloody mucus and pus for a considerable time in steadily decreasing amount; but this, though always a cause of annoyance, will in no way prevent the general good result.

V. *In cancer of the rectum there are but two methods of treatment to be recommended, extirpation and colotomy, all other operative procedures being worse than useless.*

This has already been referred to under the second proposition. Proctotomy in cancer is a dangerous procedure, both on account of shock and secondary hæmorrhage, and can do but little good. It may temporarily overcome obstruction, but for a very limited time and at great risk. The same applies to cauterization with acids or actual cautery, to partial extirpation, *râclage*, and electrolysis, the means usually adopted by those who assume to treat these cases, and yet refrain from radical surgical measures. For the man who will not extirpate and who believes colotomy to be worse than death, there is nothing else to do, it is true, but it is better to do nothing than to do harm, and such a man had better leave these cases to others. This brings us to the next proposition, that:

VI. *In the vast majority of cases of cancer, either extirpation or colotomy should be done as soon as the diagnosis is certain.*

I have seen in the aggregate many years of useful life lost by the advice of reputable surgeons, who, recognizing the disease, and the necessity for future colotomy as a means of preventing obstruction, have not recognized the utility of immediate operation for avoiding pain, loss of sleep, and exhaustion. Cancer kills in several ways, but least often, I think, by causing obstruction. Generally it is by exhaustion; and the chief elements are the rapid decline in strength and the almost constant desire for stool, with its attendant bleeding, straining, irritation of the growth, and loss of sleep. There is, moreover, but little doubt in my mind, though this is hard to prove, that the constant straining at stool caused by the growth, reacts unfavorably on the growth itself, causing its more rapid increase.

For these reasons I have made it a rule to do colotomy in nearly every case as soon as it is evident that a cancer exists which cannot safely be extirpated. The exceptions are the few cases in which, though extirpation may be contraindicated on account of the extent or location of the disease, there is still little irritation from the growth and no danger of obstruction. Such cases are occasionally seen, though not often. I have one in mind now, a young, apparently healthy woman with cancer of the upper part of the rectum involving also the peritoneum and uterus, and to my mind, therefore, not operable, in whom there were no symptoms except a discharge from the anus two or three times in twenty-four hours. In such a case it is as well to wait till either there is more local distress or some signs of obstruction, but one or the other of these equally pressing indications for operation is sure to come within a very few weeks.

It is in this sense that Bryant complains so justly that the operation of colotomy is too much regarded as a *dernier ressort*. We put it off until only a few weeks of life remain, when by doing it earlier life might be prolonged many months; and this, I suppose, will continue to be the general practice until the old idea, that the operation inflicts a disgusting deformity, is eradicated from the minds of the general profession.

VII. *The field of usefulness of the operation of excision of cancer of the rectum is very limited.*

It costs me much to write this proposition, for I have had great hope, some experience, and many failures. I know that in the attempt to cure I have more than once shortened life, and yet I have always been conservative. Let me for a moment glance at my own statistics. In one hundred and seventy-five cases of stricture, eighty-five have been malignant, or roughly speaking, one-half. In how many of these I have recommended colotomy, and in how many extirpation, I do not know, nor is it important; but in forty I have done the former, and in eighteen the latter operation. I am speaking now of cancer to the exclusion of non-malignant stricture and ulceration. The result of my extirpations is as follows, taking them in their order.

Case I.—Excision of cancerous mass on anterior wall of rectum three inches from anus, involving peritoneum. Death in fifty-two hours from exhaustion.

Case II.—Circumscribed growth confined to rectal wall at level of prostate, and covering a diameter of about two inches. Recovery from operation, but no history after the first two months.

Case III.—Cancerous stricture just within rectum, involving only about two inches of the gut, freely movable except as it involved recto-vaginal septum, and eminently suitable for extirpation.

The whole diseased part, with half an inch of healthy gut above and below, together with the recto-vaginal septum near the growth, was removed. Note the result. The disease returned almost immediately in the cicatrix, and a second operation, also completely successful, was done six months after the first. Again there was almost immediate return in the cicatrix, and one year after the first operation colotomy was performed.

Case IV.—Stricture with complete obstruction. The disease was confined to the middle and lower portions of the rectum, and was fairly suitable for extirpation. A complete circular resection was done, but the patient died in twelve hours from extravasation of fæces into the peritoneum. In this case the bowel above the cancer was much thinned by the long-standing obstruction, and the sutures tore out as they would from wet paper.

Case V.—Another perfectly suitable case for operation. The disease involved only the anus and recto-vaginal septum, and was completely removed. It returned in the cicatrix in three months, so extensively that no secondary operation could be done, and a colotomy was performed prolonging life one year.

Case VI.—In this the disease was more extensive than I should again attempt to extirpate. It was attached to the base of the bladder and involved a good deal of the peri-rectal cellular tissues. To give the patient every chance a preliminary colotomy was done a fortnight before the excision. Death followed the operation of extirpation in twelve hours, from shock.

Case VII.—Epithelioma of margin of anus. No return of the disease after two years as far as known.

Case VIII.—Circumscribed cancerous ulcer on side of

bowel about three inches long by two wide. Two-thirds of circumference of rectum removed for lower three inches. No return for three years.

Case IX.—Cancer attached at deep urethra and prostate, but movable at all other points. Extirpation of lower three inches of rectum. Return of disease in the wound before cicatrization, and death from secondary disease in liver a few months later.

Case X.—Cancer involving anus, base of bladder, and prostate. Amputation of lower three inches of rectum with removal of seminal vesicles and part of prostate. Death from exhaustion on tenth day.

Case XI.—Cancer of margin of anus, lower part of rectum, and recto-vaginal septum. Amputation of about three inches of rectum. Return in both groins in six months. Second operation, followed by return in three months.

It is unnecessary to report more cases in detail.

In four cases death was directly due to the operation. The chapter of accidents has been large in these cases, it is true, one dying from an injection of persulphate of iron into the peritoneal cavity by an attendant who became terrified by a slight oozing from the rectum during my absence; and one being exhausted by hiccough on the ninth day. But though bad luck and accidents will make the rate of mortality larger, it will of necessity always be large in this operation. For extirpation of the rectum is a serious and difficult operation, necessarily attended by great shock and loss of blood, and the possible complications are many and serious.

In two cases the disease, though thoroughly removed, returned soon in the cicatrix and the operation did no good. Both of these were typical cases for the operation, the mass being easily reached and freely movable.

In one case it is impossible to tell how much good was done by the first and second operations. Possibly life was prolonged over what it would have been by a colotomy performed as soon as the disease was recognized, perhaps not. At all events two serious operations on the disease itself only postponed the colotomy one year.

Our good results are reduced, therefore, in the cases quoted, to three cases of epithelioma of the margin of the anus and rectum, and to possibly one in which the result is unknown.

It seems to me that in such a question as this we should consider not so much the fact that by an operation attended necessarily by a high death-rate we can remove a cancer of the rectum, but the length of life which is likely to be gained as compared with other methods of treatment. In the fatal cases we sacrifice much life which might have been greatly prolonged by colotomy. In cases of immediate recurrence in the wound we certainly do not gain enough to pay for the risk. In those in which recurrence takes place only after an interval of months we may be fairly said to have accomplished good.

As to the prospect of cure in any but exceptional cases, such as epithelioma of the margin of the anus and rectum, it is rather a matter of hope than of probability.

In this operation of excision history bids fair to repeat itself. It was established as a legitimate mode of treatment by Lisfranc in 1830, and was subsequently almost abandoned on account of its use in improper cases and the necessarily bad results. Again, within the last twenty years it has become very popular, and once more it may be best to consider very carefully its results, particularly in the light of what can be accomplished without risk by colotomy in the same class of cases. Years ago Van Buren laid down a very simple rule as to the class of cases in which excision might reasonably be expected to do good. They were the cases in which the growth was movable on the subjacent tissues, distinctly circumscribed, and within reach from the perineum. Since the high sacral incision has come into use the distance of the growth from the anus and consequent opening of the perineum are no longer in themselves contra-indications to operation; but the limited extent of the disease and its movability are still the two things on which the decision to extirpate should turn.

To refer once more to my own experience, I may say that I am done trying to dissect a cancerous rectum away from the deep urethra with knife and dissecting forceps, as I am also done removing the deep urethra, prostate, seminal vesicles, and base of the bladder for the sake of getting out a cancer of the rectum. Epithelioma of the anus and adjacent rectum should of course be removed where we can cut wide of the disease, as we do in epithelioma of the lip; and these cases give us our real successes. Annular carcinoma in any part of the rectum, high or low, which is freely movable, may also be excised, but the chances are enormously in favor of a return within a few months, even in the cases most favorable for operation. There is no escape from the conclusion that cancer of any part of the alimentary canal holds out little hope of radical cure by removal, and is very likely to return after a comparatively short interval, no matter how thoroughly it may be extirpated. The technique of the operation has been greatly improved, and many cases have been brought within the field of justifiable operation, which a few years ago were considered inoperable. It is indeed wonderful how much can now be removed without fatal result; but the length of days gained by the patient bears small relation to the brilliancy of the surgery.

Our last proposition is this:

VIII. *The utility and advisability of inguinal colotomy in cancer of the rectum are unquestionable and the results most gratifying.*

In any case suitable for extirpation—that is, in any case where the disease is confined to the alimentary tube and does not in addition involve more or less of the pelvic contents—the surgeon may choose between extirpation, with all its risks, and colotomy. He may indeed first extirpate merely with the hope of gaining time before recurrence, and be prepared subsequently to do colotomy, as I have done in several cases, with some lengthening of life and avoidance of pain over what would have been gained by colotomy alone. But the cases which present themselves at this early stage are but a small minority of the whole, and in all others colotomy is the only proper treatment.

Colotomy is an operation which in suitable hands has scarcely any mortality, if performed early. In the last stages of the disease, unless complete obstruction is imminent, it may not be worth while to do it at all, for then there is a risk, as there would be in any other surgical interference, however trivial, and the patient will hardly live long enough to benefit. It is in the earlier stages of the disease that its greatest benefits are seen, when the tenesmus and frequent passages of bloody mucus are rapidly carrying the sufferer to the grave. Here we get the immediate relief of almost all suffering, the patient improves rapidly in health and weight, the frequent calls to empty the rectum are reduced to the passage of a little bloody mucus once or twice in twenty-four hours, and it is cruelty to try and impress upon the patient that he or she is not on the road to perfect recovery, as they sometimes fondly hope in spite of the clearest diagnosis and prognosis in the beginning.

Compared with extirpation, these results are most satisfactory and are obtained without risk. It is true we have not tried to cure; we have simply tried to prolong life by cutting off the diseased rectum from all part in the function of defecation, but in this we succeed and sometimes to a wonderful degree.

In the great majority of cases as they present themselves, colotomy is manifestly the only treatment. In a small number extirpation is indicated with equal clearness. But given twenty of the cases ordinarily considered suitable for extirpation, cases of annular carcinoma of the rectal pouch where the mass is still movable on subjacent tissues, and I am quite sure that a greater average length of life would be obtained by performing an early colotomy on all of them than by extirpation.

Charles B. Kelsey.

RESOPYRIN. The name given to a compound formed by the union of resorcin and antipyrine. It is obtained by the interaction of the two when mixed together in

molecular proportions; in solution, one part to three of water, an oily mass forms in abundance, which upon agitation changes into a hard, white, opaque body. It may be prepared from alcoholic solutions, in which it forms in rhombic crystals. It is odorless; insoluble in water; soluble in ether, one part in one hundred; in chloroform, one in thirty; in alcohol, one in five; in the latter menstruum it is not precipitated by the addition of water. Resopyrin differs chemically from resorcin by not giving a precipitate with lead subacetate, nor a blue color with ferric chloride. When heated it separates into an oily and an aqueous layer. It possesses the medicinal properties of both its constituents, but its therapeutic action is as yet undetermined. *Beaumont Small.*

RESORCIN. This drug is now rarely employed as an antipyretic in febrile disorders, as numerous unfavorable symptoms have been traced to its use, and many other more suitable antipyretics have been introduced. Its internal use is now directed particularly to its action as a stomachic and intestinal antiseptic. It is used in all forms of gastritis, dyspepsias following indiscretions in eating or drinking, in gastro-enteritis of children, cholera nostras, vomiting of pregnancy, sea-sickness, in gastric ulcer, and in cancerous disease. It is given in five-grain doses three times a day, and in addition to its antiseptic action it exerts a decided analgesic action, relieving pain and irritability of the stomach, and enabling it to retain food which otherwise would not be tolerated. Dr. Menche, of Bonn, who called attention to its use in digestive disorders, prepared a solution of three to five parts in a thousand; of this he gives to children one or two teaspoonfuls every two hours. A few drops of tincture of opium may be added if the relaxation is very marked. For adults the dose, as an intestinal antiseptic, is one and a half to two grains every two hours. It may be given in solution, or as a powder with sugar of milk. Only the resublimed resorcin should be employed for internal medication. A one per cent. solution has also been used to irrigate the stomach.

In addition to its general use as an antiseptic in the treatment of wounds, ulcerated surfaces, etc., it has been highly recommended as a topical application in diphtheria. A ten per cent. solution in glycerine is used, and this is applied to the diseased surface every hour during the day, and every two hours during the night. It acts by neutralizing the poison on the surface of the membrane, and by penetrating to the mucous membrane and lymphatics. It also is rapidly absorbed and counteracts the influence of the poison of the disease when present in the blood. The drug may also be used by diffusing in the room a twenty per cent. solution, by means of a spray.

The local application of an eighty to one hundred per cent. solution has been proposed in tuberculous ulcers of the pharynx and larynx, a five per cent. spray being used at the same time.

In pertussis it has been used with very remarkable success, the cough and paroxysms disappearing in four or five days. The treatment was introduced by Moncorvo, of Rio de Janeiro, and has been used with equally good results by others. A two per cent. aqueous solution is applied as a spray to nose, pharynx, and larynx, every two hours; the treatment should be continued for some time after the disease has developed. Its use also acts as a prophylactic, and prevents the disease from spreading to other inmates of the house. Some prefer to apply a one per cent. solution directly to the mucous membrane of the larynx.

In its use in general surgery and in diseases of the skin, it has been pointed out that weak solutions of one to three per cent. harden the skin, while stronger solutions, ten to fifty per cent., macerate and destroy it.

Beaumont Small.

RETINOL, RESINOL, ROSINOL. This substance, discovered in 1838, by Pelletier and Walter, has lately been recommended as a vehicle for various drugs. It is obtained by the destructive distillation of resin, which breaks up into four different bodies: retinpath, isomeric with toluene, and boiling at 108° C.; retinyle, isomeric with cumene, and boiling at 150° C.; retinol, which boils at 238° C.; and metanaphthalene, isomeric with naphthalene, and boiling at 235° C. Retinol has a formula of $C_{35}H_{16}$, and a density of 0.900; it is neutral in reaction, possessed of a slightly bitter taste, and has a faint peculiar odor similar to that of the fir-tree. It is of an oily consistence, pale yellow in color, resembling oil of sweet almonds. It contains a varying proportion of terebene, colophone, cresylol, phenol, and creosote. It is a very stable fluid, free from any irritating properties, and powerfully antiseptic.

Retinol has been administered internally as a remedy in septic fevers, in colds, bronchitis, laryngitis, and various other disorders of a catarrhal character, the quantity given ranging from a few drops to a teaspoonful. This use, however, has not been maintained. Locally it is a useful application to ulcers, wounds, diseases of the skin and of mucous membranes. It may be used as an ointment or applied as a tampon.

It is now employed as a solvent for numerous remedies which are insoluble in water and other ordinary vehicles. It mixes with fats, oils, glycerine, lanoline, carbolic acid, turpentine, alcohol, and ether, in all proportions; salol is soluble, one part in ten; naphthol, one part in fifty; aristol, one in fifty; camphor, one in twenty; chrysophanic acid, one in forty; cocaine, one in thirty. Resorcin, if dissolved in glycerine, may be mixed with it freely, and, so may iodoform if dissolved first in a little ether. Being unoxidizable, it is an excellent vehicle for phosphorus, a solution of which remains unchanged for an indefinite period. A solution is prepared by heating the retinol to 212° F. for a short time, and allowing it to cool in a clean dry bottle; to it one per cent. of dry phosphorus is added, which readily dissolves with the aid of a little heat.

One of the latest applications of retinol in combination with salol, is in the treatment of cystitis. The bladder is first irrigated with boric-acid solution, and then from two drachms to one ounce of a six per cent. solution of the salol in retinol is injected. The longer the solution is retained the better is the effect obtained; traces of it may be detected for several days. The treatment is applicable to various forms of cystitis, but its effect is most marked in chronic and subacute cases. In acute cases it may prove irritating and the solution be forcibly expelled. *Beaumont Small.*

RETRO-PERITONEAL TUMORS. Along the lines of study pursued by abdominal surgeons we can plainly trace the earnest work being done in an effort to clear up and place on a more secure footing this most difficult problem in surgery.

Whether success or failure is to be the result in this attempt, time only can solve. That it is a subject of much thought and earnest research at the present time cannot be denied. Thus far, investigations go to show that in the past there has been much confusion in the pathology of these growths, many errors in diagnosis, and not a very satisfactory record regarding operative interference. Like many other problems in this great field of surgery, an early, careful study of the case, a judicious weighing of all symptoms, subjective and objective, an experienced touch, no haste, are doing much to place on a more secure basis of classification these rare growths. Careful workers in the pathology of these tumors are doing much to clear up doubtful points, and establish on a more secure basis their true nature. Operating surgeons, when the tumor has obtained full size, have not found the work of removal at all encouraging, yet it is plainly to be observed that when the growth has been reached early, a percentage of recoveries has been secured hopeful for the future. The anatomical structure, the relations of the retro-peritoneal space, the physical changes that may occur, should claim careful study and review on the part of the surgeon who is working in this branch of surgery. The post-mortem table, the pathological laboratory, the microscope, have done much

to make clear the histology and pathology of these growths, and have given us knowledge that cannot be thrust aside ; and what seems an innocent development now, may very soon become serious in the establishing of true malignancy. Pressure, traumatisms, physical and mental periods of great exhaustion, all have their influence in making these cases go badly when once they have reached a certain size or period of development.

A careful study of retro-peritoneal tumors shows them to be of a mixed variety, containing the elements of both lipoma and myxoma tissues, which are, histologically, very closely associated. Fat is developed from embryonal mucin, and in post-fœtal life occupies those spaces in the economy which later in the fœtus are of myxomatous elements.

Again, in the retro-peritoneum both of these tissues are found, and doubtless many of these growths arise, under suitable conditions, from congenital neoplasms. There is, in these cases or classes of tumors, no inconsiderable amount of evidence to support the theory of Cohnheim relative to the origin of tumors. They are sometimes active in their growth, often become cystic, and at times reach immense proportions. Cases are reported of tumors of this kind weighing eighty pounds. The distribution of the elements is very diverse. The fat may be regularly distributed throughout the tumor or may occur as islands located here and there. These growths are very often œdematous, and by chemical analysis present a large percentage of mucin. The microscope, besides revealing the usual elements of lipoma and myxoma, very often reveals a numerous round-celled infiltration in the stroma of the growth, pointing to a sarcomatous element in their character. While not presenting all the features of active malignancy that carcinoma and sarcoma do, yet they often show a marked tendency to recur locally when removed.

Clinical histories and pathological research both show that tumors containing embryonal elements are very apt to be malignant, and can very truly be said to be always so.

The tumors found in the kidneys of young children are, for the most part, mixed tumors, chiefly myo-sarcoma. Many are surely congenital, and are an example of a new-growth developing from embryonal tissue. They have, by Grawitz, recently been compared to a series of embryonal growths which spring from the supra-renal capsules, and have the appearance of adipose tissue, but are usually sarcomatous. (Orth, "Pathologische Diagnostik.")

Even though the tumor may not at first present the condition of true malignancy, yet the operative surgeon has learned to know that the semi-malignant growth is very apt to return either in the cicatrix or the neighboring connective tissues, involving important structures, such as the large secreting glands or the lymphatics.

A careful investigation of the reported cases, together with an examination of all accessible works on pathology, impresses one that the most frequent origin of these growths is in the connective tissue of the capsular envelope of the kidney ; the next most frequent seat being the supra-renal capsules.

Mr. Hulke, of Middlesex Hospital, reports a case of myxoma surrounding the left kidney, which he operated upon. A median section was made through the tumor when it presented itself. The incision was continued through the posterior blade of the peritoneum, just beyond the descending colon. The tumor proved to be a myxoma, and, although the patient recovered from the operation, the growth returned locally. The kidney was not involved by the tumor, and could have been enucleated.

The growths embraced in this class are peculiar in several respects. None can be said to be absolutely benign, even those which are made up entirely of the histological elements of either lipoma, fibroma, or myxoma, and although they do not tend to the formation of metastases or to the infiltration of immediately surrounding tissues. It is true that they show no great tendency to recurrence when completely removed, yet from the great size to which they develop, and from their tendency to undergo degenerative changes, they cannot be classed as innocent growths.

Dr. John Homans, of Boston, has called attention in two papers to the reported cases of pure lipoma, among which were some on which he had himself operated.

Subserous lipomas rarely of themselves reach a large size. However, those going out from the peritoneum may be of sixty pounds' weight. Lipomas are usually slow-growing, the subserous particularly so. Subcutaneous lipomas sometimes grow rapidly after remaining stationary for years. Lipomas seldom change to other varieties. But they may primarily be mixed in character—myxo-lipomas.

The character of the latter group can never be determined with certainty without careful microscopical examination, as many growths having the appearance of lipomatous tissue often have the elements of myxoma and sarcoma as well. They may reach great size, but show no disposition to return after removal.

Sir Spencer Wells reports, in his first edition of "Abdominal Surgery," a case wherein the removal of such a growth was undertaken, with fatal results.

Sarcomas, either in typical form or in combination with myxomatous, lymphomatous, or fibromatous tissue, also occur, and have been observed quite often. Many of the tumors which have been described as sarcomas of the mesentery were doubtless retro-peritoneal sarcomas, arising at the root of the mesentery and presenting themselves anteriorly, after separating its folds.

Primary sarcoma springing from the mesentery is exceedingly rare. Sarcoma occurs most frequently in combination with myxomatous growths. These tumors are, histologically, very closely associated. Circulatory changes are likely to occur in them, viz., thromboses, with subsequent softening and cystic degeneration.

Carcinomas are very rare, and present the strongest type of malignancy. They are the hard, solid variety, soon forming deep and firm attachments, offering little to be hoped for from an operation. Varieties such as fibroma and cystoma have been observed. It may be said of the latter, for the most part, that they either spring from the walls of the pelvis, or from the subperitoneal connective tissue of that region. Virchow looks upon this series of growths as being analogous to those tumors which arise from the deep tissues of the neck.

A few remarks may be made in regard to the starting-point and relations of all these growths. Those which spring from the walls of the pelvis encroach upon or involve the bladder, uterus, and rectum, very often presenting features which are exceedingly perplexing in diagnosis. The origin of a smaller number is reported respectively as from the retro-peritoneal lymphatics, the bodies of the vertebræ and bones of the pelvis, and the root of the mesentery. In by far the greater proportion of the cases no exact origin is given ; indeed, from the subsequent changes in an atomical relations, it would seem quite impossible to determine the exact point of origin of many of the very large retro-peritoneal new-growths. They have almost uniformly presented themselves in the line of the least resistance, that is, anteriorly. In my case, reported in the *American Journal of the Medical Sciences*, January, 1892, the tumor presented itself in the back,—a condition which can be attributed to its origin from the extreme upper border of the kidney, where it was less completely bound down by the lumbar muscles and fascia. When the growths have reached a sufficient size to attract the attention of the patient, they are found presenting themselves at either side of the umbilicus, somewhere in the region of the lateral lines drawn in the arbitrary divisions of the abdomen into regions, although they may appear centrally. As the growths increase in size the viscera are displaced, not infrequently completely to the opposite side, although those growths which spring from the left kidney may have the descending colon externally. Owing to circulatory disturbances within them, and to their liability to a subsequent malignant infiltration, as well as to the development of cachectic conditions, they present, clinically, features which suggest a condition almost immediately hazardous to life.

As with any large abdominal growth, there is always a certain degree of encroachment upon the thorax and pressure upon other organs. In my second case, the tumor pushed the inferior border of the liver up to the fourth intercostal space, while the cæcum and ascending colon were displaced toward the left side of the abdomen.

Taking into consideration true retro-peritoneal tumors, it can be said of them they may have fat, connective tissue, fascia, muscle, or lymphatic tissue for their source. They may be homologous or heterologous in character. There can be no reasonable doubt that embryonal elements, which lie quiescent among the tissues, may, under suitable irritation, be a frequent source of their development.

Cysts have been reported by various authors as arising from the retro-peritoneum. Czerny reports particularly a case of dermoid cyst springing from the capsule of the kidney. Others have reported cases of similar growths springing from the walls of the pelvis, particularly in the neighborhood of the sacrum. The so-called cyst of the broad ligament is very often partially retro-peritoneal in character.

Whenever the physical examination reveals the character of the tumor to be a cyst, one should be exceedingly careful as to the diagnosis and prognosis. Retro-peritoneal cysts are exceedingly rare, are very likely to originate from infarctions in a more solid growth, and may be confounded with cysts from the parenchyma of the kidney or from the pancreas.

Diagnosis.—Notwithstanding our constantly increasing experience in abdominal surgery, we must admit that an exact diagnosis as to the true nature of these growths is not always possible. Nor can it be said to be absolutely necessary, especially in the lesser and more movable varieties.

I cannot well imagine a more severe task for a writer than to attempt to outline the symptoms and diagnosis of a condition which, until the present time, has baffled, quite without exception, the skill of all who have met with it. Yet, recognizing the importance of the factor of exact diagnosis, especially in abdominal surgery, I wish to call attention to all such symptoms as may be associated with these growths, and, after carefully weighing them, put together what seems useful.

In the first place, there is not a single symptom that is pathognomonic, and we are dependent for diagnosis upon the process by exclusion. Diseases and neoplasms of the uterus and its appendages, of the liver and the gall-bladder, of the spleen, pancreas, and kidney, are to be excluded, as well as aneurism of the aorta, tumors of the mesentery, and of the abdominal walls.

Sex or the history of the case may enable one to exclude the organs of generation at once, and bimanual examination will rarely fail to locate the uterus and its appendages and determine any pathological changes in them. Pelvic congenital cysts from the spinal cord or membranes should not be lost sight of. Subperitoneal fibroids are the only ones likely to be confounded with this condition; but, then, uterine fibromas are more easily movable within the abdomen, and their attachment to the uterus can be made out. Solid tumors of the ovary and broad ligament present greater difficulties, which at times cannot be surmounted.

Diseases of the liver, together with new-growths of that organ, have very often been mistaken for retro-peritoneal neoplasms. Hypertrophic cirrhosis, amyloid degeneration, hepatic abscess, hydatids, obstruction of the cystic duct, and distention of the gall-bladder, together with carcinoma and sarcoma, present physical signs which may be confounded with retro-peritoneal tumors. The history of the case, together with a painstaking weighing of general symptoms, will naturally assist in clearing a doubtful diagnosis.

Disturbances of biliary excretion may occur from pressure on the common duct by the tumor. Again, tumors of the liver always move synchronously with the respiration. Retro-peritoneal ones do not, as a rule. Very often a line of resonance is found between liver and tumor, which at once shows that the growth is not connected with the former organ.

My own experience teaches me that growths connected with the spleen make the case at times very embarrassing.

It has been said that the differentiation from hypertrophy and tumors of the spleen presents less difficulty than does the differentiation from tumors of the liver. Here palpation and percussion will be quite sufficient, if employed to locate the spleen in its normal position. Tumors of the omentum lack the fixed position of these growths. The absence of digestive disturbances, with fatty stools, will serve to exclude the rare new-growths of the pancreas.

As stated, many of these tumors have their origin in the capsule of the kidney, or in the connective tissues surrounding it. They present, at least in their earlier stages, physical signs differing in no respect from tumors of the nephritic parenchyma. An examination of the urine may give an exact clue to the diagnosis. In none of the cases reported had renal hæmorrhage or albuminuria, with or without casts, occurred; conditions which are the rule with tumors of the parenchyma of the kidney.

Regarding the use of the aspirator, while I must admit that up to the present time it has been of no especial value in the diagnosis of my cases, yet I believe that in many instances the fluid withdrawn by this instrument and carefully examined, would enable us to make a diagnosis as to classification of the tumor. In a recent case of sarcoma of the kidney, by means of the medium-sized needle I was able to draw off sufficient fluid to fully demonstrate the nature of the growth, the diagnosis being confirmed later by the autopsy. All things considered, I believe the instrument is of value in the diagnosis of retro-peritoneal tumors.

The suggestion made by Dr. W. G. Macdonald, of rectal insufflation of hydrogen gas, I believe worthy of trial, especially where a careful examination has been made before, and the percussion areas have been outlined with care upon the abdomen. The process of insufflation should be carefully watched, that the relation of the intestinal tube to the tumor may be established.

One should be very cautious, particularly if in doubt regarding new-growths springing from the pancreas, or from the surface of the kidney on the inner side. A growth springing from the latter position is, as I have intimated, likely to present some pathological evidence in the urine.

Treatment.—Without operative interference there is but one termination. The rapidity of the fatal termination varies somewhat with the character of the growth. Pure lipomas are slow-growing until a certain volume is reached, when they proceed with great rapidity to a fatal termination. From a study of the clinical histories found in the literature, I am of opinion that the mean duration of life, after the discovery of the tumor, is not more than nine months. Operative treatment offers to us much promise. Recovery has followed the removal of retro-peritoneal tumors of great weight, even those weighing fifty pounds. The immediate mortality following operations is great, from necessity; yet from the hopelessness of the conditions an operation is to be urged with great earnestness upon the part of the surgeon. Incomplete operations have been immediately more fatal than those in which the tumor has been completely removed. Like all surgical lesions, these tumors illustrate the necessity of early diagnosis and prompt operation.

Czerny, in concluding a paper in which he had reported three cases, says: "In all cases operative interference can be safely undertaken; that when the tumor is no longer encapsulated, the incision had better be closed, otherwise the growth should be enucleated."

Operations for the removal of retro-peritoneal growths will, from necessity, be subjected to considerable modification in detail. The choice of incision will usually fall in the line of the linea semi-lunaris, on one side or the other; Langenbeck's incision for removal of the kidney may be made use of. Frequently, when the incision is at first exploratory it must be made in the median line. When the anatomical relations can be

made out, and the operation continued by an extension of the cut, then the more favorable incision is in the linea semi-lunaris. By the separation of the peritoneum from the internal border of the tumor, it may be attached by sutures to the internal border of the abdominal wound, making the whole field of the operation extra-peritoneal.

The incision of the posterior fold or blade of the peritoneum should be external to the attachment of the mesentery of the colon, although this is not absolutely necessary. The removal of the growth by enucleation must be accomplished with great care; particularly is it always desirable to determine the source of the blood-supply and its relations to the great vessels. The vena cava has been wounded by accident in the enucleation of these growths. There are likely to be large, thin-walled veins located deeply in the wound, requiring ligation. It will be found at times necessary to remove the kidney with the tumor, and here the danger of hæmorrhage is very great. The supply-vessels of the kidney will frequently be found very short and difficult to reach.

The length of time required for the performance of the operation will vary, necessarily. As long a time as two and one-half hours has been consumed in a difficult operation. As in all strictly abdominal work, the operator must be prepared for any and every possible complication.

After enucleation, as well as when the kidney has been removed with the growth, the cavity must be thoroughly drained, either by full-sized drainage-tubes or by iodoform tamponade.

The after-treatment presents no indications for management other than those of a severe case of abdominal section.

As in all other conditions in surgery, there is certainly at the present time a better understanding of these cases. A more correct and early diagnosis, as is the case in all that pertains to medicine and surgery, will surely bring a larger percentage of recoveries.

These are purely surgical cases; no medicines, no mineral waters, or baths, electricity, or other lines of therapeutics, have as yet been of any service.

A. Vander Veer.

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RHEUMATISM, ACUTE. Great differences of opinion still exist as to the cases which should be placed under the head of "Acute Rheumatism." Immerman, in this connection, quotes the couplet:

> "Was man nicht definiren kann,
> Das sieht man als Rheumatismus an."

It is therefore necessary, in treating of this subject, first to decide the pathological conditions which may properly be included under the head of rheumatism. These may be given as follows:

1. Those typical cases of acute arthritis which are accompanied by fever, and in which there is a special tendency to inflammation of the membranes of the heart.

2. Atypical cases, such as those of acute muscular rheumatism, polyarthritis sine arthritide, cases of chorea of evident rheumatic origin, cases of larval rheumatism such as are described by Immermann.[1] The same author also includes[2] under the head rheumatism spastic forms of disease which affect the distribution of the accessory nerve of Willis. Edlefsen,[3] through his pupil, Classen, expresses the opinion that forms of neuralgia not due to central nervous disease, meningitis, or syphilis, are also of rheumatic character.

Friedländer[4] includes Landry's acute ascending paralysis, acute anterior polio-myelitis of the adult, acute bulbar paralysis, some cases of Basedow's disease, tetany, diabetes insipidus, and diabetes mellitus. Hirsch is of opinion that many of the cases of cold attended by pains in the limbs are really of rheumatic character.

Rehm and Immerman deny the identity of scarlatinal rheumatism with the typical disease, whereas Edlefsen and Strick consider the poisons identical.

Hirsch is opposed to the identity of the two conditions. Senator[5] excludes the following conditions: gonorrhœal rheumatism, that accompanying bronchiectasis and hæmophilia, as well as peliosis rheumatica. Painful conditions of the muscles after over-exertion, when persistent, are in the writer's opinion of rheumatic character. This, however, is denied by some. Pleurisy is sometimes, and tonsillitis often, of rheumatic character.

Although not willing to go to the length of some of the German authorities, the writer concludes, from clinical experience, that the rheumatic poison may be the main etiological factor in many diseases which have not so far been considered of rheumatic character.

ETIOLOGY.—Since 1885 very much has been written upon the etiology of acute articular rheumatism, and it may be safely said, notwithstanding the fact that the micro-organism peculiar to this disease has not yet been positively made out, that the belief is growing stronger and stronger that acute rheumatism is an infectious disease, and that the special microbe will in time be discovered.

Dr. T. J. MacLagan, in his exhaustive work upon this subject, published in 1886, arrived at the following conclusions: 1. Rheumatic poison is malarial in its nature. 2. Malarial poison is an organism, and therefore allied to the contagia. 3. That both poisons exhibit the phenomena of those which owe their morbific condition to their organic development within the system.

Since the publication of this work the organism of malarial fever has been discovered by Laveran, and the discovery confirmed by Councilman, Osler and others, so that the second conclusion has been thoroughly substantiated. The third conclusion, so far as it relates to malarial poison being reproduced in the blood, has also been thoroughly verified by subsequent discovery. Although no organism has yet been discovered which with certainty can be said to be the cause of rheumatism, bacteria have been found in many cases. Wilson [6] discovered a short bacillus in two cases of rheumatic pericarditis. Petrone [7] drew fluid from a rheumatic joint, and found a bacillus similar to that described by Klebs. Guttman's [8] case was probably of a pyæmic as well as of a rheumatic character. He found an organism similar to the staphylococcus pyogenes aureus.

Mantle [9] found two forms of micro-organisms: (1) micrococci grouped in diplococci, (2) a short thick bacillus. Leyden [10] found similar micrococci. Jaccoud [11] was unable to find micro-organisms, but Bordas, in G. Sée's clinic, found them in two out of six cases. The microbe he describes is a bacillus cultivated readily in peptone gelatine, in tubes or on plates, and still more readily in veal broth. In two instances the injection of this culture produced rise of temperature in the rabbit, and in one was followed by endocarditis with vegetations on the valves. Popow also discovered micrococci.

Dr. Angel Money [12] is of opinion that rheumatic fever is a blood-poisoning from fatigue products, the result of nitrogenous tissue metamorphosis, and the nervous system forms the secondary element in the etiology. In this connection it is interesting to know that Dr. B. W. Richardson [13] affirms the conclusion he arrived at a number of years ago in the following words: "The inference is as clear to me now as it ever was, that the secondary action of lactic acid as a cause of rheumatism is proved."

Pel,[14] of Amsterdam, expresses the opinion that the disease is of miasmatic origin, and that its frequency bears an inverse proportion to that of malaria.

The investigations made into the statistics, as well as the surroundings of rheumatic patients, afford more conclusive proof of the infectious character of the rheumatic poison than that given by the bacteriologist.

Edlefsen [15] found that laryngitis and acute bronchitis, diseases which are usually supposed to be the result of exposure to cold, were in point of frequency in inverse ratio to rheumatism, showing that the latter disease was not produced by exposure alone. He also published statistics to prove that rheumatism is a house disease, many cases occuring successively in the same house. Similarly to pneumonia and malarial fever, rheumatism is always more prevalent when the soil is drying up, and less frequent during continuous rainfalls. These facts seem to show that the rheumatic poison is a miasm, and that it exists in the soil.

Jürgensen confirmed these observations, especially the fact that it is a disease often found in certain overcrowded homes. Hirsch found that in only twenty-four per cent. of rheumatic cases were there evidences of exposure to cold. Feltkampf has made similar observations on the meteorological conditions during the prevalence of rheumatism. Mantle also found that in a large percentage of cases there was no history of taking cold

Hirsch arrives at the following conclusions: 1. Acute rheumatism is not a disease produced by cold. 2. Acute rheumatism is to be placed among the malarial diseases, for the following reasons: *a.* The greater number of cases occur when the soil is drying up, and a less number during a heavy rainfall. *b.* The virus seems to exist in greater amount in certain houses or localities. Some cases have been reported which seem to show that rheumatism is at times a contagious disease. Mantle mentions a case, and Schaefer gives an instance of the disease in a newly-born child when the mother was suffering from rheumatism. Friedländer states that in the Leipsic clinic patients coming into the hospital with other diseases, have afterward acquired rheumatism. In the same clinic, the celebrated Wagner at one time had the rheumatic cases isolated. Feltkampf gave an instance in which a convalescent from typhoid acquired rheumatism from two other patients in the same ward.

Jaccoud gives two instances where infants born at full term while their mothers were suffering from rheumatism, manifested symptoms of the disease. In one case in twelve hours, and in the other in three days, the infants were seized with well-marked acute articular rheumatism.

The metastatic character of rheumatism, as for instance where it is associated with thrombi, emboli, endocarditis, pericarditis, and brain lesions, points to its being an infectious disease. Then the appearance of the internal viscera after death is very similar to that found in cases of septicæmia: such as small hæmorrhages beneath the serous membranes, enlargement and softening of the spleen, etc. All are agreed that the predisposing causes to rheumatism, are debility from overwork, physical or mental, heredity, and exposure to cold. Men are more frequently attacked than women: three hundred and seventy-five males to two hundred and seventy-nine females, as shown by the report made by Whipham [16] to the British Medical Association. It occurs more frequently in females up to the age of twenty. It may occur at any age. Robert Bell, of Glasgow, expresses the opinion that chronic constipation is an important predisposing cause.

Clinical History.—It is not necessary here to repeat the well-known symptoms of a case of typical acute rheumatic arthritis, but simply to refer to those features to which attention has of late been drawn.

Jaksch has found peptones in the urine in twelve cases of rheumatism. Cystin is sometimes found. There is a rapid diminution of the red corpuscles in the blood and an excess of the white. Salmonson found excessive lactic acid in the blood. Cases of rheumatism have been reported in which all the joints of the body, even those of the vertebral column, have been affected.

Angel Money [17] made a systematic investigation of the cutaneous sensibility over affected joints. The acuteness of tactile sensation was found much increased, and the power of localization disturbed. Complete analgesia was at times a marked phenomenon, which might perhaps have been of a hysterical nature. The sensation of cold was usually diminished, and that of heat increased.

Faradic sensibility was diminished or abolished near the joint, and sometimes over the whole limb.

I will not again refer to the atypical cases, which are in all probability of rheumatic origin, as they have already been mentioned in the introduction to this article.

Dr. W. S. Church [18] gives the following conclusions after the study of nearly seven hundred cases. These are of special interest in connection with the prevalence of heart lesion in acute rheumatism. 1. Men suffer in somewhat larger numbers and more severely than women. 2. More than half of those affected have some cardiac lesion in their first attacks, and more than two-thirds of those who suffer from a second attack are found to have old or recent endocarditis. 3. Endocarditis attacks men and women almost equally. 4. Men suffer more than twice as frequently from pericarditis as women. 5. The heart when affected is usually implicated within the first week of the attack. 6. The liability to cardiac affection diminishes with age.

If we accept Immerman's conclusion, the condition of hyperpyrexia can be easily explained by assuming the heat centre to be especially affected in such cases. High temperature has been observed in many cases some hours after death. Brain delirium and stupor are frequently found in cases of hyperpyrexia. A peculiar form of delirium which was dwelt upon at length by Sir Thomas Watson in his lectures on the "Practice of Medicine," is found in many cases of pericarditis.

Meningitis, although sometimes present, is rare in acute rheumatism. When, however, as in ulcerative endocarditis, a septic element is introduced, meningitis is much more frequent. Convulsions and coma are sometimes the result of uræmia from nephritic complications.

According to Dr. Church's observations, lung complications are now much less frequent and much less severe than formerly.

Barlow [19] and Warren have first directed attention to small round, subcutaneous tumors, varying in size from a shot to a small pea, found most frequently on the fingers, hands, wrists, and along the spine. A case in Dr. Osler's clinic, presenting this complication, has been reported by Dr. J. K. Mitchell.[20] Dr. McPhedran, of Toronto, has reported two cases.

According to Dr. Cheadle, they are not at all uncommon in children. They are made up of recently formed fibrous tissue, and are no doubt of rheumatic origin.

In this connection I would refer to two cases of circumscribed œdema, which I have observed in connection with marked rheumatic symptoms. The skin affections which are most frequently found in connection with rheumatism are erythema multiforme and nodosum, urticaria, herpes facialis, and hyperhydrosis. The evidence in favor of the close connection between the erythema and rheumatism has been summed up as follows by Garrod: [21] 1. Both E. multiforme and E. nodosum occasionally appear in direct association with rheumatic fever. 2. They are usually attended by some degree of arthritis. 3. The arthritis which accompanies erythema may have any degree of intensity, from the severest joint lesion of acute rheumatism to the slightest joint pain. 4. Collateral evidence, such as the presence of chorea or old heart lesion, is sometimes obtained, pointing to the rheumatic nature of the slightest joint lesions. 5. Acute cardiac lesions may accompany erythema with the slightest arthritis, and probably sometimes occur in the absence of joint symptoms. 6. Erythema without joint lesion is uot uncommonly met with in patients who have previously suffered from rheumatism, but in some cases there is no evidence of association with that disease. We are uot therefore justified in concluding that such symptoms are always rheumatic.

Brocq is probably right when he states in his treatise on dermatology that erythema is an expression of the rheumatic poison in the same way as it may be produced in other infectious conditions.

Six cases of jaundice occurring in acute rheumatism have been reported by Leiblinger.[22]

Friedlnäder has divided cases of acute rheumatism into two classes, central and peripheral. In the former the brain, medulla, or cord may be affected, whereas in the latter the typical lesions are found in the joints.

Latham in his Croonian Lectures expressed the opinion that the phenomena of rheumatism, gout, and diabetes, depended on the condition of the nervous system.

According to Friedländer, there is a regularity in the length of time the fever lasts, as well as in its course. There may be but one cycle, lasting from eight to eleven days, or there may be a series of such cycles, one following the other. The fever and the arthritis begin and end at the same time. Hirsch in his observations was not able to discover any such rise and fall of temperature, nor do I think that such regularity has been shown in cases observed by me.

Dr. J. E. Atkinson, in a paper read at the meeting of the Association of American Physicians, 1891, on Bradycardia in Acute Rheumatism, arrived at the following conclusions: 1. Bradycardia is observed rarely during the active stage of acute rheumatism (inflammatory). It occurs with greater frequency during convalescence from the disease. 2. When it occurs during convalescence, probably in most cases it is identical with bradycardia following acute febrile diseases of widely different nature, and is directly the result of the febrile action itself upon the innervation of the musculature of the heart. 3. When it occurs during the active stage of rheumatic fever, it probably depends upon endocarditis, or pericarditis, or myocarditis (primary or secondary by extension), whereby the inhibitory nerves of the heart are implicated, and consequently stimulated. Even where the physical signs of cardiac inflammation are absent, bradycardia occurring during the acute stage of rheumatism may be secondary to undetected myocarditis stimulating the vagus nerve. 4. It is possible, but exceedingly improbable, that these symptoms may follow the action of the rheumatic noxa upon the cardiac muscle or nervous system directly.

The diagnosis of typical cases of acute rheumatism is easy, but it is often extremely difficult in atypical cases to say whether they are of rheumatic character or not.

Immerman speaks highly of the curative effects of the salicyl compounds, as a means of diagnosis in these cases. It is not always easy to make a diagnosis between acute necrosis, or acute osteo-myelitis and rheumatism in the earlier stages. The diagnosis too is of very great importance, owing to the difference in treatment. The greater intensity of the constitutional symptoms, the tendency of the inflammation to centre in one locality, and the involvement of the epiphyses rather than the synovial membranes, are great aids in coming to a correct conclusion.

During the past year a case of suppurative synovitis of the knee-joint which I had under observation, presented great difficulty in diagnosis during the first week. The fact that the inflammation is confined to one joint should make us pause before giving a diagnosis of rheumatism.

TREATMENT.—The salicyl compounds are still the principal remedies in the treatment of acute rheumatism. Much difference of opiuion exists as to whether these remedies are curative or simply palliative. Dr. McLagan, who preferred salicin on account of its producing a less depressing effect upon the heart's action, has spoken of it in the following terms: "Given then at the commencement of the attack, it seems sometimes to arrest the course of the malady as effectively as quinine cures an ague, or ipecac a dysentery." He was in the habit of giving very large doses, as much as an ounce in the first twenty-four hours.

Dr. James Martin [23] relates a case treated by a mixture of fl. ext. cascara and soda salicylate, with excellent results after the salicylate alone had failed. Dr. Goodwin,[24] of New York, also speaks highly of cascara in the same combination. Senator, as the result of lengthened observations on the treatment of rheumatism, considers the salicylate to be somewhat disappointing. He recommends antipyrine, autifebrin, phenacetin, and salol, as remedies which will act as specifics in the management of rheumatism. In the use of these remedies, it is necessary to individualize, as often one will succeed where another fails. If we understood the correct method of individualizing, he thinks with three or four remedies we would be successful in every case. Salol, discovered by Nencki, and first used by Sahli,[25] in presence of the pancreatic ferment divides into carbolic and salicylic acids, its component parts. Sahli thought salol had a more favorable effect in preventing cardiac complications than the salicylates.

Herrlich,[26] in Leyden's clinic, tried salol in thirty cases. He was favorably impressed with the results, but does not think it prevents endocarditis.

Dr. Church, in the report already alluded to, recommends the following remedies: alkalies, salicylates, and antipyrine. He recommends light clothing so as to lessen the fever and excessive perspiration. He is careful not to allow the patient to return too soon to a meat diet.

Dr. Osler recommends the oil of wintergreen, which he gives in twenty-minim doses every hour in milk.

Donald W. C. Wood gives statistics of 850 cases of acute rheumatism treated at Guy's and St. Bartholomew's, from which the conclusion is drawn that the salicyl compounds are as a general rule effectual in obtaining early relief from pain, and reducing temperature, but that they exert little or no influence over the duration of the disease.

Professor Benedikt claims to have obtained good re-

sults from the hypodermic injection of a solution of carbolic acid. Fränkel and N. S. Davis speak highly of the value of antipyrine. M. Vulpian recommends the salicylate of lithium in fifteen-grain doses, to be given four or five times in twenty-four hours. The salicylates, as has been shown, are not specifics for rheumatism, nor have any yet been discovered. The evidence of statistics taken from a very wide field proves that the duration of the disease is not lessened, nor do they prevent complications, and that relapses occur more frequently when they are used. Cheadle thinks the salicylates should be sparingly used in the rheumatism of children. In the prophylaxis of the disease, it is necessary to avoid exposure to cold and dampness, which we know by experience to act so frequently as a predisposing cause. Although I am quite convinced of the infectious character of the disease, the clinical history proves that, like pneumonia, exposure renders the system much more liable to become affected. *James E. Graham.*

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[23] London Lancet, 1888, ii., p. 420.
[24] New York Medical Journal, 1888, vol. xlvii., p. 629.
[25] Correspondenzblatt für Schweiz. Aerzte, 1886, pp. 12 and 13.
[26] Deutsche med. Wochenschrift, 1887, pp. 19–47.

RIPPOLDSAU. A mineral water and climatic station situated in the Black Forest, Germany.

LOCATION.—The little village of Rippoldsau is picturesquely located in a narrow valley of the Black Forest of Baden. A small stream, the Wolf, flows through this valley, and the pine-clad hills afford adequate protection from harsh winds. The climate is pleasantly invigorating, the air being pure and sub-alpine in character. The altitude of this rather fashionable resort is 2,000 feet above sea-level. The season extends from May to September. According to Bradshaw ("Climatic Health-resorts"), "the scenery is wild and romantic, precipices, ravines, and waterfalls alternate with meadows and pleasant homesteads, on the borders of an ubiquitous pine forest. Rippoldsau is one of those spots which, though easy enough of access, convey to the visitor the sensation of being at an infinite distance from the turmoil of cities and civilized life. Though nature has so amply provided for this beautiful spot, art has also aided. The gardens, avenues of trees, parks, and walks over the hills have been laid out with great care and skill. All things considered, Rippoldsau is the spot in which to pass a few weeks in summer, for rest and retirement, apart from all considerations of health.

"Some portions of the bathing establishment are modern, while others preserve their original and archaic characters.

"The excursions are very varied, and extend through the whole Black Forest. Amusements are likewise provided for; a Bohemian band plays three times daily. The buildings are all connected by covered passages, and communicate by means of electric bells. They contain large dining-rooms, ladies' room, music, coffee, reading, smoking and billiard rooms, and a large lawn tennis ground. Balls and dances are given from time to time."

ANALYSIS.—The mineral springs have the average composition of mild saline chalybeate waters.

INDICATIONS.—The place is chiefly visited by patients with anæmia, chlorosis, neurasthenia, hysteria, and moderately severe pulmonary and digestive disturbances. Consumptives are also sent there, but it does not appear that they are likely to do remarkably well there, the place being small and crowded.

ACCOMMODATIONS.—An excellent, but expensive, hotel is found here, there are facilities for hydrotherapy, milk and whey cures, pine-needle baths, etc.

E. C. Wendt.

ROYAT-LES-BAINS.—This celebrated French spa has already been briefly referred to in Vol. VI. of the HANDBOOK. Its intrinsic importance as a watering place, and the fact that many Americans now take the waters there, justify some additional information concerning its special features. According to Dr. Vintras ("Mineral Waters of France"), "the Thermal Establishment, one of the finest and most complete in France, stands in the most picturesque part of the valley, between the right bank of the Tiretaine and the road which leads from Royat to Mont-Dore. It includes no fewer than ninety-four bath-rooms, with baths of stone, each provided with apparatus for local douches, vaginal, articular, etc. It has, besides, independent apparatus for douches of various forms, two inhaling-rooms, a large public swimming bath traversed by a current of fresh water, which is reserved for ladies in the morning, and for men in the afternoon; arrangements for carbonic-acid baths and douches, as well as for the water-cure system, and lastly a gymnasium."

Dr. Brandt, in the *Climatologist*, January 15, 1892, gives an excellent account of Royat. He states that "the discovery of the Saint Victor spring, buried under the old Roman Piscina, showing in its analysis a considerable amount of arsenic and iron in combination with the salts contained in the other springs, found its application in those cases of anæmia, chlorosis, lymphatism, and general debility, which now crowd to Royat. It is only of late years that cases of gouty glycosuria, neurasthenia, and a few suffering from myxœdema, found benefit from the use of this spring. It is well to remind the reader that among the arthritic there are some cases that do better than others. The asthenic gouty are those which derive most benefit, and what is popularly called 'Poor man's gout' is the type most suited for a Royat cure; for it stands to reason that a water containing iron and arsenic is better adapted to an anæmic subject than to a plethoric beef-eater.

"If we add to the curative properties of these waters the effects of rest from all mental work, the delightful rambles through wooded vales, inhaling a pure dry air scented with the refreshing perfume of wild flowers, we shall have a complete *résumé* of the benefits that Royat-les-Bains can offer.

"For those who are fond of mundane pleasures, the company provides an excellent orchestra, which plays in the park three times a day; also a casino with its theatre, reading, and card-rooms, where the idler can amuse himself *ad libitum*. The proximity of the old town of Clermont-Ferrand affords the rambler many pleasant hours for studying the antiquated buildings—the cathedral, the old churches, museum, and many other places of interest.

"Royat is at a reasonable distance from Paris. The Paris-Lyons and Mediterranean Railway Company starts two daily express trains to Clermont-Ferrand—one in the morning, the other in the evening. The former is the one generally preferred, as it lands its passengers in good time for dinner. The journey takes nine hours."

In regard to the climatic peculiarities of Royat, Dr. Yeo ("Climate and Health-resorts") is authority for the following: "Its climate depends partly on its adjacency to the great central mountain chains of Auvergne, the Monts Dômes, and the Monts Dore, partly on the porous volcanic soil, and partly on its own particular situation. To the first it owes its sudden storms of wind and thun-

der and rain, and its sudden transitions of temperature —the characteristics, in short, of a mountain climate of moderate elevation. To its volcanic soil it owes the clouds of black and reddish dust which are blown about in eddies by the sudden gusts of wind, as well as the dryness of its roads and also the dryness of its atmosphere, this dryness of atmosphere being a most important climatic condition, counteracting the ill effects of the storms of wind and rain. Then there is the peculiar situation of Royat itself. Lying as it does in the floor of a somewhat narrow valley, surrounded on all sides by mountains, and only open to the east; running, moreover, in a direction exactly east and west, and facing the east, it is particularly exposed to the direct heat of the sun. From the moment the sun rises in the east above the mountains of Forez until it sets in the west behind the gigantic mass of the Puy-de-Dôme, Royat lies exposed to its rays; and it is therefore exceedingly difficult to find any kind of shady walks in the immediate vicinity of Royat when the sun is up and the sky is cloudless. Generally, however, when the sun goes down, the cooler upper strata of air rush down from the higher plateaux into the valley, and thus you get cool, refreshing currents of air playing through the valley on the evenings of even some of the hottest days in summer."

According to the recent analysis by M. Willm, chief of the chemical laboratory of the Medical Faculty of Paris, 1,000 grammes of the water contain :—

	Grande Source, ou Source Eugénie.	Source César.	Source St.-Mart.	Source St.-Victor.
	Grms.	Grms.	Grms.	Grms.
Carbonic acic, free	1.3355	1.8188	1.5524	1.7508
Silica	0.1025	0.0815	0.0958	0.1050
Alumina	....	....	0.0027	....
Carbonate of lime	0.7766	0.4540	0.6172	0.7058
" magnesia	0.3497	0.2560	0.4359	0.4519
" iron	0 0518	0.0340	0.0141	0.0420
Arseniate of iron	0.0008	0.0008	0.0010	0.0021
Carbonate of soda	0.7374	0.3371	0.6611	0.6777
" potash	0.1423	0.0984	0.1560	0.1564
" lithia	0.0322	0.0191	0.0229	0.0246
Sulphate of soda	0.1643	0 0893	0.1482	0.1612
Chloride of sodium	1.6728	0.6528	1.5930	1.6479
Total	4.0297	2.0249	3.7480	3.9746
In the form of bicarbonates:				
Bicarbonate of lime	1.1183	0.6538	0.8883	0.0164
" magnesia	0.4906	0.3657	0.6226	0.6456
" iron	0.0740	0.0462	0.0194	0.0580
" sodium	1.1687	0.5343	1.0478	1.0732
" potassium	0.2070	0.1484	0.2260	0.2269
" lithium	0.0592	0.0351	0.0421	0.0453
Temperature	95.2° F.	82.4° F.	84.2° F.	69.8° F.

There is also found arseniate of soda in Source César, 0.0008 grm.; St. Mart, 0.0016 grm.; St.-Victor, 0.0045 grm.

The hotel and other accommodations offered at Royat, are quite good, and the spa undoubtedly deserves the great popularity which it now enjoys.

Edmund C. Wendt.

RUBIDIUM AND AMMONIUM BROMIDE.—A double salt having the chemical formula $RbBr, 3NH_4,Br$. It is a white or yellowish-white crystalline powder, soluble in water, and possessed of a cooling and saline taste.

This salt has been proposed as a more suitable means of administering bromine than the ordinary ammonium, potassium, or sodium salts. Laufenauer (*Therap. Monatsch.*, August, 1889), reasoning from the fact that lithium bromide is more powerful than ammonium bromide, the sodium salt more so than the lithium, and the potassium salt still more powerful, was led to believe that the more strongly electro-positive the salt, and the higher its atomic weight, the greater its power in disease. As rubidium is powerfully electro-positive and has a high atomic weight, the bromide of rubidium and ammonium was prepared, and in a series of experiments was found to prove more satisfactory than the other bromides in epilepsy and other conditions in which bromides are indicated.

Further use of the drug has proved its efficacy, but has not shown any decided advantage over other bromides. It, however, has not the depressing effects of the potassium salts, and may be given where the more common compound has to be discontinued. As an antiepileptic remedy, it is given in doses of sixty to ninety grains in divided doses. As a hypnotic and sedative, sixty grains may be given in a single dose.

Beaumont Small.

SACCHARIN.—After a great deal of discussion and controversy, this compound has found its position in our materia medica as a harmless drug, its sole use being to replace sugar as a sweetening agent. For some time it was thought to exercise an injurious effect on the system, in consequence of which the governments of France and Spain prohibited its use except under the supervision of a physician. It is now regarded as perfectly harmless, and any injurious action is to be explained by the presence of other compounds formed during its preparation. It has been given to animals for a prolonged period, without producing any effect upon the organs or upon the processes of nutrition. It passes through the body unchanged and is wholly excreted by the kidneys.

Saccharin has been placed in the pharmacopœia under the title of Glusidum. It is a light, white, minutely crystalline powder, odorless but with an intensely sweet taste. It is soluble in water to the extent of one part in five hundred; in rectified spirit, one part in thirty-five; in proof spirit, one part in eighty; in glycerine, one part in fifty. Its solution gives an acid reaction, and it forms sweet salts with alkaloids and metals. When fused with potash or soda, it is decomposed and partially converted into salicylic acid, forming salicylates of potassium or sodium. Its property of combining with alkaloids is taken advantage of to supply quinine and other bitter substances in a more palatable form. The insolubility of gluside is overcome by combining it with soda to form a soda salt which is very soluble. It may be prepared by dissolving one hundred parts in water and neutralizing the solution with bicarbonate of soda and evaporating to dryness; this forms one hundred and thirteen parts of soluble gluside.

Excepting in its sweetening power, gluside is not allied to sugar in any way. It does not affect polarized light, it lacks the essential character of sugar to produce alcohol by fermentation, and when administered does not increase the production of sugar in the system. It is this latter quality that renders it of value in the treatment of diabetes, where it is desired to avoid the use of sugar as far as possible. No dose is applicable to this purpose, as the quantity required must of necessity vary greatly. Five, ten, or fifteen grains will generally be found sufficient, but as much as fifty or eighty have been given daily without any undesirable effect, excepting a distaste and nausea.

Gluside is two hundred and eighty times as sweet as sugar, and if it is remembered that an ordinary lump of sugar ranges from 150 to 300 grains, it is very evident that one-half to one grain will be an equivalent. Its disadvantages are the distaste that the patients are liable to have for it after using it for a time, and the dry, acrid sensation it produces in the pharynx. In medicines, it may also be used to replace sugar and syrup for the purpose of rendering them palatable, one grain with a six-ounce mixture furnishing sweetness equal to one ounce of ordinary syrup. To facilitate dispensing, the following solutions are prepared.

Liquor Glusidi.—From the "National Formulary" of the American Pharmaceutical Association. Gluside, 512 grains; bicarbonate of sodium, 240 grains; alcohol, 4 fluid ounces; water, sufficient to produce 16 fluid ounces. Each drachm represents four grains of gluside.

Elixir Glusidi.—From the "Unofficial Formulary" of the British Pharmaceutical Conference. Gluside, 480 grains; bicarbonate of sodium, 240 grains; rectified spirit, 2½ fluid ounces; distilled water a sufficiency.

Rub the gluside and the bicarbonate of sodium in a mortar, with half a pint of distilled water gradually added. When dissolved, add the spirit, filter and wash the filter with sufficient distilled water to make one pint. Each drachm represents three grains.

Gluside possesses antiseptic properties in common with other coal-tar derivatives, and for this reason it has been suggested as a remedy in many diseases. It has been used in pulmonary phthisis, acute articular rheumatism, scarlatina, intestinal catarrh, cystitis, and a number of other disorders in which its antiseptic action might prove of service. Of these, cystitis is the only one in which any satisfactory results have been obtained. In this condition it is administered internally and renders the urine antiseptic during its excretion. When there is pus and an alkaline reaction, this is rapidly overcome, and the urine becomes clear and normal in character; the change in the urine being accompanied by a corresponding improvement in the mucous membrane of the bladder. Three grains, in divided doses, daily, is the quantity recommended, and this is to be continued for a prolonged period. The bladder may also be irrigated at the same time. *Beaumont Small.*

SACRO-ILIAC DISEASE. Some of the later anatomists deny the presence of a synovial membrane at this joint. If there be no such membrane it disposes of the question whether the disease ever begins as a synovitis. From clinical observation it has long been our belief that tubercular disease at this joint in children invariably commences as an osteitis. We have seen none of the traumatic cases in young cavalrymen, nor have we met with the septic and gonorrhœal cases reported by others, which cases would argue the presence of synovial tissue.

The diagnosis is at times extremely difficult. Early in the disease the symptoms are few and indefinite; later, the sensitiveness at the joint may become so intense that both lumbar spine and hip-joint are held rigid, to better fix this articulation. Theoretically, forward and lateral bending of the spine should be free, and only backward bending restricted; in the same way at the hip, only extension and inward rotation during full extension should be limited; but we have met with cases so sensitive for a time that motion at the hip, as well as in the lumbar spine, was absolutely abolished.

The operative treatment of sacro-iliac tuberculosis has more justification than has the same treatment at any other joint. The joint is readily reached, and, unless extensive, the disease can be excised without risking any important structure. Recovery should be rapid and perfect. The diagnosis of local disease, however, must be certain before any operation is attempted, for, obviously, any operation on the sacro-iliac joint will be of no avail if there be lumbar spondylitis present at the same time. In children we have rarely found sacro-iliac tuberculosis without an associated tuberculosis at the lumbo-sacral junction.

Mechanical treatment should consist in rest in the horizontal position, and immobilization of the part by an effective brace. Only in this way can the superincumbent weight be removed and the part kept at rest. Traction in bed is useless, except in so far as it immobilizes by anchoring the limb to the bed, and traction by a walking splint is worse than useless. Indeed, the opposite of traction, namely, crowding together the joint surfaces by a broad girdle has been found to relieve the pain in cases where the suffering was increased by traction. The use of the compression girdle, combined with a spinal brace, has, in the hands of Dr. Benjamin Lee, of Philadelphia, been found to be a very satisfactory treatment.

Treatment by the "physiological" method of Hutchinson, by crutches and high patten on the unaffected side, is useful only in removing the superincumbent weight, and at best is only a palliative measure.

The most effective, and at the same time the most convenient and inexpensive apparatus for immobilizing while the patient is kept recumbent, is a modified double antero-posterior leverage hip-splint. A detailed description of the double hip-splint will be found under "Hip Disease" in this volume. The modification consists in adding a lateral wing to the main stem on each side, midway between the chest and thigh bands, and stretching a broad sling of strong leather from one main stem to the other, for the sacrum and posterior borders of the ilii to rest upon. The splint may extend to the middle of the leg, but is more comfortable, and usually sufficiently effective, if not carried below the flexure of the knees. *John Ridlon.*

SAINT-ALBAN. A spa in the department of Loire, France.

Location.—Saint-Alban is a village pleasantly situated on the left bank of the river Loire. Its cold alkaline chalybeate springs have made it quite popular as a watering place in recent years. Although the waters are largely exported, the place has not yet acquired much reputation outside of France. The season extends from June to September. The climate is mild and agreeable.

Access.—By the Paris, Lyons, and Mediterranean Railroad viâ Nevers to Roanne: thence by stage in one hour to the spa.

Analysis.—The composition of the four springs is quite similar. According to Lefort one thousand grammes of water contain:

	Source du Puits de César. Grammes.
Carbonic acid, free	1.9499
Bicarbonate of soda	0.8561
Bicarbonate of potash	0.0834
Bicarbonate of lime	0.9382
Bicarbonate of magnesia	0.4577
Bicarbonate of iron	0.0233
Chloride of sodium	0.0301
Silica	0.0451
Total	4.3838

Traces of iodide of sodium, arseniate of soda, and organic matter.

The other springs are the *Puits d'Antonin*, *Puits de Faustine*, and *Puits Neuf*. All the waters are clear and sparkling, and of agreeable taste. They are credited with diuretic, tonic, and stimulating properties.

Indications.—According to Vintras ("Mineral Waters of France") the therapeutical applications of Saint-Alban water are the same as those of Couzan. They will therefore be prescribed in the different varieties of dyspepsia, and chiefly in that which results from atony of the digestive organs; in the gastralgia which so often accompanies chlorosis and anæmia; in subacute nephritis and catarrhs of the bladder, and in chronic affections of the uterus. Inhalations of carbonic acid have been successfully used in cases of spasmodic asthma, chronic pharyngitis, and aphony.

The employment of carbonic-acid gas as an internal and external remedial agent gives an immense advantage to this station, and has, in fact, created for it a sort of specialty. Patients are no longer obliged to go to Germany to obtain this kind of treatment, but can find at Saint-Alban carbonic-acid baths, douches, and inhalations; and both the apparatus and all the details of the treatment are more complete and better organized than can be found anywhere else in France.

Accommodation.—The thermal establishment is modern in all its appliances, the usual douches, sprays, and inhalations being provided for. The lodging-houses are, however, on a primitive scale, and neither as comfortable nor as cleanly as they might be. Spacious hotels have not yet been erected. Pleasant excursions into the surrounding country are among the attractions of this place. *Edmund C. Wendt.*

SALICYLAMIDE. A compound prepared from salicylic acid by the introduction of the amidogen radical. Its chemical formula is $C_6H_4,OH,CONH_2$. The benefit of the combined action of this stimulating radical has already been demonstrated in chloralamide, and the same advantage is looked for in salicylamide, by overcoming the depressing effects of salicylic acid. It may be prepared by the action of concentrated ammonia upon oil of

wintergreen. When these stand in contact for some days in the cold, the liquid assumes a deep reddish-brown color, and brownish crystals begin to separate; impurities are removed by recrystallization and treatment with animal charcoal. It is also obtained by heating ammonium salicylate. It forms in colorless crystals and in thin transparent plates, melting at 142° C. It is soluble in alcohol, ether, chloroform, readily soluble in hot water, and in two hundred and fifty parts of cold water. It is quite tasteless and gives a somewhat gritty sensation between the teeth. After its administration it rapidly appears in the urine, and may be detected by the violet color following the addition of ferric chloride. It is excreted to a slight extent unaltered, but chiefly as salicyluric acid.

Salicylamide is proposed as a substitute for salicylic acid and its salts, the advantages claimed for it being its greater solubility, its tastelessness, and its freedom from any depressing action on the system. It also acts more promptly, and in smaller doses, as an analgesic. A very careful study of its physiological properties has been made by Dr. A. B. Nesbitt, of Toronto (*Therapeutic Gazette*, October, 1891). He sums up the result as follows: 1. Pharmacologically, it prevents conduction in nerve; paralyzes nerve first, then muscle. 2. On the heart, its chief effect being on motor apparatus, most probably through its activity on conduction. 3. Diminishes spinal reflex for motor impulses. 4. Diminishes spinal conductivity for painful impressions. 5. Diminishes muscular irritability. 6. In mammals, no particular effect on respiration. 7. No particular effect on blood-pressure. In medicinal doses reduces temperature, causes ataxic gait and hebetude in fowls.

It is employed for all conditions in which the salicylates are indicated, its beneficial effects being most marked in painful affections, as in neuralgia, ovarian pain, and chronic rheumatism. The dose advised is about fifteen grains daily, in divided doses of three to five grains. As an antipyretic, it requires to be given in fifteen-grain doses, repeated if necessary. *Beaumont Small.*

SALICYL-SULPHONIC ACID. Is now employed as a very delicate test for the presence of albumin in the urine. It occurs as a white crystalline body, very soluble in water and alcohol. It is formed by the action of sulphuric anhydride on salicylic acid, also by heating salicylic acid with concentrated sulphuric acid. Its formula is C_6H_3 (OH) (SO_3H) COOH.

This compound was recommended as a test for albumin by G. Roch (*Pharm. Centralblatt*, September, 1889) and by Dr. John A. Macwilliam (*British Medical Journal*, April 18, 1891), working independently of each other. It acts upon all forms of proteid bodies: (1) Native albumins (egg albumin and serum albumin); (2) derived albumin (acid and alkali albumins); (3) globulins; (4) fibrin; (5) albumoses; (6) peptones. In the case of all these substances a dense, bulky white precipitate is formed. When the proteid present is a native albumin, a derived albumin, a globulin, or fibrin, the precipitate is not dissolved upon boiling, but becomes decidedly flocculent. When the proteid is an albumose or peptone, the precipitate dissolves upon heating, to reappear on the cooling of the fluid. The peptone and albumose may be distinguished by saturating the solution with ammonium sulphate; the albumose is at once precipitated, while the peptone remains in solution. The peptone may then be detected by adding the salicyl-sulphonic test.

Compared with other tests, it acts either as an extremely delicate test or one less so, according as a cloudiness immediately (two or three seconds) appears, or follows after one-half or one minute. In the latter case it is one of the most delicate tests we possess, detecting 1 part of albumin in 12,500 of water; in the former, it is placed by Dr. Macwilliam between the cold nitric acid test and the acetic acid and heat test.

Dr. Roch recommended that a few crystals of the acid should be shaken with the urine, or that five cubic centimetres of a twenty per cent. solution should be added to ten cubic centimetres of the urine to be tested. Dr. Macwilliam is more exact in his manipulations. He recommends that a small amount of urine, about twenty minims, be placed in a small test-tube, and that to this a drop or two of a *saturated* aqueous solution of the reagent be added. The urine must not be alkaline, and, if necessary, should be acidulated. On adding the reagent the tube should be shaken quickly, to mix the contents, and the fluid should be examined at once. The occurrence of an opalescence or cloudiness immediately or within a few seconds, indicates the presence of proteids. The development of the reaction after an interval of a minute or two shows the presence of proteids in minute quantities, which are probably insignificant from a clinical point of view. The fluid is then to be heated, when the ordinary albumin is coagulated and formed into a flocculent mass. *Beaumont Small.*

SALIPYRIN. This compound is due to the chemical union of antipyrine with salicylic acid. It is a definite salt containing 57.7 parts of antipyrine and 42.3 parts of salicylic acid. It is prepared by the interaction of the two at a temperature of 100° C., or by adding to a boiling aqueous solution of antipyrine a proper molecular proportion of the acid. It forms as a white, coarsely crystalline powder, odorless, with a not unpleasant sweetish taste. It is almost insoluble in water, about one part in two hundred, sparingly soluble in ether, but readily soluble in alcohol. It is decomposed by acids and alkalies.

It possesses antipyretic and antirheumatic properties, and the advantage claimed for it is its harmlessness. It was introduced as a remedy for rheumatic troubles and has been used with much success in acute rheumatism, but in the chronic form it has not proved reliable. It is probably equally as serviceable as salicylic acid or antipyrine, but is equally inefficient in preventing relapses, and does not seem to offer any special advantage over other remedies for rheumatism. The amount to be given is one drachm and a half, in divided doses, during the day; the first dose being thirty grains and the subsequent doses about fifteen grains each.

As an antipyretic it is not very satisfactory; it requires to be given in doses of thirty grains, to be repeated every hour if necessary. It has been found to have its best effect when the temperature is very high; the nearer the temperature is to the normal the less noticeable is its action. Normal temperature is not influenced to any extent. It has been used very extensively in influenza, with very satisfactory results, the pains in the head and fever being relieved. As an analgesic it has proved of value in sciatica, the pains of myelitis, neuralgia, and in nervous disease accompanied by pain. Salipyrin has no direct effect on the heart, the pulse and respiration remaining unchanged, but sweating is frequently produced, and heart-burn and flatulency are of common occurrence. The drug can be detected in the urine in a very short time, but it has not any diuretic action, nor is the color affected in any way.

The results of its employment show it to be a harmless and useful drug, but not very reliable. It probably will not supersede either of its component parts.

Beaumont Small.

SALOL. (Phenyl salicylate. $C_6H_4OHCOOC_6H_5$.) The original mode of preparing salol was by causing molecular proportions of salicylate of soda and sodium-phenol to react, by prolonged heating, in the presence of phosphoric oxychloride. The reaction is as follows: $2C_6H_5ONa + 2C_6H_4OHCOONa + POCl_3 = 3NaCl + NaPO_3 + 2C_6H_4OHCOOC_6H_5$. The product is washed till free from the chloride and phosphite, and finally crystallized from alcohol. More recently a simpler method has been patented which consists in heating salicylic acid without access of air to 240° C. Under this condition the salicylic acid is decomposed and salol formed, water and carbon dioxide being separated. The change is explained in two ways. The phenol resulting from the decomposition of a molecule of the acid may, at the moment of its libera-

tion, react with another molecule of the acid so as to form phenyl-salicylate and water; or, the change may consist in the formation in the first instance of salicylic anhydride by separation of water; and, at a later stage, this is transformed into salol with the evolution of carbon dioxide.

The presence of free acids may be detected by blue litmus paper, and phenol or salicylic acid by the action of an alcoholic solution with three times the volume of water, to which a drop or two of ferric chloride has been added; a permanent violet color is produced if these impurities be present.

Since its introduction in 1886, the continuous and widespread use has confirmed the valuable properties claimed for it, and has placed it among the most important of the new drugs. Its toxic action is slight, and in ordinary medicinal use there has been but little record of unfavorable results. Its decomposition in the duodenum into its two constituents, and its excretion with the urine as salicyluric acid and phenol compounds, has been clearly demonstrated, and it is the rapidity of its course throughout the system and its free escape that render it safe and devoid of dangerous effects. When the function of the kidney is impeded, or when the drug is given in excessive quantities, poisonous symptoms may be produced. It is also advisable that a free action of the bowels should be maintained, as it has been found that when the bowels are sluggish and constipation exists, the absorption is slow and prolonged and a cumulative action is induced. When poisonous symptoms arise they are such as are referable to the phenol compounds, viz., nausea, vertigo, somnolence, weakness of the limbs, and at times irritation of the digestive tract. Salol is detected in the urine within thirty minutes of its administration, and advantage has been taken of this rapid excretion to diagnose occlusion of the pyloric orifice and motor inactivity of the walls of the stomach. In a number of cases where the outlet of the stomach was obstructed, the salol failed to appear in the urine, or was greatly delayed; and in dilatation of the organ, or where the activity of the walls was diminished, its appearance was also delayed.

The decomposition into salicylic acid and phenol in the intestines is the most important property of this drug, and has led to its employment in a vast number of intestinal disorders with decided success. Wherever intestinal antisepsis is desired it may be used with benefit. In chronic and acute intestinal disorders accompanied by fermentation, flatulence, and offensive stools, whether there be inflammatory action or not, it will rapidly check the putrefactive changes, render the stools less offensive, and reduce their frequency. In the summer complaints of children it has proved very efficacious, as much as two or three grains being given to children under one year of age, and repeated two or three times a day, or even every hour when urgency was indicated. In dysentery and other troubles of the large intestine it has proved equally serviceable. Its antiseptic action has been directed to the forms of disease in which special bacteria are present in the intestines. In typhoid fever, in addition to its very useful action as an intestinal antiseptic, it is supposed to exert a destructive action on the bacteria and shorten the course of the disease. This specific action is not very evident, nor has it been shown that the course of the disease is in any way shortened, but its antiseptic action is of undoubted value in improving the character of the contents of the bowels and preventing numerous complications that are due to the presence of the poisonous matter. In this disease various means have been tried to counteract or prevent the putrefactive changes in the bowels; charcoal, naphthalene, naphthol, and other antiseptics have been used, but salol has replaced them all, on account of its non-irritating action, and particularly, as its beneficial action is directed solely to the intestines.

The effect of salol on the bacillus of cholera has been studied more definitely. Löwenthal has conducted a series of investigations, both on the cholera bacillus and on the effects produced when administered as a remedy for the disease. A solution of salol in pancreatic juice was found to render a culture of the bacillus sterile in twenty-four hours, and in animals the administration of salol proved a protective against inoculation. As a remedy for cholera it is given in thirty-grain doses, to be followed by fifteen grains every half-hour or hour. It has been used to a great extent, and reports of the results obtained are very favorable. Dr. Francisco Gonzalez, in the Philippine Islands, where cholera is endemic, reports its use in fifty-three cases with only six deaths. Dr. Nicholson, of Patna, India, employed it in eighteen cases, in all of which recovery took place, although eleven were in a state of collapse when treatment was begun; and Hehir reports eleven cases treated, with no deaths. In all intestinal disorders the drug is best administered with an alkali, as bismuth, bicarbonate of sodium, or chalk mixture; the salicylate of bismuth or the salicylate of magnesium may also be used and adds to the antiseptic action. Naphthol has also been combined with it. The dose usually employed is eight or ten grains every three or four hours, until it produces its effect, and then it is given in smaller doses to maintain antisepsis. It may be given in powder in sachets, or in emulsion, in oil, or in mucilage.

The rapid excretion of salol by the kidneys in the form of salicyluric acid and compounds of phenol, renders it of great value as a remedy in various disorders of the genito-urinary organs. The property of rendering urine aseptic is of the greatest practical importance, and is taken advantage of in all forms of chronic inflammation of the bladder, in which the urine is alkaline and loaded with mucus. It renders the urine acid, the sediment rapidly disappears, and the condition of the diseased mucous membrane is improved. It has been found of great service in such cases in combination with vesical irrigation. When febrile reaction follows the introduction of the catheter or sound, its use for a few days is found to prevent this change, and its administration for a week previous to the operation of litholapaxy, enabled a patient, who previously was subject to a chill upon the slightest examination of the bladder, to undergo the operation without the occurrence of any unpleasant after-effect. It has proved of service in gonorrhœal inflammation, and has recently been advocated as a remedy in catarrhal states of all mucous membranes, as the pharynx, larynx, bronchial tubes. In all the conditions in which its excretion from the system is utilized, its beneficial action is increased by combining with it terpin hydrate, copaiba, or oil of sandal wood, in all of which it is readily soluble to the extent of one-third of their weight. Ten grains three times a day, have been found sufficient to secure its action in these cases, and this may be given in all periods of the inflammation without causing any unfavorable action, although it is in chronic inflammation that it proves most serviceable.

Salol has been used in the treatment of rheumatism, and was thought to be a remedy that would prove of decided value. The results have not been equal to what was expected, and such use is secondary to its employment in the other diseases mentioned. In many instances it has been used with benefit, but it is not equal to the salicylates and other anti-rheumatic remedies. For this purpose it is given in doses of fifteen and twenty grains, the aggregate during the twenty-four hours being from four scruples to two drachms.

It has recently been recommended in the treatment of diabetes. In doses of thirty grains it was found that the glycosuria is lessened or caused to disappear, and the amount of urea diminished. It should be used in cases in which the diet is carefully regulated, and in which there is no albuminuria or nephritis.

Externally, salol is used as an antiseptic and deodorant in the treatment of wounds, ulcers, suppurating surfaces, parasitic skin diseases, and all conditions in which iodoform and other antiseptics prove of value. As a powder it is mixed with equal parts of starch, or French chalk, or boric acid. It may be used in collodion, four parts to four of ether and thirty of collodion; or in the form of five to ten per cent. alcoholic solutions. The latter may be diluted with water for gargling or for local applications. *Beaumont Small.*

SALOL - CAMPHOR. These two substances, when mixed in certain proportions, alter their physical state and become an oily, colorless liquid, insoluble in water, freely soluble in ether, chloroform, and oils. It is prepared by adding twenty parts, by weight, of powdered camphor to thirty parts of salol, and warming gently until fusion is complete, without adding either alcohol or water. It should be filtered and preserved in a green glass bottle, well closed, as under the influence of air and light it is readily decomposed.

It possesses the properties of its constituents, and is highly recommended as a stimulating antiseptic. It is used especially for the treatment of suppurative otitis of the middle ear. The manner of employing it is to cleanse the external auditory canal and tympanum, and then introduce into the ear a small pledget of absorbent cotton impregnated with the camphorated salol. This should not be allowed to remain more than twelve or twenty-four hours. During the intervals the ear should be well syringed with a warm solution of boric acid. The treatment should be continued for some weeks, and is said to produce a cure in many cases. The application is neither painful nor irritating, and almost invariably exercises its antiseptic and disinfectant action. *Beaumont Small.*

SALOPHEN. (Acetyl-para-amido-salol.) A patented compound which is, chemically, salol in which one atom of hydrogen in the phenyl group is replaced by the monivalent group $NHCOCH_3$. It occurs in minute, white, crystalline plates, insoluble in cold water, very slightly soluble in hot water, soluble in alcohol and ether. Alkalies render it soluble, even in cold water. It is without taste or odor, and is neutral in reaction. Salicylic acid is present to the extent of fifty-one per cent. The acid secretion of the stomach has no effect upon it, but when it comes in contact with the pancreatic ferments it is decomposed into salicylic acid and acetyl-para-amidophenol. The object in view in the production of this compound was to improve upon salol by combining with the salicylic acid a phenol compound which was perfectly harmless. This, however, causes a great difference in the therapeutic properties, and it is solely to the salicylic acid that salophen owes its medicinal action, the phenol compound not being absorbed and having very little, if any, effect upon the system.

It is recommended as a remedy for acute articular rheumatism in doses of sixty to seventy-five grains during the day, the usual dose being fifteen grains every three or four hours. Several reports of its employment have been published, in all of which it appears to have proved satisfactory. The pain and swelling are rapidly relieved, and the temperature reduced to normal in two or three days. It does not disagree with the stomach nor produce any toxic symptoms. Relapses, however, take place and the ordinary complications are not prevented. In chronic rheumatism it has been used without affording any marked relief or improvement. It is suggested as an intestinal antiseptic in diarrhœa, typhoid fever, and cholera, but no cases have yet been reported in which it has been used.

Upon the urine it has little action, and has not been found to be of any benefit in urinary disorders.

Beaumont Small.

SALZBRUNN. A popular spa in Silesia, Germany.

LOCATION.—Salzbrunn is a village pleasantly situated in the wooded district of Breslau, at an elevation of twelve hundred and fifty feet above the level of the sea. Its mineral springs enjoy considerable reputation in the treatment of a variety of diseases. The place is midway between Waldenburg and Freiburg. Season, May to October.

ACCESS.—Salzbruun is a railroad station on the Breslau-Freiburg branch line.

ANALYSIS.—The principal spring is the *Oberbrunn*, but there are quite a number of other springs, such as the *Wiesenbrunnen*, *Sonnenbrunnen*, and *Heilbrunnen*, the waters of which are employed for baths, douches, etc. The *Kronenquelle* (private property) is also a favorite spring. Salzbrunn is often alluded to as the *cold Ems*, although the composition of its mineral springs is by no means identical with that of the Ems water. One quart of Salzbrunn water contains (average analysis):

	Grains.
Sodium bicarbonate	26.00
Bicarbonate of lime	7.20
Bicarbonate of magnesia	7.60
Bicarbonate of protoxide of iron	0.004
Sodium chloride	2.60
Sodium sulphate	9.40

There is also a large proportion of free carbonic-acid gas.

INDICATIONS.—Salzbrunn is chiefly visited by patients with catarrhal troubles of the respiratory organs, including phthisis. But invalids with gouty and rheumatic affections, nervous disturbances, diseases of the bladder and kidneys, also frequent this spa. There are facilities on a large scale for milk- and whey-cures, and the thermal establishments are modern and complete in every detail.

ACCOMMODATION.—The hotels and lodging-houses are good. The authorities provide the usual amusements of spa life. There are good opportunities for interesting walks and excursions. The place is semi-fashionable, and prices are therefore moderately high.

Edmund C. Wendt.

SANITARY INSPECTION. 1. DAIRY-FARMS, DAIRIES, AND MILK SHOPS.—Cow's milk has been denominated a model food, because it is perfectly adapted to the needs of the human economy. Its use is universal. It often constitutes the sole food of infants and sick persons, and enters very generally into the diet of most individuals. It is therefore of the utmost importance that its purity be maintained.

The sanitary and economic advantages of milk inspection cannot he over-estimated. Injury to health which results from the use of adulterated or impure milk is due to deficient nutritive value or to contamination by the specific contagium of such diseases as scarlet fever, typhoid fever, diphtheria, tuberculosis, possibly of anthrax or malignant pustule, and foot-and-mouth disease, or to some abnormal condition imparted to it by the cow, or arising after the milk has been taken from the gland. Milk may he poisoned by the animals feeding on improper food or hy improper management. Tyrotoxicon, an organic poison, is sometimes developed under the latter circumstance, its effect upon the young infant being very serious.

As commonly practised, adulteration consists either in the addition of water, or in the removal of more or less of the cream, or both. The effect of lowering the nutritive value of an article that enters so largely into human diet, that is so much depended on in the sick-room, and that is so universally used as food for infants, can be readily comprehended. The pecuniary loss suffered by the purchasers of adulterated milk, though a lesser consideration, is a feature of the question which concerns the public in no slight degree.

In order to insure the purity of milk it is necessary to enlarge the scope of milk inspection as commonly practised. The law directs that only pure milk shall be sold, and yet the means of accomplishing this object fail in some most important particulars. Milk may be the vehicle of conveying the poison of disease. It has been proved beyond doubt that the materies morbi of enteric fever, of scarlet fever, and of diphtheria has been conveyed through this medium, and it is extremely probable that tuberculosis can be transmitted in the same way. The tests ordinarily applied to milk fail to detect the specific germs of these diseases.

Chemical analysis, though of the greatest advantage in determining the composition of milk, and in detecting adulteration, is unable to discover the living pathogenic entities, which are the more dangerous because of their power of directly producing disease. In order, therefore, to guard against this subtle danger, and to render

milk inspection a positive protection, it is necessary to resort to other methods of investigation. Fortunately, in biologic examination we have a valuable means of supplementing chemical analysis. If biologic examination were only occasionally the means of detecting the tubercle bacillus in milk, the discovery would be of sufficient value to compensate for the investigation, for by it the dairy-farm where the milk was obtained could easily be discovered, and the diseased animals that day after day caused the milk of the entire herd to be infected could be promptly destroyed.

But the investigation need not be confined to tuberculosis. Biologic science has made rapid strides, and is constantly adding to our knowledge of the rôle played by micro-organisms in the causation of disease. This knowledge, whenever practicable, should be made use of in conserving the public health. Both chemical analysis and biologic examination have their special and well-defined fields of exploration. When one fails the other may be able to make valuable discoveries. Their office is to aid one another and to supply each other's deficiencies. Hence, the best results are to be obtained when the two methods of examination are combined.

Another means of protection, and a most important one, because it strikes at the source of contamination, is the systematic inspection of dairy-farms, dairies, and milk shops. It is to this part of the subject that special attention is directed, as provision is seldom made for such inspection. This practice is required by the English law, and to some extent is carried out, but in America it is almost entirely neglected.

Milk may be contaminated by the addition of impure water in the milk-houses, and is frequently adulterated after it leaves the dairy-farm; but the most dangerous source of contamination is at the dairy-farm itself. For this reason inspection is very incomplete that does not include a watchful supervision of the cattle, their environment and treatment, and all the conditions under which the milk is prepared for the market. The seeds of tuberculosis lie concealed in what to all appearances is wholesome milk, and who can tell what amount of disease is distributed through the unsuspected agency of this common article of food? There is less likelihood of infection from anthrax or malignant pustule, and foot-and-mouth disease, as self-interest prompts the dairyman to quickly exclude from his herd animals sick with these diseases.

It has not been determined whether or not the milk of cows suffering from actinomycosis, caused by malignant ray-fungus, is capable, through its ingestion, of propagating disease, but until this point is decided, milk from cows suffering from this affection should be rejected as suspicious. Mr. Ernest Hart has tabulated a number of epidemics of enteric fever, scarlet fever, and diphtheria that have been definitely traced to milk infected at the dairy-farm. The milk of cows fed on distillery swill, or that are sickly, or in bad condition from unsuitable food, impure water, bad housing and care, or that have recently calved, or that have become exhausted from any cause, cannot be regarded otherwise than with suspicion. Milk is known to have been infected by the hands of the milker convalescent from scarlet fever. Typhoid fever has been propagated by the use of infected water for rinsing the milk cans and diluting the milk.

It is seen that the liability to contamination to which milk is exposed at the place of collection is very great, and constitutes the chief source of danger, especially so, as most of the elements of danger may escape detection by the ordinary methods of laboratory investigation. Hence the necessity of establishing systematic inspection of all dairy-farms, as well as of milk shops, by competent officers amply clothed with authority to compel the observance of regulations for their proper sanitary administration.

It is important that none but healthy cattle should be permitted in the herd. Cows affected with tuberculosis, or other dangerous infectious or contagious diseases, should at once be isolated or destroyed. In order to detect these diseases, especially in the prodromal stage, it is necessary to make use of the knowledge of the expert veterinarian. The farmer cannot be expected to possess the knowledge and tact required to make a reliable diagnosis. Until the diagnostic value of tuberculin was discovered, even the skilled veterinarian frequently failed to detect the disease when not in its advanced stages. To this difficulty of diagnosis and the lack of proper inspection, may be attributed the prevalence of the disease. If it could have been more easily detected in living animals, it is safe to say that the attempts made by the owners of cattle to eradicate it from their herds would have been more successful.

Only healthy cattle can be expected to produce wholesome milk. Hence, the environment, care, and feeding of the stock should be studied with the view of obtaining the best hygienic results. Pure water is quite as essential to the health of cattle as is wholesome food. Special attention should be directed to the housing of the cattle. Cleanliness, light, and ventilation are most important requirements. The drainage should receive the strictest examination. Dampness is especially to be avoided. The greatest cleanliness is to be observed in handling and storing the milk. The possibility of contamination of the water-supply from any source, especially by the cesspool, is to be guarded against. The proper cooling of the milk is a precaution the value of which the dairyman should fully understand.

Should contagious disease break out in the dairyman's family, he should be prepared by previous instruction to guard the milk-supply from this source of danger. Printed instructions, covering the management of the dairy-farm, should be supplied to the farmer, and the inspections should be sufficiently frequent to see that the instructions are faithfully carried out. By adopting the plan thus briefly outlined, in conjunction with inspection performed in the city, supplemented by the tests made in the laboratory, there is the assurance that the milk-supply will be most effectively guarded against adulteration and contamination.

Cities obtain their milk-supply from surrounding and even distant counties, it may be from neighboring States, from territory lying beyond their jurisdiction, and they are, therefore, powerless to exercise for their own protection the necessary supervision at the source of supply. This is also true to some extent of towns and villages, though in the case of these there is less difficulty in gaining knowledge of the conditions under which the milk is procured for the market. In order, therefore, to bring about the desired results, inspection of dairy-farms and dairies should be conducted under the provisions of a law applying to the whole State.

The eradication of infectious disease from among cattle benefits the farmer, both directly and indirectly, and at the same time protects the consumer of milk against disease liable to be communicated through this medium. This is one of the objects accomplished by a comprehensive system of sanitary inspection and management of dairy-farms, dairies, and milk shops, which aims to prevent the dangers connected with the milk-supply. In the absence of a general law, individual communities can protect themselves by not permitting the sale of milk except under license granted to those producers only who are willing to submit to inspection of their herds and farms by qualified persons, at such stated periods of time as may be determined upon, the license to be valid only so long as the results of such investigation are shown to be satisfactory. The feasibility of this plan is foreshadowed by the fact that some producers, from self-interest, have put into practice a system of periodic inspection of their farms, and of certification of the health of the stock and the sanitary condition of the surroundings. The value of such inspection depends upon the impartiality and reliability of the person conducting it, and is apt to be impaired by prejudice in favor of the interests of the employer. Uncertainty of result is avoided by placing the inspection service under the absolute control of the civic authorities. The voluntary adoption of the plan of inspection is a recognition of the fact that a public sentiment exists in favor of more stringent meas-

ures of protection against dangers in our milk-supply, and, therefore, deserves to be encouraged.

2. Contagious and Infectious Diseases. — The prompt recognition of the first cases of contagious or infectious disease is of the greatest importance, as upon it will often depend the possibility of preventing its spread. It is important not only that these cases be early recognized, but when recognized that they be immediately reported to the local health authority, in order that measures be employed to prevent the scattering of seeds of contagion. Prompt notification is a step so necessary to the precautionary supervision of contagious and infectious diseases, that in communities where good sanitary organization exists it is made obligatory by penal statute. Whether the obligation to report such cases be placed upon the physician or upon the head of the family, is a matter of secondary importance.

The object of prompt notification is to enable the sanitary authorities at the very outbreak of the disease to inquire into all the circumstances of the case, to cooperate with the medical attendant in his efforts to prevent the spread of contagion, and when necessary, to resort to such measures to protect the public health as it is the prerogative of these authorities alone to enforce.

Whenever it comes to the knowledge of the local health authorities that a case of dangerous contagious or infectious disease exists, it is their duty to at once cause a thorough inquiry to be made into all the particulars of the case by a sanitary inspector qualified for the responsible duty by experience and sound medical training. The inspector should consult the medical attendant and satisfy himself as to the true nature of the disease, learn its origin and history, and acquaint himself with the surroundings, the plan of isolation adopted, and the other measures employed to prevent the spread of the disease. He should determine upon this examination whether the patient can be properly and safely cared for at home, with respect to the patient himself, the occupants of the house, and the public. If from poverty or inadequate facilities for managing the case, or the impossibility of isolating the sick person, or for any sufficient cause, this cannot be done, it is his duty to at once recommend the removal of the patient to a hospital for the treatment of such diseases. After removal of the patient, which the authorities should be empowered to direct, prompt and thorough disinfection and other precautionary measures should be carried out under the direct supervision of the inspector. The household should thereafter be kept under close observation until the period of incubation of the disease, dating from the latest exposure to contagion, has passed.

On the other hand, when the inspector finds that every necessary measure of precaution is being faithfully carried out, and that the sanitary management is satisfactory, he will report the fact and keep the case under observation. Between these two classes of cases there are those not so easily disposed of, in which the course of action to be pursued will have to be determined by the best judgment of the inspector according to the circumstances.

Printed instructions, explaining in plain language the nature of the disease, its mode of propagation, the means of isolation and disinfection, and all the precautionary measures necessary to observe from the beginning to the end of the disease, and thereafter, should be left with the family of the sick in every case, and explained when necessary.

The duties of the inspector are delicate as well as responsible. He has nothing whatever to do with the medical treatment of the patient, and comment thereon, especially before the family, is out of place. He should respect the rights of the medical attendant and should endeavor, as far as possible, to make his visits at the time when the physician is expected to be present. While nothing necessary to be known should escape observation, he should be careful not to excite opposition by inquiring into matters that do not strictly pertain to the object of his mission. By tact and politeness it is possible in nearly all instances to obtain the co-operation desired. When, however, through ignorance or prejudice, or for whatever reason, the instructions of the inspector are disregarded and measures of precaution are ignored, steps should at once be taken to compel obedience.

The sick should be isolated either at home or by admission to a special hospital. Every community should provide a hospital for contagious diseases, and when possible each disease should be treated in a separate pavilion. In locating such a hospital convenience of access should be a prime consideration. In transferring a patient it is not permissible to use a public conveyance, but an ambulance so constructed and equipped as to insure comfortable and safe transportation. Disinfection of the ambulance after each time it has been used should not be neglected. Every effort should be made to overcome the prejudice against removal to a public hospital which so commonly exists. If the transportation, accommodation, care, and treatment of the patient be without fault and the expense nominal, opposition to removal will be reduced to its lowest point. It is detrimental to the patient and to the service to resort to compulsion, yet there are circumstances which fully justify it.

It is advisable to remove the well persons in the family from the house when practicable, if there is reason to suppose that they have not become infected. Intercourse with the house should be restricted or prohibited altogether, according to circumstances. The inmates are not to visit or to attend public gatherings, and children of the family are to be prohibited from attending school until all danger of communicating the disease has passed. Isolation of the sick at home is practically seldom perfect, and it is therefore prudent to act upon this assumption. Inspection should be sufficiently frequent to determine whether these rules are observed. When there is reason to mistrust compliance, there is the alternative of removing the patient or of placing a watchman on duty to compel obedience to the law.

The sanitary inspector should satisfy himself that all the details in the preventive management of the case are being strictly carried out under the direct supervision of the medical attendant. When he is not thus satisfied, it is his duty to interfere to the extent of personally directing the necessary measures to be observed. Isolation of the sick person, thorough cleanliness, ventilation, disinfection of the discharges, and of everything before it leaves the sick-room, must be insisted upon. Printed directions as to the various observances, to be left with the family for reference, will be of the greatest assistance to them in comprehending what is required to be done.

As it is often practically impossible to properly disinfect at home some articles used in the sick-room, it is necessary that every community should provide a public disinfecting plant to supply this deficiency. Steam-disinfecting chambers, constructed preferably of steel, in which articles can be disinfected by dry or moist heat at a given temperature, are indispensable in the management of contagious or infectious diseases. Their use should be offered to the poor gratuitously, and to those able to pay at a nominal charge.

While the sanitary inspector should have knowledge of the principles and practice of disinfection, so as to be capable of giving instruction, it is not expected that he shall personally do the work. The health department of a city is not deemed fully equipped unless it includes in its personnel one or more disinfectors. "The object of disinfection is to prevent the extension of infectious diseases by destroying the specific infectious material which gives rise to them. This is accomplished by the use of disinfectants. There can be no partial disinfection of such material—either its infecting power is destroyed, or it is not. In the latter case there is a failure to disinfect." On account of the great importance of having this work properly performed, it is necessary to intrust it to persons specially qualified by knowledge and experience. The disinfectors should be under the direction and control of the sanitary inspectors, who should be held responsible for the faithful performance of the work.

It is not intended that the disinfector shall obtrude his presence in the sick-room during its occupancy by the

patient, as the medical attendant can supervise the necessary measures there required. But after the termination of the sickness it is his duty to personally take charge of disinfection of the sick-room and the premises, to superintend the removal of such articles as are required to be taken to the public disinfecting chamber, and to see that all the details of the work are properly carried out. He is to supply the necessary apparatus and materials when needed.

Careful discrimination is required on the part of the sanitary inspector in regard to the cases coming under his observation. It is only when he is satisfied that the work cannot be properly performed without his intervention, that he is justified in employing the services of the disinfector.

It is the duty of the sanitary inspector to follow each case to its termination. In the event of death he is to see that all regulations governing such cases are strictly observed, especially that no public funeral takes place. In any event, he should satisfy himself that every necessary measure of precaution is fully carried out.

There is a difference of opinion as to the advisability of placarding houses in which contagious or infectious diseases exist. There are benefits to be derived from warning the public of danger; but, on the other hand, the common aversion to the requirement may lead to the suppression of the true knowledge of the disease, which may be attended with disastrous consequences. Under a well-organized system of sanitary inspection this practice might be dispensed with.

Small-pox is prevented by vaccination. When a person is stricken with this disease the greatest diligence should be exercised in tracing its origin, in locating all persons and things that may have been exposed to the contagion, and in making use of the means necessary for arresting the spread of the disease. All unprotected persons should be promptly vaccinated, in order to prevent the disease or modify its character. Persons exposed to the contagion, although previously vaccinated, should, for the sake of prudence, have the operation repeated, unless the evidence of protection is undoubted. An epidemic may be prevented by the early recognition of the first cases, and the prompt application of the means of restriction.

The utmost vigilance is required when cholera threatens a community. Lest the true nature of the disease be overlooked on account of the similarity of the early symptoms of Asiatic cholera and cholera morbus, it is prudent to regard all cases of severe choleraic diarrhœa as suspicious, and to hold them under strict observation until a positive diagnosis is made by means of the results of a biological examination of the discharges. As it will take from twenty-four to forty-eight hours to make this test, during this time, and while there is a doubt as to the true nature of the disease, the case should be carefully watched, and the precautionary measures necessary in the management of Asiatic cholera strictly carried out. When cholera is impending, every physician called to a case at all suspicious, stands in a position of great responsibility, not only to the patient, but to the public. He should be wary, therefore, that no remissness be charged against him. He should report promptly his suspicions to the health authorities and offer them his full co-operation.

When a case of Asiatic cholera occurs it should be placed under constant sanitary surveillance, and every avenue by which the disease might be spread carefully guarded until all danger has passed. What is possible to be done at the very introduction of the disease, becomes a discouraging and formidable undertaking when once it has assumed an epidemic form. Hence the utmost vigilance should be used with regard to all first cases, and everything should be done to prevent them from becoming foci of contagion.

Accurate records should be kept of all cases of contagious and infectious diseases reported. These records should show the name, age, sex, color, and residence of the sick, the disease and its termination, and such other data as may be of value.

3. Railroads, Cars, Stations, Passengers, Etc.—The object of such inspection is to ascertain whether all necessary measures of precaution are practised to protect the health of the travelling public; and further, whether measures are formulated and understood, and are ready for instant application, to prevent the spread of contagion either occasionally introduced, or which is imminent when an epidemic is impending or actually exists. The transportation of immigrants from an infected locality may spread disease at their destination or along the route, if not carefully conducted upon established sanitary principles. Contagion may lurk in cars to the injury of the unsuspecting traveller, if disinfection is not practised.

Sanitary and precautionary regulations for the government of railroads should be prescribed under State laws and administered by State boards of health. Uniformity of regulations and practice is desirable, and is best attained by concerted action of these boards in formulating and executing the necessary measures. The enforcement of these regulations is secured by sanitary inspection, which, under ordinary circumstances, should be performed periodically and at sufficiently frequent intervals to secure the object. During the prevalence of an epidemic of contagious or infectious disease, or when such is impending, it will be necessary to have a rigid inspection service established at threatened points. It may be on the frontier, at the seaboard, State lines, or at important railroad centres. Such service should be conducted under co-operation of different State authorities, with the general Government, when necessary, so as to accomplish the desired results without unnecessarily multiplying the acts of official interference and needlessly embarrassing the transportation companies and interfering with travel.

Sanitary regulations governing railroads should prescribe the precautionary and preventive measures to be carried out at all times under the direct supervision of special officers of the companies, and also such restrictive and repressive measures as become necessary during the prevalence of an epidemic of contagious disease.

Precautionary and *preventive* measures aim to secure clean air, clean water, and clean environment, and the prevention or removal of all causes that tend to their defilement. The water-supply should be of known and reliable purity of source. The utmost cleanliness should be enjoined in storing and handling it, and with regard to all receptacles. Water-coolers should be cleaned frequently under strict supervision. In the event of diseases being prevalent, such as may be communicated through the medium of drinking-water, as cholera, for example, it is imperative that the water used for drinking purposes in cars, stations, etc., should be boiled for at least half an hour. The greatest care should be observed in selecting ice of known purity, as well as in storing and handling it. Drinking glasses or cups, which are liable to communicate disease, should, under the circumstances, be subjected to frequent and thorough disinfection, supplemented by washing in clean water.

Thorough cleanliness of passenger cars, disinfection and scrubbing of floors and woodwork, and the heating and cleaning of seats, carpets, drapery, etc., and thorough cleanliness of stations in every particular, of floors, hangings, carpets, closets, cuspidors, and neighboring track spaces, are all most essential.

The cabinets and the receptacles for fecal matter should be so constructed that the most perfect cleanliness can be easily maintained. The floors and wainscoting should be made of non-absorbent material, and no cracks or corners should be left to collect matter. Enclosed spaces about the fixtures are not permissible.

The practice of discharging excreta through open tubes upon the roadway is an uncleanly one, and is further and mainly objectionable on account of the risk involved to the public health. The danger is not from healthy fecal matter, but from diseased matter which, under the present arrangement, cannot be intercepted and prevented from being scattered along the surface of the road-bed, from which it may be washed into water-

courses and specifically contaminate the supply of water used for domestic purposes.

The cabinets as well as the receptacles should be frequently disinfected, and thereafter scrubbed or washed with soap and water.

No railroad is complete in its equipment that does not possess at its terminals, or at convenient points, the appliances and means for efficient disinfection. Railroad companies are under obligation to transport the public in a safe and comfortable manner. They also have the further obligation to protect the health of travellers while in their charge. Developed cases of contagious diseases are easily discovered and disposed of, and disinfection performed according to established rules. But the subtle poison of contagion more commonly escapes detection, and lurks in the sleeping-berth, the drapery, carpets, drinking-cup, and in the excreta cast recklessly upon the roadway. Practically speaking, nothing is ever done to destroy such poison. The so-called cleansing is according to the usual custom and satisfies the senses only, but as it is not aimed to destroy the disease germs, it is deceptive, since it lacks this most important object. Even under the observance of the strictest precaution, contagious diseases may be communicated by all of these media. Without it the danger is many times multiplied. Now that it is well established that tuberculosis, that most destructive of diseases, is communicated through the expectoration of the sick person, it becomes obligatory upon the railroad companies to guard their patrons while in their charge by well-known means from hazard from this and other communicable diseases, as far as is practicable.

For the reason that the danger is constant, though it escapes ordinary attention, periodical and systematic disinfection of the carpets, matting, hangings, beds and bedding, drinking-glasses, water-closets, and woodwork should be enjoined. Cleansing, as usually practised, is insufficient. Chambers for disinfecting by moist and dry heat are now considered to be an essential part of the sanitary equipment of every railroad.

Ventilation, heating, and lighting of cars and stations, deserve consideration. There would be little difficulty in securing proper ventilation of cars during the summer season, if it were not for the constant presence of dust, smoke, and cinders in the atmosphere surrounding a moving train. With stone-ballasted roadbeds and the use of devices for consuming smoke, the objection to ventilation by the open windows or transoms vanishes. But during that portion of the year when artificial heating is necessary, no satisfactory system for supplying passengers with wholesome air warmed to an agreeable temperature has yet been introduced. Tests made to determine the amount of carbon dioxide in the air of occupied coaches in the winter season, when doors and windows are closed, show, by the mean of all analyses made, that the air contains an excessive amount of this impurity, and prove that the means of ventilation in cars is inadequate to supply a wholesome atmosphere.

In order to accomplish the proper ventilation of cars mechanical means must be resorted to. And these means should be adequate to introduce within the car, at all times, a sufficient amount of fresh air to maintain the standard of purity. When artificial warmth is required, the air should be passed over heating apparatus, and thus warm the car as well as ventilate it. Whether a system of ventilation by extraction, or by propulsion, or both methods combined, be adopted, is immaterial so far as the main object is concerned. The question of expense is a subordinate consideration.

The fact that within recent years railroad trains run over extensive routes without change of cars, and that people live upon these cars for days as in any other place of residence, makes it highly important that the sanitary conditions necessary to comfort and health should receive most careful attention.

The old plan of heating by stoves should be discarded as unsatisfactory and extremely dangerous, and in lieu thereof a system of heating by means of steam or hot-water pipes should be substituted, it being more easily regulated, more satisfactory in its results, and immeasurably safer. Coal-oil lamps are unsatisfactory, and are open to the objection that they contaminate the confined air by the products of combustion, but more particularly on account of the risk of explosion and fire. Gas burners, with ventilating flues, are preferable. The Siemens or Lungren gas burner has powerful illuminating qualities, and the further advantage of discharging the products of combustion outside the car. The incandescent electric light is the ideal hygienic light, and, barring expense, is preferable to all other means of illumination.

Every appliance that conduces to the safety and protection of the lives of passengers and crew should be promptly adopted by the railroad companies. The so-called block system of signals has frequently averted accident and thereby saved life, and should be universally introduced. Statistics show that a large number of lives are annually sacrificed by the unnecessary and persistent employment of the link and pin coupling for cars. Strange to say, there is an opposition among the men employed to the substitution of the automatic coupler for this dangerous appliance, possibly for the reason that the new invention, which is safe and well adapted to its use, requires no special dexterity, and its adoption will lead to a reduction of wages and a reduction in the number of men required to perform this work. Where life is unnecessarily jeopardized the law should intervene and make the adoption of some form of automatic coupler obligatory.

The discharge of volumes of smoke, especially from engines using bituminous coal, is a nuisance not only to travellers, but to persons living in the vicinity of railroad yards, and even along the built-up portion of the routes. It is not so much a question of health as one of comfort, but the two are intimately related. A smoky, dirty atmosphere, however, is not conducive to health. Appliances have been invented which thoroughly consume the smoke, and their adaptation to locomotive engines has been a success, and there can be no valid reason why they should not be put into general use.

Railroads are occasionally liable to transport infected persons, and therefore should be prepared at all times to deal with such cases. But during an epidemic of contagious or infectious disease the liability becomes constant, particularly along such roads as are immediately connected with the disease centres. Under such circumstances the use of *restrictive* and *repressive* measures becomes imperative. They are primarily *inspection, cleanliness, isolation,* and *disinfection*. Cleanliness in the strictest sense of the word is at no time more important. Cleanliness with regard to the water-supply, vehicles, stations, closets, etc., should be strictly observed. The precautionary and preventive measures already advised should be executed with fidelity and precision. With regard to the water-supply, the greatest safety lies in boiling all water used for drinking purposes, for which adequate provision should be made.

The inspection of passengers and cars at proper stations by skilled officers, for the purpose of detecting disease, supervising the sanitary condition of the vehicles, and disposing of the sick, is imperative. A sanitary officer should accompany every immigrant train, in order to have early knowledge of any sickness that may occur and direct the proper measures to be taken. The transportation of all suspicious cases of disease should be refused. Immigrants should be transported on special trains, but should be detained until satisfactory inspection has been made as to their health conditions. The health authorities at the place of destination should be notified in advance of the coming of such trains, and a certificate of health (issued by the proper official) should be in the possession of each immigrant. State boards of health should be promptly furnished with a list of the names and ultimate destination of persons coming from an infected district.

Arrangements should be made for treating the sick and for disinfecting cars and their contents at convenient stations, such as the inspection stations, patient-delivery stations, and at the terminals of the roads. Patient-delivery stations are such stations as are provided with a

suitable place for the reception of the sick while awaiting the means of transportation, and with accommodation in hospital. An inspection station and a delivery station may sometimes be advantageously combined.

At a number of these stations, and at stations where a considerable number of passengers arrive from an infected district, and at all important railway centres, under the direction of the sanitary authorities, physicians should always be in attendance when trains arrive, in order to render assistance to persons sick, or suspected of being sick, with the prevalent disease. They are to render assistance when requested by the sick travellers, or when information is given them by the conductors who have obtained it by their personal observation, or upon the statement of travellers.

The selection of these stations should be made by the sanitary authorities with the concurrence of the railroad officials, and with reference to the character of the epidemic and the conditions of traffic.

A list of all delivery and inspection stations should be furnished the conductor of every passenger train, and he is to deliver persons taken sick with suspicious symptoms at the next station on the list. The delivery of cholera-suspicious persons at other than the designated stations should, as a rule, be prohibited. If, however, a passenger insists upon leaving the train before such station is reached it may be permitted, unless there is a police regulation against it; but in such case the conductor should notify the officer in charge of the station, giving the name, place, and residence of the sick person, in order that the proper authorities may at once have full knowledge of all the facts.

Immediate telegraphic notice should be sent to the nearest delivery station when suspicious sickness occurs on any train. When a case, or the suspicion of a case, of cholera appears, all persons in the car, excepting friends of the sick person who wish to remain to take care of him, should be removed; and such persons, upon arrival of the train at the station, must at once be pointed out to the sanitary official in order that he may give the necessary instructions with regard to them. The sick should be made as comfortable as possible. Arriving at the station, the car should be side-tracked and placed under the direction of the sanitary officer.

Suitable rules should be prepared for the use of train officials in disinfecting themselves after having been in contact with the ejections of sick persons, and they should call the attention of travellers who have been exposed to infection to the necessity of disinfection. All persons coming in contact with cholera patients must strictly avoid eating, drinking, smoking, or bringing their hands in contact with the face before disinfection has taken place, as infection may occur by direct introduction of poisonous matter through the mouth into the body. Workmen employed to disinfect should be equally careful to disinfect themselves immediately after they have come in contact with infected things. Every confirmed case of cholera should be reported at once in writing by the station-master, to the local police authorities, and to the friends of the patient, with information as to the place whence he or she came, name, age, and business, as well as the destination.

The foregoing instructions should apply to all train officials who may be taken sick during the journey.

Disinfection of car closets should be frequent and thorough. In order to prevent infecting the roadway, and from this source neighboring streams, whereby disease may be communicated, movable iron buckets or boxes should be substituted in the place of all car closets, or some other mechanical device should be used by which excreta shall be prevented from escaping upon the road-bed without disinfection. This measure is important with respect to all trains, but it is particularly applicable to immigrant trains starting from the seaboard, when vessels are arriving from infected countries. The disposal of excrement should be under strict regulation.

The disinfection of cushions, drapery, carpets, beds, bedding, etc., by means of steam, is deemed essential when these articles have been exposed to the infection of such diseases as small-pox, cholera, etc. For this purpose steam-disinfecting chambers should be provided at the inspection stations, or some equally satisfactory arrangement be made for carrying this object into effect. The disinfection of the personal effects of the sick or of suspects is best accomplished by means of steam, and should be performed at the place where the cars are side-tracked. Cars exposed to infection should be thoroughly disinfected while at the stations, according to well-established methods. With ample provision and good management all these measures can be carried into execution with but trifling hindrance to traffic. Circulars of instruction should be in the hands of all officials of the road liable to take part in the service.

4. Steamboats, Ferryboats, Stations, Etc.—The sanitary inspection of steamboats, though less important than that of railroads, is necessary for the protection of the public health. The vast rivers and inland waters of the United States afford numerous and convenient channels of communication which are extensively utilized for passenger traffic and commercial purposes. Safety in navigating these waterways depends on knowledge of the channel and the proper construction, equipment, and management of the transports. The Government, in the exercise of its sovereign authority, seeks to prevent accidents and protect life by the enforcement of necessary regulations, such as those limiting the number of passengers, providing adequate life-boats and life-preservers, prescribing the inspection of boilers, requiring the employment of competent pilots and captains, and providing other means of insuring safety. In certain grave emergencies, which fortunately seldom arise, provision is made under State laws for the inspection and quarantining of boats traversing our waterways. The sanitary equipment and management, though quite as important in their ultimate results, are, however, left to the direction and control of the companies. Official supervision by the sanitary authorities is the rare exception. The result is that those things most essential for the protection of health are liable to be slighted or entirely overlooked. The companies are not entirely responsible for these deficiencies. They are the purveyors to the people and aim to supply the demands of their patrons. These demands are the outgrowth of a pampered desire for elegant apartments, attractive surroundings, convenience and comfort, rather than the expression of the sanitary needs of the travelling public. When the public are instructed and know what to demand, corporations will not be slow to supply the deficiencies. What, however, may be accomplished indirectly and slowly by fostered public sentiment, can be promptly and satisfactorily brought about by authorized sanitary inspection.

Sanitary supervision of passenger traffic on rivers and lakes should be conducted under State or general Government laws according to jurisdiction, by State boards of health, or the central health authority. By concert of action of the authorities a standard code of regulations could be agreed upon, and its observance secured by means of periodic inspection. These regulations should embody the prime requirements of hygiene, and have particular reference to cleanliness, the water-supply, closets, berthing, ventilation, heating, lighting, and exceptionally the provisional care and disposal of the sick with contagious or infectious diseases, isolation, and disinfection.

More than the ordinary forms of cleanliness are required where the public assemble at will, and where discrimination in regard to them is not permissible and is not even possible. This requirement applies, of course, to the cabins, state-rooms, closets, and other enclosed spaces. Besides the ordinary forms of uncleanliness, there are the insidious and more potent forms to guard against which are derived from diseased persons. Persons from the sick-chamber carrying with them the fomites of dangerous diseases, and even the unsuspected sick themselves, may convey infection to public apartments, state-rooms, to the drapery, beds, bedding, and like absorbent materials. Tuberculosis, the more dangerous because its subjects constantly mingle with the pub-

lic, is liable to be spread by means of the disease-bearing sputum.

For the protection of the public, cleanliness should conform to a high standard. Not the glossing over of the surface, nor the perfunctory performance of a conventional practice, but a thorough, radical cleansing, or house-cleaning, the cleaning of paint, the scrubbing of woodwork and floors, the beating and steaming of carpets, drapery, and coverings, should be done at stated intervals as supplemental to the daily cleansings.

It is no unreasonable exaction to demand that beds and bedding continually in use in confined apartments, by all sorts of persons of unknown antecedents, should be frequently aired and sunned, and occasionally radically purified by exposure in a steam chamber to a disease-germ-destroying temperature. This cannot be deemed an unnecessary refinement, when its object is to promote the public comfort and the public health.

Every vessel carrying passengers should, for convenience and economy, be fitted up with a chamber for disinfecting by dry and moist heat, so that the necessary treatment of articles can be regularly and systematically conducted.

The advantages for maintaining cleanliness upon river craft are exceptionally great. With perfect drainage, cleanly environment, facilities for ventilation, free use of hot water and steam, and motive power at hand for appliances, there can be no valid reason why ideal cleanliness should not be maintained on all passenger transports on rivers and lakes.

The provision and storage of the water-supply should be so supervised as to guard against impurity. The cisterns should be properly made and placed and protected, so as to guard against the sources of accidental contamination. They should be regularly cleaned to prevent any possible contamination from deposits which form in stored water. It would be much safer, particularly during the presence of an epidemic, to depend entirely on sterilized water for drinking purposes. Apparatus can be obtained for automatically sterilizing water in steam-tight chambers at a given temperature, and delivering it to air-tight receivers of any capacity. Thence it may be conducted to taps, passing on the way through coils surrounded by ice or cold water for reducing it to an agreeable temperature. If desired, the water may be filtered before being sterilized. The adoption of such a plan guards against the danger from impurities in water and ice, and settles satisfactorily a question which oftentimes causes much anxiety, by guaranteeing a certainty and reliability of result which often fails under ordinary management.

Under ordinary circumstances the closets may discharge through tubes directly into the river. But where passenger boats ply upon rivers the water of which is utilized for drinking purposes, the closets should be provided with movable water-tight receptacles or with latrines, the contents of which should be discharged only after thorough disinfection has taken place. The closets should be scrubbed with soap and water and occasionally disinfected before cleansing. The tubes will require swabbing out with disinfecting solution at regular intervals. Milk of lime is useful for this purpose. During the prevalence of cholera the strictest regulations for disinfecting should be enforced.

The cleanliness of state-rooms and berths should conform to a high standard. Clean linen and a tidy appearance are not the only essentials from a hygienic standpoint. Danger lurks in the beds and bedding used for long periods without an attempt at purification or even airing, although liable to be occupied by persons infected with dangerous communicable diseases and by those suffering from tuberculosis, without suspicion being excited. So long as ignorance and unconcern as to the true condition exist, cleanliness will be restricted to the ordinary usages. It remains for the sanitary inspector to point out the fault and insist upon its correction. Public sentiment, when once established, will demand this needed innovation.

Pillows, beds, and bedding are, in fact, only superficially cleaned, except in special cases, for the reason that they cannot be washed without injury. But this is not an insuperable difficulty, as these articles can be purified by a convenient, safe, and effective method through the use of heat in closed chambers. A disinfecting chamber is an essential part of the outfit of every passenger transport, and should constantly be brought into use, as a most indispensable adjunct to the conventional methods of cleansing.

There need be no difficulty in meeting every sanitary requirement as to ventilation, heating, and lighting, as the conditions are favorable to the execution of satisfactory plans. By means of funnels, shafts, and steam-driven fans, fresh air can be introduced in the cabins and apartments below deck in ample volume to maintain the standard of purity, and by means of steam coils or radiators the air can be maintained at a healthful temperature. By combining the system of ventilation by propulsion with that by extraction, the best results can be obtained. The motive power can also be utilized in generating electricity for supplying incandescent electric lights, which neither deprive the air of its oxygen nor impart to it impurities.

Arrangements should be matured for the provisional care of persons sick with contagious or infectious disease. Whenever such cases are detected, they should be promptly separated from the rest of the passengers and confined in an apartment specially set apart for the purpose, until the proper authorities at the place of landing are notified. After removal of the sick everything liable to contamination should be subjected to thorough disinfection in the manner already indicated.

During an epidemic of contagious or infectious disease the strictest vigilance will be required to protect the travelling public from the danger of contact with the sick. Hence it is especially necessary at such times to place passenger boats under strict sanitary supervision. It may even be necessary, under special circumstances, to require sanitary inspections to be made at the points of departure and destination. When cholera or small-pox is prevalent the lines of communication from the infected district may spread disease broadcast through passengers or fomites, and therefore, as a precautionary measure, close inspection should be practised. The sick, suspicious cases, and suspicious baggage should not be received on board. Should sickness occur on board, arrangements for taking care of and disposing of the sick, for disinfection, for protecting the well, similar to those advised in the case of railroad trains under like circumstances, should be carried into execution.

As the object of inspection is to detect sickness or whatever may harbor disease, to insure the necessary provision for any emergency that may arise, and to see that every sanitary requirement is carried out, this service is the main dependence in protecting health and in preventing the spread of diseases through the avenues of travel, and should therefore be made as efficient as possible. The captains of steamboats should be held to a strict accountability for the observance of all needful sanitary regulations. Inspection is the means of determining whether this obligation is faithfully performed.

William H. Ford.

SAN REMO. Brief mention of this Mediterranean resort has already been made under the article "Riviera" in Vol. VIII. of the HANDBOOK. But the universally acknowledged importance of the place, and its recent growth and development as an international winter sanitarium, justify a somewhat fuller account of its peculiarities than has been given in the article referred to.

The writer, having recently spent several weeks at San Remo, was able to report, in the main, favorably on its claims to be considered as a first-class winter health-resort. (*The Medical Record*, August 13 and 20, 1892.)

In his report, the writer has stated that San Remo is the largest, the best, and in all respects the most important, winter station on the Italian Riviera. Its natural advantages, *i.e.*, situation, protection from winds, etc., give it a winter climate fully as mild and equable as that of Mentone. In addition thereto this little Italian town has

been fairly well piloted of late years as regards the introduction of a number of substantial improvements. Thus, since the new aqueduct has been completed, no better drinking water is found in all Italy than at San Remo. New streets have been constructed, old ones have been repaved, cosey villas have been erected, and well-equipped modern stores have sprung up. Cafés, restaurants, a theatre, spacious hotels with attractive gardens, all point to the flourishing condition of this city. Then, again, it speaks well for the common sense of the community that no attempt has been made to create a sudden boom, but that the people have been content to promote the healthy, steady growth of their town, which is so largely dependent on the continued good will of the foreign element.

At present, under the powerful impulse of a new municipal administration, at the head of which stands the energetic Syndic (mayor) Signor Alessandro Escoffier, serious attention is being given to the introduction of a system of needful sanitary reforms, which, if intelligently carried out, will make San Remo one of the healthiest, as it is now one of the most popular, winter resorts on the north shore of the Mediterranean.

Like so many Riviera towns, San Remo is picturesquely situated on several slopes running down to a beautiful bay. The bay forms an inlet of the Gulf of Genoa, and where the new town stands it is shaped somewhat like an elongated S. The new mole which protects the shallow little harbor projects like a hook into the sea. The larger bay, extending beyond the city limits, stretches out for over four miles, with four minor indentations, in the shape of a graceful crescent. The eastern boundary is formed by a bold headland called Capo Verdo (350 feet high), while the western extremity is marked by the still higher headland of Capo Nero (800 feet high). Hills and mountains rise from these promontories, protecting the town almost as effectually as Ospedaletti is sheltered. Monte Bignone towers up back of the city to the height of four thousand two hundred and seventy feet. The hills are green with olive-trees, firs, pines, and large chestnut-trees, so that the peculiar splendor imparted by a barren background of bare rock, as at Monte Carlo and Mentone, is not here seen, where a softer character is found in all the lovely landscape.

San Remo faces southwest. It lies about thirty-one miles in an easterly direction from Nice, sixteen miles from Mentone, and eighty-five miles west of Genoa.

The biting north winds and the dreaded mistral are, therefore, never *severely* felt at San Remo. But to say that they are quite unknown there is a wilful misrepresentation. During the writer's stay at San Remo he was treated to dusty and violent east winds, which were almost as disagreeable as the true mistral at Hyères and Cannes. Nevertheless the general mildness of the winter climate at this place is amply shown by the luxuriant semi-tropical character of its vegetation. There is no doubt that the triple rampart of its encircling mountains gives it very substantial protection, more particularly because the hills are not here cleft by deep gorges and wide open valleys, as is the case at most of the resorts on the Riviera.

Fig. 549.—View of San Remo from the Mediterranean Sea.

In addition to its climatic advantages, it is gratifying to know that San Remo is a healthy town. It has an average death-rate of less than twenty per thousand of the native population. Mention may here be made of the fact that the authorities were erecting a public disinfectory at the time of the writer's visit. It is intended that in all cases of contagious maladies, whether occurring in hotels, lodging-houses, or villas, the entire clothing outfit, linen, bedding, etc., are to be sent to the disinfectory, where they will be subjected to the action of superheated steam, applied in the efficient manner devised by modern science. This certainly shows that the interests of visitors are to be cared for by those aware of the value of sanitation, which is more than can be truthfully said of certain other alleged health-resorts on the Riviera.

It must not be concluded from these remarks, however, that an altogether ideal sanitary state was found by the writer in San Remo. Hygienic improvements are called for in the direction of better drainage and sewerage, improved methods of drinking-water distribution, etc. But the fact remains that San Remo is salubrious, and that

the foreign colony has nothing to fear from local fevers or other endemic maladies.

Through the kindness of Dr. Hassall the writer is able to present to the reader the following reliable meteorological data, based on eleven years' consecutive observation by that careful observer:

TABLE SHOWING THE WINTER SEASON CLIMATE AT SAN REMO.

	SEASON.[1]											
TEMPERATURE.	1879-80.	1880-81.	1881-82.	1882-83.	1883-84.	1884-85.	1885-86.	1886-87.	1887-88.	1888-89.	1889-90.	*Mean of* 11 *years.*
Mean shade	52.00	54.30	54.40	52.58	53.98	52.72	52.82	52.30	49.61	52.02	52.23	52.63 Fahrenheit.
Mean maximum shade	57.69	59.70	58.60	56.93	57.99	56.62	56.86	56.10	54.87	56.28	57.05	57.15 Fahrenheit.
Mean minimum shade	45.76	48.60	48.17	46.76	48.07	46.08	46.32	45.14	45.28	45.83	45.80	46.53 Fahrenheit.
Times shade reached freezing	6	0	0	0	0	0	1	0	0	2	0.9	
Mean minimum on ground	.....	44.80	.....	39.53	42.82	38.44	40.77	38.60	.....	39 88	.....	40.69 Fahrenheit.
Times of freezing on ground	.....	3	0	20	4	29	13	34	12	26	12	15
Snow fell	1	0	0	2	0	0	0	0	0	0	3	
SUN AND SUNSHINE.[2]												
Mean sun-heat by naked thermometer	.....	73	72	67.58								*Mean of* 9 *years.*
Mean sun-heat in vacuo	119	.....	115	105 06	108	108	106	105.05	.....	105	.....	109 Fahrenheit.
Days on which the sun shone	166	160	167	160	171	163	162	166	.....	157	.....	164 days.
Mean sunshine per day, in hours and minutes	8.05	7.18	8.27	6.23	7.07	6.51	5.30	5.50	.....	6.12	.....	651 hours.
Total sunshine, in hours	1,331	1,177	1,412	1,171	1,290	1,242	999	1,255	.....	1,114	... .	1,221 total sunshine.
RAIN, RAINFALL, AND RELATIVE HUMIDITY.												*Mean of* 11 *years.*
Days of rain[3]	27	43	18	33	25	38	42	30	52	40	31	34 days of rain.
Hours of day rain	117	81	161	132	91	140	137	134	239	174	145	141 hours of day rain.
Total rainfall in inches	10.26	16.64	15.27	17.27	10.14	11.21	11.29	23.54	24.45	.....	17.90	16 total rainfall in in.
Mean relative humidity[4]	67.80	68.70	72.80	71.20	71.00	69.36	71.73	68.62	71.60	71.34	68.94	70.28 relative humidity

[1] The season lasts from November 1 to April 30. [2] In the first three years the mean sun-heat in air and in vacuo is based on the days on which the sun actually shone, but in the following years it is spread over all the days of the season, even those on which the sun did not shine; hence a lower mean is shown in the eight later years. [3] Every day on which as little as the $^1/_{100}$ of an inch of rain fell is counted as a rainy day.
[4] Based on three daily observations, at 9 A.M., 9 P.M., and 3 P.M.

In the way of amusements San Remo does not come up to Nice, but perhaps this is an advantage to real invalids in quest of health.

The walks in and about the town offer sufficient attractions to make them enjoyable, although there is not the great extent and variety found at Nice and Cannes. Mountain climbing and donkey rides may be profitably indulged in by the more robust. It is quite unfortunate that the railroad has been allowed to run close to the shore, as the town has thus been robbed of a sea promenade that might have rivalled the famous Promenade des Anglais at Nice. Excursions in carriages are less popular here than at other Riviera places, for the roads are dusty and offer few compensatory inducements in the way of beautiful views.

There is a singular unanimity of opinion among medical and other competent writers relative to the advantages of San Remo as a winter health-resort. Dr. Hassall[1] has given the following fair *résumé* of the characteristics of the climate: "It is moderately warm during the winter, even in the shade, the temperature being fairly equable. It is very sunny; there are but few days on which the sun does not shine, and the duration of the sunshine is very considerable. In consequence of the power of the sun and the duration of the sunshine the air is for the most part clear, the sky bright, and there is abundance of light. There are but few days on which rain falls, and the air is moderately dry. Owing mainly to the sea and land breezes, the air is kept in movement day and night, and is consequently refreshing and exhilarating. The combined effect of these several characteristics is that the climate of San Remo is, during the winter season, moderately stimulant and decidedly tonic. A climate possessing the qualities above mentioned cannot fail to exert a very powerful influence on the functions of the body, for good or evil, in a great variety of diseases. Owing to the mildness of the climate there is less wear and tear and less strain. The several functions are performed in a more moderate and uniform manner. There being less expenditure of power and less waste, a smaller quantity of food is required, and the stomach has less work to do. The circulation, in particular the heart and its vessels, is exempt from the severe strains entailed by extremes of cold and heat, and which in themselves are often injurious, and not unattended with danger. The action of the sun on the human body is very complex; the effects are not confined to the warmth derived from its calorific rays; the luminous and chemical rays all exert powerful effects. The sun acts as a stimulant to most of the bodily functions: to elimination, secretion, and absorption; it determines many chemical changes, and promotes sanguification and the coloration or bronzing of the skin."

San Remo has many excellent hotels, like the West End and the Hôtel des Anglais, where prices are rather high. For slender purses, less pretentious establishments exist in plenty. The expense of living well is as high as elsewhere on the Riviera, although Italy is, in general, a rather cheaper country than France. Foreigners are always expected to pay more than natives, but actual extortion is not a common practice at San Remo.

Respecting the class of invalids likely to derive more or less benefit from a winter's residence at San Remo, it is not necessary to repeat the indications previously formulated with regard to Riviera resorts generally. Physicians who intend to send patients to San Remo, will do well to bear in mind, however, that this Italian station is at present very largely patronized by Germans, and that English-speaking invalids do not predominate as at Hyères, Cannes, and Nice. An excellent account of San Remo has been quite recently published by Dr. Rieth.[2]

Edmund C. Wendt.

[1] San Remo Climatically and Medically Considered. London: Longmans, Green & Co. 1883.

[2] San Remo, eine deutsche Winterkolonie. Von Dr. R. Koerner, neu bearbeitet von Dr. C. Rieth, K. Badearzt in Bertrich (Moselthal). Leipzig: Otto Wigand. 1892.

SANTONIN-OXIM.—A derivative of santonin, obtained by the action of hydrochlorate of hydroxylamine, in alcoholic solution, upon santonin. Its chemical formula is $C_{15}H_{18}O_2NOH$, that of santonine being $C_{15}H_{18}O_3$. It is a white crystalline substance, having a melting point

of 323° F. It is scarcely soluble in water, but soluble in alcohol and ether, and in weak alkaline or weak acid solutions.

Santonin-oxim is recommended as a substitute for santonin, as it is said to be free from any toxic properties, its anthelmintic action being effected without any influence on the general system. The dose for children of two or three years is one grain; from four to six, one and one-half grain; six to nine, two grains; and for adults, five grains. This quantity is to be given in two portions, an hour intervening between them. The dose should be repeated for two or three days, and followed by a purgative. *Beaumont Small.*

SARCOMA AND CARCINOMA, CURATIVE TREATMENT OF, BY ERYSIPELAS.—There is perhaps no subject in the whole field of medical science that has received a larger share of thought and careful investigation than cancer; yet when we sum up the results of all this, so far as their actual practical value is concerned, we cannot but be struck with their insignificance.

It is true that we know more about the pathology of cancer and its various anatomical forms than ever before; we even realize the importance of early diagnosis and operation better than our predecessors. Yet when this has been said, in seventy-five per cent. of all cases of cancer that have commanded the best surgical and medical skill, the tumor recurs, becomes inoperable, and the patient is left to a fate the more horrible as it is slow and sure.

It has been with a view of benefiting such hopeless cases as these that erysipelas inoculations have been tried. No extravagant and ill-founded claims that erysipelas can cure all cases of malignant disease are made. Yet at the present moment sufficient clinical and experimental data exist to establish beyond question that erysipelas possesses an active principle that in some way is *antagonistic* to *sarcoma* and to a less degree to *carcinoma*; and in a certain, and by no means insignificant, proportion is *curative* of the same.

In addition to the personal experiments carried on in a large series of cases during the past two years, I have collected as far as possible all the evidence from other sources, and my results have very recently been published in the *American Journal of the Medical Sciences* (May, 1893), where the details of the cases may be found.

In a paper published in the *Annals of Surgery*, September, 1891, entitled "A Contribution to the Knowledge of Sarcoma," I referred at some length to the curative effect of erysipelas upon sarcoma, and reported the results of three original cases treated by inoculation. In all of those cases I failed to produce a true erysipelas, but the frequently repeated injections of pure liquid cultures had the effect of temporarily checking the growth.

Since that time I have continued my investigations in fifteen additional cases, including the cases treated by the toxic products of erysipelas. In the spring of 1890, while making a collection of all the cases of sarcoma operated upon at the New York Hospital during fifteen years, I found a case that convinced me that erysipelas possessed a powerful principle antagonistic to sarcoma.

Whether or not this principle could be isolated or utilized in the practical treatment of sarcoma, was quite another question, yet one of sufficient interest and importance to lead me at once into making a thorough study of the subject.

The case referred to was very briefly as follows: A round-celled sarcoma of the neck occurring in a German aged thirty-one. Five operations had been performed by Dr. William T. Bull within a space of three years.

At the last operation, a very extensive one, it was found impossible to remove all of the tumor, and a portion was left attached to the carotid artery. The case was regarded as hopeless.

The tumor had already begun to grow when a well-marked attack of erysipelas accidentally occurred, followed shortly after by a second attack. During the course of the erysipelas the remains of the sarcoma disappeared; the wound, originally, five inches by four, and left open, healed rapidly, and the patient was seen both by Dr. Bull and myself alive and well *seven years* afterward; at which time a photograph, of which the accompanying cut is a faithful copy, was taken.

FIG. 550.

The diagnosis in this case had been repeatedly confirmed by well-known pathologists, and there was no possibility of attributing the cure to any other cause than erysipelas.

If erysipelas, a disease supposed to be produced by a specific organism, could, when occurring accidentally, cure a case of undoubted sarcoma, it seemed fair to presume that the same benign action would be excited in a similar case if erysipelas could be artificially produced.

Having satisfied myself that the mortality of erysipelas uncomplicated was very slight, I determined to inoculate the first case of inoperable sarcoma that should present itself.

On May 1, 1891, I inoculated a case of recurrent sarcoma of the neck and tonsil, kindly referred to me by Dr. William T. Bull. The subsequent history of the case is briefly as follows:

The patient was an Italian, thirty-five years of age, operated upon previously in Rome by Professor Durante, and in April, 1891, by Dr. Bull, at the New York Hospital. At the latter operation the growth was found too extensive to remove. At the time of my first inoculation the tumor of the neck was growing, and the right tonsil was the seat of a tumor the size of a hen's egg and almost completely blocking up the pharynx. Solid food could not be taken, and liquids frequently regurgitated through the nose. The patient's condition was very bad. He was emaciated and cachectic. The dangers attendant upon an attack of erysipelas were explained to him, and in view of the hopelessness of his condition and the impossibility of obtaining further surgical relief, he consented to erysipelas inoculation.

The details of the earlier treatment are given in a former paper,* and I will not repeat them here; suffice it to say that the inoculations were made by injecting small quantities of bouillon cultures (½ to 2 c.c.) into the tumor itself, scarification (Fehleisen's method) having proved unsatisfactory. The inoculations were continued at short intervals during May and a part of June. Slight

* Annals of Surgery, September, 1891.

local and constitutional reaction followed the inoculations, the tumor of the neck diminished in size, and the general condition improved. The tonsil tumor was also smaller and the voice much better.

During August and September the treatment was discontinued, and the tumors at once began to increase in size and the general coudition to deteriorate.

October 1st, they had reached their former size, and the patient's condition was little different from that at the time the inoculations were begun. At this time I succeeded in getting a culture of streptococcus erysipelatis kindly brought me by Dr. Farquhar Ferguson direct from Koch's laboratory, and I decided to make a further trial. One-half a cubic centimetre of a fresh culture was injected into the tumor substance. Up to this time he had had no attack of true erysipelas, the slight local reaction passing away in from twenty-four to forty-eight hours, and the temperature thereupon becoming normal. Within an hour he had severe pain, nausea, vomiting, and a chill lasting forty minutes. His temperature rose to 105° F., and within twelve hours a patch of perfectly typical erysipelas, the size of the palm of the hand, appeared upon the neck. This gradually extended over the face and head, and met upon the opposite side.

The disease ran the usual course, and I made little effort to check it, save to apply some ichthyol upon the forehead to prevent its extending to the scalp (which, I may add, it failed to do). At the end of ten days the pulse and temperature had become normal. The tumor of the neck began to break down on the second day, and discharged until the end of the attack. The discharge was not pus, but resembled the caseous material of a tubercular gland. The outlying nodules disappeared by absorption without breaking down. The tonsil tumor was smaller, but the diminution in size was not great. At the end of two weeks the tumor of the neck had disappeared, and there remained only the induration from the previous operation. The appetite began soon to improve and he gained rapidly in flesh and strength. There has been up to the present time (July, 1893) no return of the tumor in the neck, and although the tonsil tumor has remained about the same in size, its malignant character must have been destroyed, as sarcoma of the tousil is known to be rapidly fatal.

The patient's general condition at present (more than two years) is excellent, although he is suffering from a confirmed morphine habit which he had contracted previous to the inoculations.

Case II. *Periosteal Sarcoma of the Lower End of the Femur.*—The patient, aged sixteen, had been treated at several hospitals for supposed tubercular disease of the knee. An exploratory operation by Dr. R. F. Weir and microscopical examination proved the trouble to be sarcoma. Amputation was advised, but absolutely refused by both parents and patient. Erysipelas inoculations were tried and repeated at short intervals during four weeks. Injections of pure bouillon cultures, 1 to 2 c.c., were made directly into the tumor. Well-marked reactions followed within one-half to two hours after the injections, the temperature frequently rising as high as 104° or 104½° F. The general symptoms corresponded to those seen at the beginning of an attack of erysipelas, yet no visible erysipelas was produced, and the reactiou usually subsided in twenty-four to forty-eight hours. The tumor, which was very large (size of man's head) and ulcerated in part, showed temporary improvement, but owing to the size of the tumor and the poor condition of the patient, as well as to the failure to produce a true erysipelas, the injections were discontinued. Death occurred from exhaustion four months later.

Case III. *Periosteal Sarcoma of Spine (Upper Dorsal).*—The patient, a woman aged twenty-six, had injured her back by a fall about two years previously, and two operations had been performed and were followed by rapid recurrence, before the erysipelas was tried. Cultures from three different sources were tried, yet I was unable to produce erysipelas. The tumor became much softer and more movable, and slightly smaller. Only five injections were made; they were then discontinued on account of the failure to produce erysipelas, and a third operation was performed (August, 1891). The disease recurred quickly and developed with great rapidity. Paralysis of the lower extremities soon followed, and death occurred six months after the last operation.

These two cases are, so far as I have been able to ascertain, the only cases of bone tumors where inoculation has been tried; although Dr. Gerster reported at the Surgical Society, a year ago, a most remarkable case of sarcoma of the lower end of the femur, with amputation at the trochanter minor, followed by rapid recurrence in the stump. An attack of *accidental erysipelas* ensued a few weeks later, whereupon the tumor entirely disappeared, and the patient has been seen by Dr. Gerster five years afterward, free from recurrence.

This case of Dr. Gerster's is alone sufficient to demonstrate that the curative effect of erysipelas may be exerted upon sarcoma of the bone as well as upon sarcoma of the soft parts.

Cases IV. and V., the one a very extensive carcinoma of the face, and the other a very large sarcoma of the back (17½ × 18½ inches) deserve but brief mention, for the reason that the cultures were much attenuated, and not only was no erysipelas produced, but the reaction was so very slight that the injections were soon discontinued.

Case VI. *Large Sarcoma of Back and Groin—Operation (Groin Tumor)—January*, 1892— *Recurrence in One Month—Successful Erysipelas Inoculation—Entire Disappearance of Both Tumors in Two Weeks—Recurrence Three Months later—Second Inoculation—Second Disappearance—Recurrence—Final Disappearance under Injections of Toxic Products of Erysipelas—Patient well and free from Recurrence July* 14, 1893.*—The patient, a German, forty-six years of age, cigar-maker, with a good family and personal history, applied at the Hospital for Ruptured and Crippled early in January, 1891, for treatment for a swelling in the right groin.

At that time there was a tumor the size of a goose-egg —hard, slightly nodular, deeply seated in the region of the inguinal glands, without any signs of an inflammatory nature. Hernia could easily be excluded, and the usual causes of an adenitis were absent. The patient had first noticed the tumor five months before; it had slowly but steadily increased in size, and was slightly painful. I made the diagnosis of malignant disease, in spite of the fact that careful questioning failed to elicit any history of a primary tumor elsewhere. A few days later I operated upon the tumor of the groin, at the Post-Graduate Hospital. The tumor was found to consist principally of degenerated glandular tissue, but no pus was present. The microscopical examination was unsatisfactory. While putting on a spica bandage I discovered a large flat tumor in the lumbar region of the back, measuring six inches by four, elliptical in shape, and projecting from the normal surface about one-half to one inch. It was very hard and nodular, presenting numerous tuberosities. Its color varied from a bright red to a plum color. It was freely movable, and was evidently situated entirely in the skin and subcutaneous tissue. The patient stated that it had been there five years, but having caused him little inconvenience, he had paid slight attention to it.

Aside from an indefinite history of injury in the army in 1870, no cause could be found for the tumor.

Soon after leaving the hospital Dr. George H. Fox kindly saw the case with me, and his diagnosis was sarcoma of the skin. A photograph was taken at the time, February, 1891, and a copy of it is shown in Fig. 551.

Shortly afterward I removed two sections of the tumor under cocaine, for microscopical examination, and the diagnosis of sarcoma was confirmed by the careful examination of Dr. Farquhar Ferguson, the pathologist of the New York Hospital. At this date, February 22, 1892, the tumor of the groin had already recurred and was growing rapidly. The tumor of the back was also increasing in size. In view of the rapid recurrence in the

* As this is, perhaps, the most interesting and suggestive of my cases, it is given somewhat in detail.

groin and the large size of the tumor of the back, the patient was advised, both by Dr. Bull and myself, to have erysipelas tried. After some deliberation he consented, and on April 12, 1892, I began inoculations.

During the first three weeks of treatment the inoculations were made at intervals of two or three days. Well-marked constitutional reaction followed, accompanied by slight local redness at site of puncture; the condition returning to normal at the end of twenty-four to forty-eight hours. The effect on the tumor was a perceptible decrease in size; there was no formation of pus, nor was there any breaking down of the tumor tissue. At the beginning of the fourth week I used a new and stronger culture. The first injection of 0.7 c.c. produced a reaction quite similar to that obtained from the other culture. The second, of 1½ c.c., two days later, produced a perfectly typical attack of erysipelas, both in the back and groin (injections having been made in both places).

Four hours after inoculation the patient had a very severe chill, with nausea and vomiting and marked prostration. The temperature rose to 105½° F. and the pulse to 130. The subsequent history was that of a typical but severe attack of erysipelas. The disease did not extend over a very large area, although no measures were taken to check it.

Fig. 551.—Sarcoma of Back and Groin. Entire disappearance after erysipelas inoculation. (Coley.)

From the beginning of the attack the change that took place in the tumor was nothing short of marvellous. It lost its lustre and color, and had shrunk visibly in size within twenty-four hours. Several sinuses formed on the second day and discharged necrosed tumor tissue. A few days later the tumor of the groin, which was about the size of a goose-egg, and very hard when the inoculations were begun, broke down and discharged a large amount of similar material. This continued for two weeks, after which time the sinuses gradually closed. The most projecting portion of the tumor of the back ulcerated over an area one and a half inch in diameter, but this rapidly healed.

Three weeks from the date of the attack both tumors had *entirely disappeared*, and there was scarcely any induration remaining. The patient's general condition improved rapidly. He gained seven pounds in twelve days. There was no recurrence of the tumors until July 1st, when a small nodule, the size of a pea, appeared at the site of the former tumor of the back.

July 18th, there were six small nodules within an area of from two to four inches, the largest of which was seven-eighths of an inch in diameter.

On July 3d, injections of the fluid culture were begun and continued at intervals of two or three days for several weeks. Some of the nodules disappeared entirely, and the tumor, as a whole, was held in check, but as soon as the injections ceased the growth was very rapid. A second attack of erysipelas was not produced until November 14th.

At this time the tumor in the back had nearly reached its original size, having increased to 5 × 3½ inches, with a projection of ½ to ¾ inch. The tumor in the groin was the size of an English walnut.

On November 14th, 1.5 c.c. of a culture two weeks old (obtained early in October from a very virulent case of erysipelas) having been previously tested upon rabbits, was injected into the tumor in the back. (Injections of this same stock, except that the cultures were younger, had been used for three weeks without producing erysipelas.)

Fourteen hours after the injection a severe chill occurred, and a few hours later an area of well-marked erysipelas appeared. Several inches from the point of inoculation the disease ran a typical course, subsiding at the end of a week.

The area of erysipelas never exceeded eighteen inches in diameter, although no attempt was made to limit it, and the condition was at no time serious.

The changes produced upon the tumors by this second attack were no less remarkable than those observed in the first attack. Within twelve hours of the onset the tumor became dull and lustreless, and began to break down. Four or five sinuses formed from which degenerated tissue escaped during and after the attack of erysipelas.

At the end of thirty-six hours the tumor had diminished one-half, and at the end of a week there was nothing left save a slight induration at the site of the tumor in the groin: it had entirely disappeared by absorption *without* breaking down.

It is worthy of careful note that in this case the erysipelas was chiefly confined to the right buttock and at no time extended within several inches of the sarcoma either in the back or groin, yet the effect was quite as marked. Two weeks later a recurrence appeared in the back, and grew rapidly.

The latter part of December the patient had a third, but much less severe, attack of erysipelas, in this case spontaneous, probably from the streptococci remaining in the skin, at the site of the previous attack. During the next three weeks two similar attacks occurred in the same locality.

The effects of the last attacks upon the tumor were less marked and more temporary. In January, 1893, I removed the focus of disease in the back. The wound was left open and partially covered with Thiersch's skin grafts. Most of the grafts failed to take, and the wound healed badly. Sarcomatous granulations appeared three weeks after the operation and the tumor in the groin recurred. Injections of *filtered cultures* of erysipelas were then begun. The injections were made into the

groin tumor only, and were repeated every forty-eight hours.

Slight local and considerable constitutional reaction followed, but the condition usually became normal within two days. The flabby sarcomatous granulations in the back at once began to disappear and the wound rapidly healed. The tumor in the groin, which had reached the size of an English walnut, also gradually decreased in size, and at the end of four weeks had entirely disappeared. The patient has regained his normal weight, one hundred and sixty-five pounds, and has resumed his work. No return of the disease, July 14, 1893.

Whether or not the tumor will recur, it is as yet impossible to say, but the case is by far the most important of all, as it illustrates not only the effect of true erysipelas upon a case of sarcoma, but also proves that *one* successful inoculation does not render the patient immune to subsequent inoculations, and furthermore, that the toxic principles of erysipelas contained in the filtered cultures may still exert a curative effect after several previous attacks of true erysipelas.

Case VII. *Sarcoma of Breast—Inoculation of Erysipelas after Seven Recurrences—Partial Disappearance of the Tumor—Second Successful Inoculation Four Weeks after First—Effect upon Tumors Temporary.*—The history of the case is given in detail in the paper already referred to.

The patient was a female aged thirty-eight years, single and without any family history of cancer. The tumor had first appeared five years before, and was operated upon for the first time in 1889. It recurred promptly, and the subsequent history up to June, 1892, when inoculations were begun, was simply a repetition of operation and recurrence. The last operation was performed by Dr. W. T. Bull, in April, 1892. On June 1st, three separate tumors had appeared at site of cicatrix, and in view of the hopelessness of benefit from further operation, inoculation was suggested by Dr. Bull. The first inoculation was made June 2d, 1.5 c.c. of a culture five weeks old was used; two hours later a severe chill occurred, and six hours from the time of inoculation the temperature had risen to 104.2° F. Twelve hours after inoculation an erysipelatous blush extended a distance of seven inches from the point of inoculation. The disease ran a typical course of a week's duration.

The tumors broke down on the second day and discharged degenerated tissue, as in the preceding cases. The tumors decreased very much in size, one of them almost disappearing. They soon began to grow again, and others appeared in neighboring parts. The inoculations were repeated, but a second attack of erysipelas was not produced until July 2d.

June 30th. At this time the lower tumor was scraped out with a sharp spoon under cocaine, and ten minims of culture, two weeks old, put into the wound. Twenty-six hours later she vomited and had chilly sensations, but no distinct chill. The temperature was 99.4°, and steadily rose until 12 M., July 4th, when it had reached 104°. It remained high for several days, reaching 105° on two days.

The erysipelas spread over a considerable portion of the back and down the left arm to the hand. The temperature did not fall to normal until the eleventh day of the disease. Although all of the nodules were diminished in size and some even disappeared, the check proved but temporary, and they soon began to increase in size. Although the last attack of erysipelas was a severe one, the recovery was very rapid, and the general condition was soon as good, if not better, than before the attack. The tumors grew very rapidly and were exceedingly painful. In October there were three distinct tumors, the largest of which was as large as a cocoanut, without ulceration, very soft, in consistence almost fluctuating. There was a second tumor, as large as a large orange; it had a fungoid appearance, with a small pedicle. These tumors were removed by operation the latter part of October. Recurrence quickly followed.

In February, 1893, she developed a spontaneous erysipelas at site of previous attack in the preceding July. The attack was as severe as the former ones and the effect upon the tumor was marked, yet the benefit proved temporary and the tumor grew as rapidly afterward. It is very large at present and the condition of the patient hopeless. The character of the sarcoma in this case was very different from the common forms. In consistence it was so soft that it furnished all the evidences of fluctuation. It was composed of mucoid gelatinous material, and vascularity was nearly absent.

This case, along with one of a similar type of sarcoma recently treated by the toxic products of erysipelas, would seem to show that this variety (myxo-sarcoma) is less affected by erysipelas than the more usual forms.

Case VIII. *Recurrent Carcinoma of the Breast—Repeated Inoculations of Erysipelas—Diminution in Size of Tumor—Improvement Temporary.*—The tumor occurred in a woman forty years of age, who was married and had had children. Predisposing causes were to be found in a family history of cancer, and also in a personal history of mastitis. The tumor was first noticed one and a half year before. Four operations had been performed within less than a year. The tumor at the time of inoculation was the size of a goose-egg, five by three inches, and occupied the upper part of the region of the left breast. The growth was markedly protuberant and ulcerated over an area the size of a silver half-dollar. A thin, serous discharge, very profuse, necessitated frequent dressings. There was also a hard tumor, the size of an egg, adherent to the skin on the right breast, which was unmistakably carcinoma.

Inoculations were begun August 1, 1892, and continued at short intervals for two months. Moderate constitutional reactions followed the injections, and there was partial degeneration of the tumor, and considerable diminution in its size. The general condition of the patient was perfect, and not perceptibly the worse for the treatment. The reaction usually passed away in twenty-four to forty-eight hours, and the patient was able to be up and out most of the time. I did not succeed in producing a true attack of erysipelas, although I used the same cultures as in the preceding case. The inoculations were discontinued in the early part of October, and the tumor began soon to increase in size.

Case IX. *Recurrent Carcinoma of the Cervical Glands—Repeated Inoculations—Partial Degeneration of Tumor.*—The patient was a man fifty-five years old, operated upon by Dr. Frank Hartley, for a large carcinoma of the neck, in July, 1892, with rapid recurrence following,

He was treated for three weeks in October, 1892, at the New York Cancer Hospital Cottage, with repeated inoculations of a pure culture of erysipelas. Marked reaction followed, but erysipelas was never produced. The larger tumor (small egg) broke down, and for several days there was considerable discharge of degenerated tissue, and the tumor decreased in size about one-third.

Case X. *Large Carcinoma of Inguinal Glands Following Amputation of Carcinomatous Penis one Year before—Repeated Inoculations—Temporary Improvement.*—The history of this case, as far as the erysipelas is concerned, is almost exactly parallel to the one just described. The tumor was the size of an orange, in the right inguinal region. The patient was seventy-five years of age, and very feeble, having chronic bronchitis and a weak heart. I did not succeed in giving him erysipelas, yet partial degeneration of the tumor followed the repeated injections of the streptococci.

Case XI. *Large Recurrent Sarcoma of the Neck—Erysipelas Inoculation—Death on Fifth Day.*—The patient was sixty-five years of age, and his general health had been much impaired both by the disease and by a very extensive and recent operation. After having failed to produce a reaction with injections of toxic products, as well as with cultures from same sources as previously used, I decided to inoculate with a new and virulent culture. A small amount, five grammes only, was used. A chill occurred six hours later, and the temperature rose to 102½° F. The condition was not serious until the third day, when he became rapidly worse, and died on the fifth day. The erysipelas had spread over neck and face.

The tumor had diminished very much in size without breaking down.

Case XII. *Sarcoma of the Foot and Thigh.*—M. G., aged thirty-two, female, single. Two years ago she noticed a small wart-like swelling on the inner side of the left instep. It ulcerated upon the surface and was twice removed or "tied off." It never reached a size larger than a cherry, and was not painful. In April, 1893, she came to the New York Cancer Hospital with a tumor in the left femoral region, the size of two fists and ulcerated in part. There was also a hard swelling, extending above Poupart's ligament to within two inches of the umbilicus, and from the median line to within two inches of anterior superior spine.

The tumor in the groin was removed in part by Dr. C. A. Powers, in April, 1893. One week after the operation I began injections of filtered cultures of erysipelas repeated every forty-eight hours. Good reaction followed a dose of two c.c. The effect upon the tumor (the one in groin had already recurred) had not become apparent when (two weeks after beginning of injection) the patient developed a spontaneous erysipelas in vicinity of the wound.*

The effect of the erysipelas upon the tumor was a temporary check to its growth, but as soon as the attack had subsided the tumor again began to grow rapidly. Two weeks later (at the date of writing) injections of the toxic product were again commenced, but with tumors so large and growing so rapidly, there is no expectation of permanent benefit.

In addition to these twelve cases, I have treated six others by the toxic products of erysipelas without attempting to produce erysipelas. These cases have not yet been published, as the experiments have, most of them, been recent and the cases are still under treatment. The results are already sufficiently important to deserve mention. For more than a year I have been trying to find some satisfactory way of isolating the active principles of erysipelas, in order to test their effect upon malignant tumors. If it could be proven that the same effect could be produced by these toxic principles as by the erysipelas itself, a very great step in advance would be made, since the danger element would be entirely eliminated and the necessity of isolating the patient would be avoided.

My first experiments were made with liquid cultures subjected to a temperature of 100° C. The reaction in these cases was very similar in character (although slightly less severe in degree) to that obtained by pure cultures containing the living streptococci. The effect upon the sarcomata was also similar, yet far less marked than in the cases where a true erysipelas occurred. It seemed probable that the action of heat might have changed the chemical relations of the products, and I determined to try cultures rendered sterile by *filtration* through porcelain without the use of heat. I was unable to obtain such a preparation for some time. In January, 1893, I began using filtered liquid cultures (without heat) prepared by Dr. Alexander Lambert, at the laboratory of the College of Physicians and Surgeons of New York. This preparation was made from cultures somewhat attenuated, and although a slight reaction was obtained, the effect upon the tumor was not apparent.

Early in February, 1893, Dr. Lambert made a new preparation in the same way from a fresh culture obtained from a fatal case of erysipelas, and I began at once using it in two cases of sarcoma.

Cases of Sarcoma Treated by Toxic Products of Erysipelas.—Case I.—Boy, sixteen years of age, German, with good family and personal history. He had a large inoperable sarcoma of the abdominal wall, strongly attached to the pelvis below and extending nearly as far as the umbilicus above. Its transverse diameter measured seven inches and its vertical five inches at the time I began the injection of the toxic principles of erysipelas (January 18, 1893). The tumor could be easily felt by the rectum, and was firmly attached to the pelvis. The general condition of the boy was bad, and marked irritation of the bladder was already present.

A section of the tumor was removed, and examination by the hospital pathologist showed it to be sarcoma. As the case was inoperable, it was kindly placed under my care by Dr. L. B. Bangs, with a view of producing artificial erysipelas. Before inoculating with erysipelas it was decided to try the effect of injections of filtered cultures, reserving inoculation until later, in case of the failure of the toxic principles. My first injection produced little reaction and no perceptible effect upon the tumor. Early in February I began using the stronger preparation referred to, and doses of 0.5 to 1 c.c. produced well-marked reaction, severe chill, and temperature rising to 103° and 104° F. The treatment was kept up until May 5, 1893, or a period of three months. The later injections were given at longer intervals than the earlier. The patient was confined to his bed but a few days of the entire time, and was about and out of doors most of the time. Careful measurements made from time to time showed the tumor to be steadily decreasing in size, and the general condition of the patient correspondingly improved.

June 1, 1893, the tumor has so far disappeared that it is no longer visible, and the patient states that it has entirely gone. Examination shows a small movable mass in the abdominal wall, at site of original tumor (just above pubes), measuring less than two inches in diameter. When the treatment was begun, February 1st, the measurements recorded were seven inches by five inches.

The boy has gained ten pounds during the last month, and all bladder irritation has disappeared. The later injections had to be increased somewhat in quantity, to produce the same reaction; but 1.5 c.c. was the largest dose given. Injection of 0.2 to 0.7 c.c. of toxic products of the bacillus prodigiosus were frequently given along with those of the erysipelas, and repeated trials showed that the reaction (and apparently the beneficial action upon the tumor) was greatly intensified by the combination. This mutual action of the germs themselves has been noted by Roger in experiments upon rabbits.

Whether the tumor will entirely disappear it is yet too early to state; yet there seems to be ground for hoping that the improvement will continue. The injections have all been made directly *into* the substance of the tumor, and there has not been the slightest softening or tendency to break down, as has frequently been the case where true erysipelas has occurred.

Case II. (Vide Case VI. above).—This case was the one already described. The toxic products were injected into the sarcomatous tumors which had recurred after they had twice disappeared through the action of erysipelas artificially produced. There was some reason for believing that their action would in this case be either *nil* or very feeble, but on the contrary the tumors disappeared, and at present, four months since the injections were discontinued, there has been *no recurrence.*

Case III. *Recurrent Sarcoma of Thigh.*—M. B——, aged fifty-five. In July, 1889, a small swelling was observed just above the patella on the left thigh. It was not painful, but grew slowly. In November, 1891, it was the size of an egg, and was removed by operation. Second operation done July, 1892; third, January, 1893.

Each recurrence was more rapid in spite of more extensive operations, and each tumor grew faster than the preceding. On March 12, 1893, examination showed a tumor two inches in diameter attached to skin, but movable upon deeper parts, situated just above outer condyle of left femur, in region of old cicatrix. Just above the patella there was an induration two inches in diameter; a little farther up there was a distinct separate nodule three-fourths of an inch in diameter.

The toxic products of erysipelas were begun March 12, 1893, and given in the same way as in the two preceding cases.

* The infection in this case undoubtedly came from a case that had been brought to the ward from the isolating cottage two months previously, before desquamation had ceased. In 1890, I made experiments with the scales following erysipelas, and streptococci were found alive two weeks after all symptoms and redness had subsided, showing that the usual time of isolation is insufficient.

Much larger doses were given, and even then no appreciable rise of temperature followed. The only reaction that followed was severe headache, general muscular pain, and weakness. Locally, the tumor became swollen soon after the injections, and later decreased in size.

While the *filtered cultures* (prepared without heat) were used, the tumors not only did not increase in size, but decreased considerably.

The smallest one could scarcely be detected after six weeks. At the end of eight weeks, having no more of the filtered culture on hand, cultures sterilized by heat were tried. A severer reaction, both general and local, followed. The temperature rose to 103.4° F., and the patient had a severe chill. The cultures were exactly the same as previously used, except in respect to the method of sterilizing—no heat having been used in the *filtered cultures*.

The injections were continued three weeks, but the tumor began to grow again, and on May 31st had attained the original size of March 12th. The tumors were then removed by the knife, with the view of removing the larger part of the disease, and in the hope of destroying the remainder with erysipelas. The tumors removed were of the soft myxomatous variety, similar to Case VIII., where erysipelas produced only temporary improvement; therefore the prognosis is not so favorable.

Case IV. *Recurrent Sarcoma of Hand* (Three Recurrences).—Female, aged twenty-two years. This case, a patient of Dr. Samuel Lloyd, was operated upon, the last time, in January, 1893. The disease very quickly recurred a few weeks after the operation, and grew rapidly.

Injections of toxic products of erysipelas (filtered cultures) were begun in March, 1893. The local reaction was well marked and the usual constitutional symptoms followed.

The reaction gradually became less severe and the toxic products of the bacillus prodigiosus were used, with the same effect as in Case I. The tumor has slowly but steadily diminished in size, and the case is still under treatment.

Case V. *Sarcoma of Back — Recurrence in Axilla.*—Treatment but recently begun.

Case VI. Vide Case XII. above.

The results from the use of the toxic principles of erysipelas in the limited number of cases described, are sufficiently encouraging to make further experiments very desirable. Similar experiments have been very recently carried on in Holland, by Dr. C. H. H. Spronck, Professor at the University of Utrecht, and published in the October, 1892, No. of the *Annales de l'Institut Pasteur*. Spronck and his co-workers treated twenty-six cases of malignant tumors with a preparation of the toxic products of erysipelas.

Although Lassar had previously tried, somewhat earlier, local interstitial injections of sterilized cultures of erysipelas in a case of lupus carcinoma (*Deut. med. Woch.*, 1891, No. 29), Spronck determined to push the same idea further.

While Lassar sought for *local* action, Spronck aimed to get the *systemic* action, and accordingly made his injections remote from the tumor, usually in the gluteal region or back.

He prepared his toxic products in the same way that Koch did tuberculin, heating liquid cultures to 100° C., after addition of five per cent. glycerine. The liquid was then evaporated to one-tenth its volume, cooled, and filtered through porcelain. This preparation was then tried upon animals. In certain doses, varying with the virulence of the cultures from which it was derived, when injected into the circulation of a rabbit it caused death in from twenty-four to forty-eight hours.

The more virulent the culture, the more rapid the death and the smaller the fatal dose. A dose of ten to fifteen cubic centimetres per kilogramme weight of animal, injected into the circulation, usually killed rabbits in from twenty-four to forty-eight hours.

The symptoms preceding death were elevation of temperature, loss of appetite, diarrhœa, albuminuria, and paresis of posterior extremities. No noteworthy changes were observed at autopsy.

Spronck then experimented upon tumors in dogs. Some of the tumors were benign, others malignant. Subcutaneous injections of the toxic products were made in two cases at a distance from the tumors. The doses were repeated several times and increased in quantity, yet no effect was observed upon the tumors. They were removed, and examination showed the one to be a lipoma and the other a carcinoma (of anus).

With five other dogs, however, there was a more or less marked effect upon the tumors. After several injections (remote from tumors) the color of the tumors became of a bluish-red and the tumors themselves were warmer and more sensitive to the touch. Subsequently there occurred a softening and necrosis of the neoplasms.

"In two cases these latter changes manifested themselves with astonishing rapidity." After the treatment had been continued a short time the remaining portions of the tumors were extirpated and examined. Two were found to be *sarcoma* and three *carcinoma*. In all there was found a condition of fatty degeneration and necrosis, with an infiltration of polynuclear leucocytes from the blood.

Spronck very properly admits that such changes frequently occur in malignant tumors; hence it would be difficult to prove the entire effect to be due to the injections; yet in view of the symptoms following the injection, and the change in the tumors dating from the beginning of such injections, a causative relation seems indisputable.

One of his experiments upon dogs is worthy of special note. A large dog, cachectic, had a *very hard* tumor the size of an infant's head, situated in the region of the right shoulder. It was a local recurrence from a small tumor which had been extirpated the previous year. On the fourth day of the treatment the tumor developed a slight swelling and at the same time it became a bluish-red color, warmer and more sensitive to touch. Shortly afterward the consistence of the tumor diminished, and on the eighth day fluctuation was present. Three days later the entire tumor was transformed into a soft fluctuating mass, covered only by the skin. Incision was followed by the escape of a voluminous sac filled with a puriform liquid in which were suspended necrosed fragments of tumor, which proved on microscopic examination to be composed of detritus of the tumor and a large number of leucocytes. Somewhat later the dog died.

The autopsy showed that of the entire tumor there remained only a small fragment the size of a pullet's egg, where the tumor had been adherent to the skin. Microscopical examination proved it to be *adeno-carcinoma*. There can be scarcely any doubt that these wonderful changes were produced by the toxic products of erysipelas, and when we reflect that the tumor was *carcinoma*, and not *sarcoma*, the significance is far greater.

With the co-operation of Meulen, Renssen, Salzer, and seven other physicians, Spronck extended his experiments to twenty-five inoperable malignant tumors in man—eight sarcoma and the remainder carcinoma.

The same preparation of toxic products already described was used, and the injections were made, without exception, at points *remote* from the tumor. The utmost care was used in these experiments, and the doses were very small. The effect upon the tumors was by no means constant. In a certain number there was no appreciable change; in a second class, they continued to increase in size, but the growth appeared retarded; in a third class, there was *complete arrest* of growth; and in a fourth *diminution* in size took place.

In the same patient with several tumors, the tumors did not diminish with equal rapidity; while some disappeared entirely, a total disappearance of all tumors present was not observed in a single case. In most of them the improvement was only temporary. The effect upon carcinoma was much less marked than upon sarcoma, still in one case (recurrent cancer of the breast) there was pro-

duced an almost complete absorption of the lymphatic enlargements, though they afterward returned.

The most favorable effect was observed in a case of inoperable *sarcoma* treated by Renssen. After several weeks' treatment the primary tumor, of very considerable size, *completely disappeared*, and the secondary tumors were much diminished in size.

They were no larger than a pea, with one exception, and that the size of a pigeon's egg. Failing to decrease further, they were extirpated. Sufficient time had not elapsed to determine whether or not a radical cure had been obtained.

The symptoms following the injections were very similar to those observed in my own cases, and already noted. Elevation of temperature varying with the doses used, and with different subjects, was the most constant symptom. In most cases the rise in temperature began four to five hours after the injections, never went beyond 103.1° F., and usually returned to normal at the end of twelve hours. In my cases, the temperature has a few times risen beyond 105° F., but usually it has ranged between 101° F. and 103.5° F.

I have frequently observed a much more rapid onset, a chill occurring within a quarter of an hour after the injection, quickly followed by a sharp rise of temperature. Nausea, vomiting, severe headache, general muscular pain, and malaise, were more or less constantly seen. Spronck found that the relative susceptibility of the different patients varied greatly, some being entirely refractory. I have noted the same thing in my cases, yet in one case that had failed to show any rise of temperature after frequent injections of my preparation of toxic products (sterilized without heat), showed a marked rise, 103.4° F., when cultures from the *same* source and of the same virulence, sterilized by heat, were used. The important difference, however, in the effect of the two preparations, was that the first, although producing less constitutional reaction than the heated cultures, caused a *diminution* in the size of the tumor (sarcoma), while the second failed to even check its growth. My experiments in this case, together with others carried on in 1892, with cultures sterilized by heat, have convinced me that a portion at least of the value of the toxic principles is destroyed by a temperature of 100° C.

Although I had practically arrived at this conclusion almost a year ago (before the publication of Spronck's cases), I was unable to obtain a good preparation of toxic products of erysipelas sterilized without heat, until February, 1893. My results, although they cover a smaller number of cases than Spronck's, are yet more remarkable. In one case the sarcomata have entirely disappeared under injections of toxic products, and the patient is still free from recurrence. In a second case, a very large inoperable sarcoma of the abdominal wall, the tumor has so far diminished in size that only a small nodule remains. In two others there was decrease in size, and they are still under treatment.

The remaining cases are too recent to more than mention. In one, however, the improvement has been very doubtful. The elaborate investigations of Roger with the toxic products of erysipelas, upon animals, recently published in the *Rev. de Méd.*, December, 1891, show that instead of a single toxic principle, the erysipelas germ grown in bouillon forms a considerable number of soluble products, some of which differ so widely from others that they are directly antagonistic. He further found that these toxic products were capable of killing animals in doses of 13 to 20 c.c. per kilogramme weight, and that they are precipitated by alcohol and destroyed by heat. He also found that *filtered* cultures *not heated*, in doses of 5 to 12 c.c. injected into the circulation of rabbits, exercised a predisposing action, making the animal more susceptible to inoculation. On the other hand, *heated* cultures (104–110° C.) rendered the animals immune. In extremely large doses these products produced a more or less chronic form of septicæmia, which caused death in periods varying from a few hours to several weeks. Space will not permit a more detailed account of these experiments. They are cited to prove that in the soluble products of erysipelas, we have a very powerful and complex combination of active principles; that some are directly antagonistic to others; and finally, that heat has a very decided effect upon them. Aside from the difference in the method of preparation of the soluble products of erysipelas, my experiments differ from Spronck's in the fact that he sought for a systemic action alone, whereas I have endeavored to obtain both systemic and local action by making the injections into the tumor, or its immediate vicinity, and I believe my results show this to be the better plan.

Spronck, in conclusion, says: "If in man, the results have been less satisfactory (than in dogs), one should not lose sight of the numerous difficulties that lie in the way of these first attempts toward a clinical application, or of the unfavorable conditions in which we have been placed, or finally, of the fact that in nearly all of the patients the tumors were in a very advanced stage." He further states: "I believe that I am authorized to conclude that the products of erysipelas, in certain cases at least, can act in a curative manner upon malignant tumors."

In addition to the 18 cases of my own, treated either by pure living cultures of erysipelas or by the soluble products, I have collected and tabulated all the reported cases of carcinoma and sarcoma in which erysipelas, either spontaneous or artificial, intervened. It is upon a careful study and analysis of these cases, as well as upon the more practical experience derived from my own cases, that my conclusions are based. Time will not permit me to go into these in detail, and I can do nothing more than give a brief summary of the results.

We find a total of 43 cases of malignant disease in which an erysipelas has occurred, either by accident or by intent. Of these 43 cases the erysipelas occurred accidentally in 26 cases, and was the result of inoculation in 17 cases (including my own); 20 cases were carcinoma, 19 cases were sarcoma, 4 either sarcoma or carcinoma. The immediate and final results were as follows:

Carcinoma.—Of the 20 cases, 3 were permanently cured. In addition, 1 case of probable carcinoma (Hutchinson's) was well five years after the attack of erysipelas. Of the remaining 16, 11 showed improvement which, although temporary, undoubtedly added to the life of the patient in most cases. One case (Janike's) died, as a result of the erysipelas, on the fourth day.

Sarcoma.—In turning to sarcoma we find the curative action of the erysipelas even more marked, Of the 19 cases of sarcoma we find eight, or forty-two per cent., well and free from recurrence from one to seven years after the attack of erysipelas. Nearly all of these 7 cases have a remarkable history. The case of Dr. Bull and Dr. Gerster, and two of my own have already been described.

The remaining 4 were as follows: The first (Biedert's) was a very large round-celled sarcoma, involving mouth, face, nose, and orbit of a child ten years of age. The features were greatly distorted, and the general condition so bad that death from exhaustion was anticipated soon. While in daily expectation of being obliged to do a tracheotomy, a severe attack of facial erysipelas occurred. The tumor disappeared, as if by magic, during the course of the erysipelas. The child recovered, and at the end of a year was perfectly well, with no indication whatever of a recurrence.

The next case (Bruns') was a melanotic sarcoma of the breast, with entire disappearance and no recurrence.

The sixth case (Busch's) was a multiple sarcoma of the face that entirely disappeared after an attack of facial erysipelas, and did not return.

The seventh case (Klechlatt's) was a lympho-sarcoma of the neck, very large; the erysipelas in this case being the result of inoculation.

In addition to these seven cases there is one other, a probable sarcoma of the breast, that was cured. Ten of the remaining eleven showed more or less marked improvement; in some cases the tumor entirely disappearing, and not recurring for several months. One case died as a probable result of the erysipelas, which was in this instance accidental, and a second died from inoculation.

These cases have been in no way selected, and I have made every effort to include all cases resting upon competent authority; yet it might be urged as an objection to accepting these figures as representing the true percentage of cures, that cases have probably occurred which, owing to no marked improvement following the erysipelas, naturally failed to be reported. This objection, though valid as far as the accidental cases are concerned, would cease to hold in the cases of inoculation for the reason that, being so few in number, all, or nearly all, have probably been reported.

Grouping by themselves, then, the cases where the erysipelas was artificially produced, we find 7 cases of carcinoma, 1 cure, or 14.3 per cent., and 8 cases of sarcoma, 3 cures, thirty-seven per cent. These cases were as follows: Fehleisen, 2; Kleeblatt, 2; Busch, 1; the remaining 3 cases being my own.

These figures may then be taken to fairly represent the curative effect upon carcinoma and sarcoma in the worst cases; and when we reflect that in nearly every instance the tumor was not a primary growth, amenable to operative treatment, but either a recurrence after operation had been tried and failed, or from its nature inoperable, then, and then only, are we in a position to fully estimate the importance and value of erysipelas as a *curative* agent.

In a former paper (vid. supra) I referred briefly to the different theories offered in explanation of this benign action, and even then I was inclined to believe it due to "antagonistic bacterial action," the neoplasm being regarded as dependent upon some unknown micro-organism.

Since that time the evidence in favor of the micro-parasitic origin of cancer has been steadily and rapidly accumulating until, at the present moment it amounts to almost an absolute demonstration. Time will not permit more than a brief mention of the more salient points of this evidence, yet since a proper appreciation of its character and strength is necessary to anything like a clear understanding of the probable action of erysipelas upon malignant tumors, we cannot pass over it unnoticed. We shall consider:

1. *The Close Resemblance of Cancer to other Diseases known to be of Bacterial Origin.*—The striking analogy between cancer and tuberculosis was noticed long before the tubercle bacillus was discovered. Sir John Simon in 1877, clearly pointed out this analogy, and in fact even then argued very strongly in favor of a micro-parasitic origin of cancer. His paper states the points at issue so clearly and briefly, and moreover the facts adduced and the conclusions drawn—showing as they do an almost prophetic insight—make it a paper that can be read with the greatest interest and profit to-day. He pointed out the error in the earlier investigations in allowing the "anatomical forms," interesting enough in themselves, to obscure the more important "property of infectiousness," which he regarded as the "real puzzle" of the disease. "The anatomical forms are matters of mere local accident, but the infectiousness of cancer represents its very cause." He showed that the element of heredity plays an entirely different *rôle* in cancerous and non-cancerous tumors; that while in the latter the hereditary influence often seems to be the *entire* cause of the tumor—an "embryonic fault" belonging to the same pathological class as supernumerary toes and fingers,—in *cancer* it supplies only that portion of the cause which, as in tuberculosis, is familiarly known as *predisposing conditions*. This opinion we know is generally accepted at the present day. There is, moreover, a growing tendency to no longer adhere to the stereotyped classification of tumors, and we venture to predict that in the near future, instead of "tumors," a class at present embracing elements without the remotest analogy, either in their etiology or mode of development, we shall have two main groups—the first of which might be designated as *congenital hypertrophies*; the second, *neoplasms*, etiologically dependent upon infection from without.

This statement may seem a trifle strong, since Cohnheim's embryonic theory of the origin of cancer is not only still held by the larger body of medical men, but has quite recently been maintained by Baumgarten in Germany as well as by distinguished pathologists in this country. In spite of all the objections and criticisms, the micro-parasitic theory has steadily gained ground, and just now the confirmations are rapidly outnumbering the objections. These objections, the most of which were formulated by Cohnheim himself, ten years ago, have nearly all been answered. He argued that cancer could not be of microbic origin, first, because it was neither epidemic nor endemic. Tuberculosis is neither epidemic nor endemic, yet is due to Koch's bacillus. Malaria is neither contagious nor epidemic, yet is caused by an intra-cellular parasite; again, tetanus is not contagious, and hardly more endemic than cancer itself, as shown by the researches of Haviland, and confirmed by recent investigations.* The second objection was, that cancer could not be inoculated from one individual to another or to animals.

Cancer has been transferred from one part of the body to others in the same individual (Hahn and Von Bergmann) by inoculation, and moreover, it has been transferred from one animal to others in a few cases. That most of the experiments in inoculating animals have failed is really no objection to the theory. We know that there are many vegetable and animal parasites whose life history embraces a long cycle of changes in form and development, only a brief portion of which is found in the "host."

The *evolution* of *parasites* is a subject of great interest and importance, yet one that, as yet, has been but little investigated by the trained naturalist and biologist.

For a clear understanding of the "laws of parasitism," and their relation to specific diseases, we are much indebted to the recent and valuable contribution of Dr. Joseph Frank Payne, of London. If his view, that there is a definite relation between the contagiosity of a specific disease and its chronicity, be correct, we at once see a striking analogy between cancer on the one hand, and leprosy and tuberculosis on the other, and there is no need to go further for an explanation of the slight contagiosity of cancer. Ballance and Shattuck go so far as to assert that "there is no fact in the etiology or life history of carcinoma or sarcoma that has not its counterpart in tuberculosis."

2. *Analogous Diseases in Animals and Plants known to be of Parasitic Origin.*—In the vegetable kingdom we find a large variety of "tumors" known as "galls." One by one these have all been proven to be of parasitic origin. If we turn to the lower animals, we find in "coccidial infection" an analogy so striking, that many observers have considered it identical with cancer. Without entering into any discussion of this question, this much may be regarded as proven: That certain low organisms or protozoa known as coccidia, have been found in animals, chiefly rabbits; that they possess the very *rare* property of being able to set up a proliferation of epithelium; that in the animals in question, and at least in one case (Leuckhart's), if not in two cases in man, they have produced multiple tumors associated with the same clinical symptoms and pathological changes that are found in true cancer.

We must further admit that several independent observers, notably Sawtschenko on the Continent, and Ruffer and Walker in England, by the use of improved methods of staining, have been able to demonstrate the constant presence of protozoa in a very large number of specimens of carcinoma. That these are true parasites and not "invaginated cells" or "degenerated metamorphoses," as many have been inclined to regard them, has been very recently confirmed by the testimony of Metschnikoff, the highest living authority in micro-zoölogy.

These protozoa are so similar to the coccidia already referred to, that they can scarcely be differentiated. Whether or not they are identical, seems to me a matter of indifference; that they are very closely allied forms seems more than probable. That they have not yet been cultivated outside the body is no evidence against their

* The researches of Gueilliot prove cancer to be mildly contagious.

being the cause of cancer, when we consider how much time it has taken to discover their mere presence.

If, with a distinguished authority, we admit that "for the development of cancer it is necessary that there should be a continuous irritation, and one capable of multiplication," and knowing as we do that the irritants capable of fulfilling these conditions are limited almost entirely to the animal and vegetable parasites, we can scarcely fail to accept the micro-parasitic theory. The great merit of this theory, as Ballance and Shattuck have pointed out, is that "it not only offers a working hypothesis for further investigation with which none other can compare, but it holds out the hope that it may one day admit of scientific treatment based on the same lines as other micro-parasitic diseases." Having endeavored to make clear the grounds for believing in the parasitic origin of cancer, the explanation of the action of erysipelas is not difficult. If a small quantity of blood-serum of an animal rendered immune to tetanus is capable of destroying or rendering inert the virulent bacilli in a fresh case, it is quite as easy to understand that the toxic products of the erysipelas streptococci might bring about such changes in the blood-serum as to destroy the parasite of cancer. The parasite having been destroyed, the irritation would consequently cease, and this would lessen the hyperæmia of the parts, upon which factor the life of the tumor-cells of low vitality largely depends.

This theory, if it may be called such, has occurred to me as offering the best explanation of all the phenomena observed. It explains the rapid degeneration, with a breaking down of the tumor tissue, as well as the slower disappearance by absorption. It also explains those interesting cases, several in number, where an erysipelas remote from the tumor has caused a disappearance in precisely the same way as a local attack. These latter cases, it would seem, prove the phagocytosis theory insufficient to explain the action of erysipelas. It is worthy of note that the action of erysipelas upon lupus and the secondary and tertiary lesions of syphilis (see Mauriac) is similar to that in malignant tumors, and this fact, joined to the fact that erysipelas has never been known to affect non-malignant tumors, is another point in favor of the parasitic origin of cancer. The attempt to explain its action on the theory of a mere local irritation, classing it with the various caustics, needs only to be mentioned to be disproved.

The clinical facts already mentioned, that a number of malignant tumors have disappeared as a result of an erysipelas in another region of the body, coupled with the very recent experiments of Professor Spronck and his co-workers, settle the point beyond dispute.

Dangers Associated with Erysipelas.—I have endeavored to ascertain as far as possible the actual mortality of uncomplicated erysipelas. Nearly everything that has been written upon the subject is of little value in determining this point, because the term "erysipelas" has been used in a very loose way, including many cases of cellulitis and septic infection. I do not believe in the identity of the streptococcus of erysipelas and the streptococcus pyogenes, although I am aware that the opposite opinion is held by many of the leading bacteriologists. Those who hold to the identity of the two germs, base their opinion largely upon the close resemblance, morphologically and biologically, and they claim that the clinical differences are due to the different sites of infection and variations in virulence of cultures; that the same germ in the outer layers of the skin will produce true erysipelas; that injected deeply into the tissues it will cause cellulitis and multiple abscesses. I believe this explanation to be entirely theoretical and not supported by facts. During the course of these experiments I have injected, upward of one hundred and fifty times, pure cultures of the streptococcus of erysipelas, of almost every degree of virulence, into the (human) tissues, superficially and deeply. In but two cases did I see an abscess, and in one of them a careful bacteriological examination was made of the pus (before it had become contaminated), and mixed cultures were found, the staphylococcus aureus being present with the streptococcus.

There appears to be good ground for believing that when suppurative processes are associated with erysipelas, a mixed infection is present, and that there is a real and important difference between the germ of erysipelas and the streptococcus pyogenes, in spite of their close resemblance. The fact that they are pathogenic for different animals respectively, and also their different action with reference to lactic acid, are other points against their identity.

The most elaborate, as well as the most recent, investigations on the subject of the identity of the streptococcus of erysipelas and the streptococcus pyogenes, were made by Professor Cruikshank and reported at the last International Congress of Hygiene and Demography (1892, vol. ii., sec. ii.). The results of these investigations were against the identity of the germs.

If we include the cases of diphtheria inoculated with erysipelas (Babtschinski), we have a total of forty cases where erysipelas has been artificially produced, with but two deaths—five per cent. We know that the virulence of the germ varies within wide limits, and that it can be modified at will by passing it through animals; therefore it seems reasonable to assume that with proper precautions its mortality in inoculation can be made trifling or *nil*.

Conclusions.—1. The curative effect of erysipelas upon malignant tumors is an established fact. 2. The action upon sarcoma is more powerful than upon carcinoma. 3. The treatment of inoperable malignant tumors by repeated inoculations of erysipelas is both practicable and not attended with great risk. 4. The curative action is systemic as well as local, and probably due chiefly to the toxic products of the streptococcus, which products may be isolated and used without producing erysipelas. 5. This method should *not be employed indiscriminately* until further experiments have proved its limitations.

William B. Coley.

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SAW PALMETTO. This palm, *Serenoa serrulata*, forms the common palmetto scrub of South Carolina, Georgia, and Florida. The whole plant has marked demulcent and nutritive properties, and is extensively used as a local remedial agent in all forms of disease of the mucous membranes, especially when associated with debility and wasting. Its use is followed by an improved digestion, increased strength and flesh, and a soothing influence on any irritable state of the membranes. It is used in catarrh, ozæna, and bronchitis, and has a special value in diseases of the bladder and reproductive organs. Reginald Harrison has found it very beneficial in irritable states of the bladder, and compares its action to pareira. It is also reported to be of benefit in affections of the prostate gland. Another property that is claimed for it is its vitalizing and strengthening action upon weakened and wasted glands of the generative organs. It is said to cause a rapid development of the mammæ, ovaries, and testes, when these organs are debilitated as the result of masturbation and sexual excessess of all kinds.

The fluid extract of the seeds is the most convenient form for administering the drug; it is given in half to one drachm doses, repeated three or four times a day.

Beaumont Small.

SCOLIOSIS. No new facts as to the pathology and etiology of scoliosis have recently been advanced, though the writer has observed cases that clinically present all the symptoms of tubercular spondylitis, except the posterior knuckle of that disease, and in their course are quite unlike the ordinary cases of scoliosis. It being now recognized that one of the earliest symptoms of spondylitis is a lateral curvature of the spine, and this lateral curvature, if sufficiently severe and prolonged, presents the same evidences of rotation of the vertebræ that are found in scoliosis, it has been suggested that some cases of scoliosis may be truly cases of the dry form of spinal caries in which the lateral deformity has obscured the usual long, rounded posterior curvature. The treatment to which these cases have been subjected appears to confirm this view, that is to say, they have grown steadily worse under manipulations and exercises, and steadily better under immobilization. Be this as it may, the observation has an important bearing upon treatment, a point to which reference will again be made.

In advanced cases of scoliosis the deformity is so entirely different from the usual deformity of Pott's disease, that there will be no difficulty in making the diagnosis; but in cases of slight deformity such is not the case, and without observing the patient for some time, or noting the results of treatment, it may not be possible to differentiate. The primary curve of scoliosis is usually first noticed in girls at about the age of puberty; it is, as a rule, located in the mid-dorsal region with the convexity to the right. The lateral deviation of commencing spondylitis is quite as often found in younger children, in boys, with convexity to the left and in any portion of the spine.

Potts' disease is often accompanied by distant pain; scoliosis never is, except in old and very great deformities. In Pott's disease the patient often moves and bends with anxious care; in scoliosis this is wanting. But the chief diagnostic point is the rigidity of the curvature. In Pott's disease the curve is rigid from its very beginning and to motion in all directions; in scoliosis it is not at all rigid for some time, and then only in the direction of diminishing the curvature: and not until true synostosis has taken place in the concave side is it rigid to bending in all directions. Forcible manipulations to correct the curvature, and exercises, increase the rigidity and the deformity in Pott's disease, but reduce both rigidity and deformity in scoliosis.

Treatment.—At the present time there are three well-defined plans of treatment, namely, by exercise alone; by exercise and some form of removable retention cor set or brace; and by forced correction of the deformity and retention by permanent plaster jacket, to be followed subsequently by a removable corset and exercise, and ultimately by exercise alone.

The most well known method of treatment by exercise alone is that of the Ling system of Swedish gymnastics. This we will not describe, inasmuch as we believe it has been improved upon by Mr. Bernard Roth, of London. The key-note of Mr. Roth's work is that he puts the patient in such posture as will most perfectly correct the deformity, and in that posture exercises him. Many of the exercises are conducted while the patient is recumbent, the best posture at first being during recumbency. The exercises are administered daily for three months, the patient then continues them at home for three months; again they are administered by the surgeon for two months, and then at home for six months; then by the surgeon for one month, and finally at home for one year, when the final examination and record is made. Roth does not expect to correct any osseous change, and only claims to make the patient hold himself habitually in that best posture which he can maintain for a few minutes at the first examination.

The exercises are as follows:

1. Lying on back; arms by the sides of the body; palms upward; slow, deep inspiration by the nose; slow expiration by the mouth. (Repeated four times.)
2. Similar exercises with the arms extended by the sides of the head. (Repeated four times.)
3. Same position as 1; head rotation on axis to right and left alternately. (Repeated four times.)
4. Lying on back; simultaneous circumduction of both shoulder-joints from before backward; elbows and wrists kept extended. (Repeated twelve times.)
5. Lying on back; one hip circumduction both ways; knee kept extended. (Repeated ten times.)
6. Lying on back; simultaneous extension of arms upward, outward, and downward, from a position with the elbows flexed and close to the trunk. (Repeated four times.)
7. Lying forward; one hip circumduction both ways; knee kept extended. (Repeated ten times.)
8. Sitting on couch, with back at an angle of forty-five degrees; ankle circumduction down, in, up, and out, while the toes are directed inward the whole time. (Repeated twenty times.) Also foot adduction, patient resisting, abduction, surgeon resisting. (Repeated eight times.) (For flat-foot.)
9. Lying on back; with arms extended upward by the sides of the head; flexion of both arms, surgeon resisting by grasping the hands, followed by extension, patient resisting. (Repeated six to eight times.) (The patient's knees flexed over the end of the table, fix his trunk.)
10. Patient astride a narrow table or chair without back, with arms down and hands supinated; trunk flexion at lumbar vertebræ, patient resisting slightly, fol-

lowed by trunk extension, surgeon resisting by his hand against the back of patient's head. (Repeated six to eight times.)

11. Patient, with arms extended upward, stands with head, back, and heels against a vertical post with pegs on each side, which he grasps. The surgeon gently pulls the patient's pelvis forward by his hands on the sacrum, patient resisting; and then the patient moves back the pelvis to the post, surgeon resisting. At no time are the patient's heels to be raised from the floor. Also pelvis rotation on its axis to right and left alternately, surgeon resisting with his hands on each side of pelvis. (Repeated six to eight times.)

12. Lying on back, with head and neck projecting beyond the end of the table; arms by the sides of the body, palms up; the head is gently flexed by the surgeon's hand on the occiput; patient resisting, followed by head extension, surgeon resisting. (Repeated eight times.)

The second plan of treatment aims to constantly maintain the best possible posture, by aid of some removable corset or brace, and at the same time to develop the muscular system by exercises. Moderately severe cases ultimately lay aside the support, but the inveterate deformities must be supported a very long time. The most readily applied support is the plaster-of-Paris corset. It is applied in the same manner as the ordinary plaster jacket, but before fully setting is cut down the front, sprung off, and after being trimmed out, covered, and supplied with laces, is applied to the patient, who is partially suspended as in the original application of the jacket. A well-made plaster corset will last from two to six months.

For the sake of having a more durable corset various substances have been employed. Three only merit description: The leather corset as made by Dr. A. J. Steele, of St. Louis; the Waltuck wood corset as made by Dr. A. M. Phelps, of New York; and the paper corset as made by Dr. L. A. Weigl, of Rochester. In making either of these corsets a plaster jacket is first made upon the patient partially suspended. This jacket is filled with plaster-of-Paris cream, which sets to form a cast of the patient. Upon this cast the corset is constructed.

The Leather Corset is made from a kind of leather, undressed with oil, known as saddle skirting. It is soaked in water until quite soft, wrapped around the plaster mould, and wound with a small, strong rope. This rope must be wound very snugly, and for this a specially devised machine is necessary. It is quite impossible to draw the rope by hand sufficiently tight to force the leather into place. The whole is then subjected to a baking process to harden the leather. The heat used must not be too extreme, or the leather will become brittle. It is then bored with small holes, lined with kid, and supplied with hooks for lacing.

The Wood Corset, devised by Dr. Joseph Waltuck, of Odessa, Russia, and introduced into this country by Dr. A. M. Phelps, of New York, is made as follows:

Suspend the patient after the tight-fitting shirt has been applied. Indicate with the blue pencil marks around the body on the shirt, the length of the corset desired. Apply the plaster-of-Paris bandages as in making an ordinary plaster-of-Paris corset. When the plaster is set, remove it from the body by cutting it down in the front. Strip out the shirt from the corset, when the blue pencil marks will be seen on the inside of the plaster corset.

A few turns of the plaster bandage around the plaster corset are necessary. Put in a large dish a quantity of oakum picked up finely. Mix with this a quantity of plaster-of-Paris. After having greased the inside of the corset with vaseline, stir water into the plaster-of-Paris and oakum until it is of the consistency of thick mud. Apply this over the inside of the corset to the thickness of three inches. After it is set remove the corset, and a perfect cast of the body will be the result. The blue line will be transferred from the plaster mould to the cast. The oakum is put in the plaster to facilitate the modelling, and also to make the cast tough, because

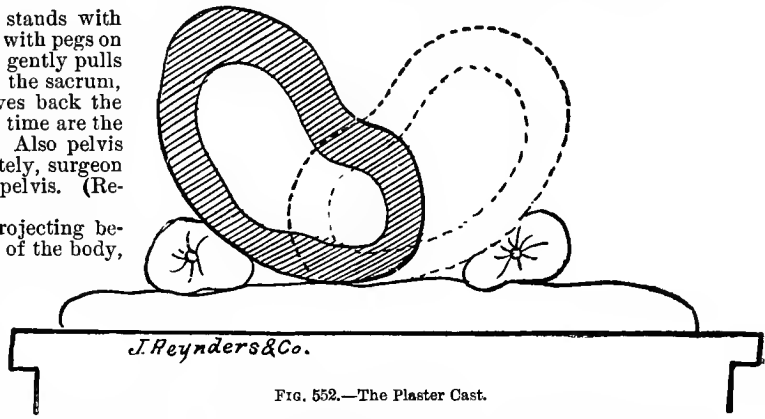

Fig. 552.—The Plaster Cast.

considerable hammering has to be done upon it. The cast should dry two or three days in a temperature not

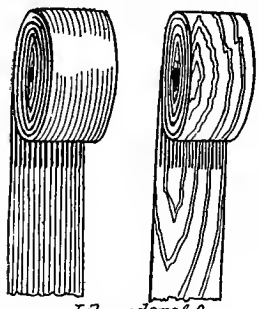

Fig. 553.—Proper Grain.

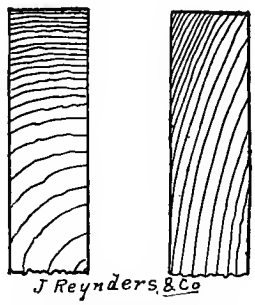

Fig. 554.—Imperfect Grain.

exceeding one hundred and fifty degrees. Any imperfection in the cast should be remedied with plaster-of-Paris, building out such points over the breast and hips

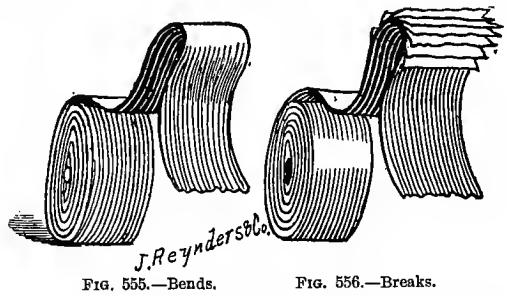

Fig. 555.—Bends.

Fig. 556.—Breaks.

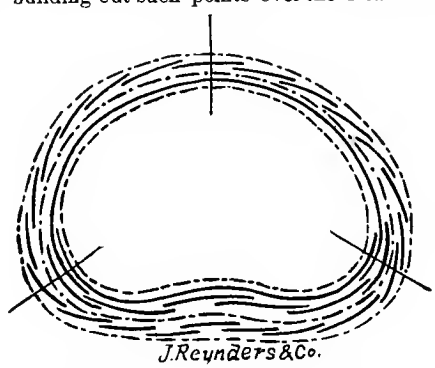

Fig. 557.—Shows Layers of Wood and Linen.

and deformed portions as may seem necessary to make an artistic corset. Cover the cast with raw linen which has been wet for the purpose. Some difficulty will be experienced unless the workman has seen the work done. The cast is placed on a table with the sandbags, as seen in Fig. 552.

The wood from which the corset is made is taken from the edge of a plank the grain of which is as seen in Fig. 553. Fig. 554 shows imperfect grain. The grain running as in Fig. 553 makes a tough strip that will bend as seen in Fig. 555. When the grain runs as in Fig. 554 and the wood is bent, it will present the appearance of Fig. 556, which has an element of weakness.

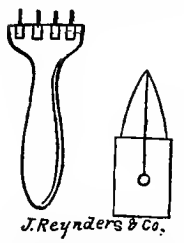

Fig. 558.—Tool for Splitting Wood, and Pincers Used in Construction of the Corset.

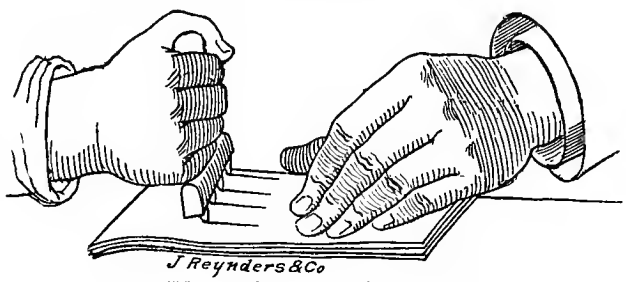

Fig. 559.—Splitting Several Thicknesses at Once.

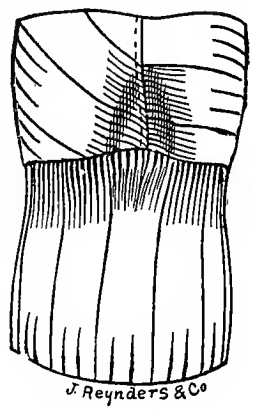

Fig. 560.

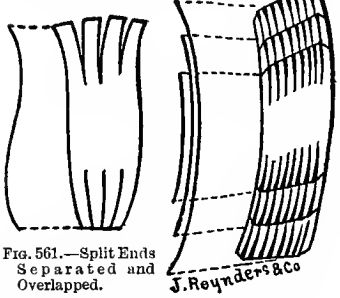

Fig. 561.—Split Ends Separated and Overlapped.

The layers of wood and linen are explained in Fig. 557, the dotted lines being linen, the black lines wood, and it will be seen that there are three layers of linen and two of wood in the front of the corset, with three layers of linen and three layers of wood in the back and side.

Over the hips extra pieces are put in, making it even thicker, which will be explained later.

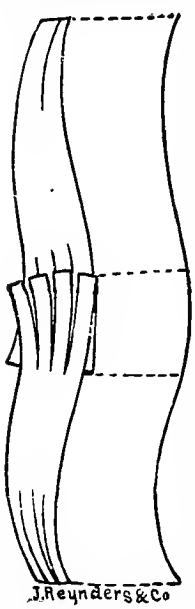

Fig. 562.—Spreading and Lapping Split Ends.

The cast is now laid with the back up. Draw three longitudinal lines, one in the centre in front, and one on each side, dividing the cast in three equal parts. Cut several strips of wood in length long enough to overlap the lateral lines two inches.

With the tool, Fig. 558, split the ends of the wood as seen in Fig. 559. The object of this is to allow the ends of the wood to spread or to overlap, so as to fit all inequalities, as seen in Figs. 561, 562, 563, 564, and 565. Prepare the glue by soaking it in water over night, then melt it. To a pot (holding one quart) of glue, add one tablespoonful of glycerine. Dip the glue-brush into the glue, wiping it as dry as possible on the edge of the pot, so as to use the least possible quantity.

A strip of wood is covered with glue, and the brush drawn along the part of the cast where the wood is to be laid, beginning at the top of the cast with a transverse layer; strip after strip is applied, and overlapping the strip above one-eighth of an inch. Cover this layer of wood with the linen and glue, and hammer the whole together. Turn the cast on the side, and working from the centre in front, put the strips on horizontally, overlapping the strips already on two inches. Cover this with linen, lapping on the back two inches. Finish the opposite side in the same manner.

Beginning in the back, put on the strips longitudinally, overlapping four inches in the centre of the cast from the top and bottom. Left side.

Hammer the wood well together with an ordinary shoemaker's hammer. Now stay the corset with wood over the hips, and also strengthen the corset by putting on another layer of wood diagonally from the shoulder to the opposite hip, meeting at a point in the centre of the waist. Cover the entire work with linen, putting the least amount of glue on the wood before the linen is applied. After twenty-four hours the corset can be removed from the cast, fitted to the patient, and sent to the trimmer, who will treat it in the following manner. Corsets made according to the method followed at the time I observed the process, were not as perfect as they should be.

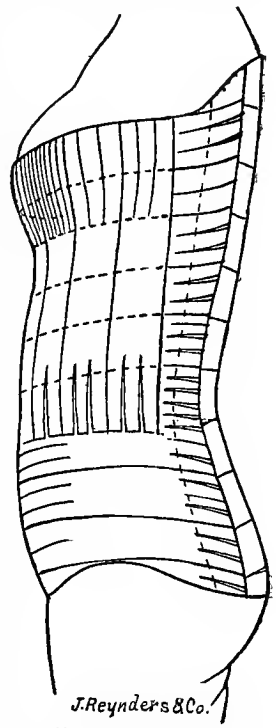

Fig. 563.—Showing the Relation of the Horizontal and Vertical Layers.

1. The slightest excess of glue moistened by the perspiration of the body coming in contact with the shirt or the skin, was exceedingly disagreeable. 2. The perforations in this corset weakened it, and allowed the glue to exude during perspiration.

To obviate all this, the corset has been perforated, as seen in Fig. 568, in which perforation eyelets are punched. A special machine facilitates the perforating and the punching of the eyelets. The lacings are stitched on as in Fig. 568. Trim the top and bottom with kid. The entire corset is shellacked inside and outside with two or three coats of shellac, which renders it impervious to moisture, the eyelets ventilating it perfectly.

Weigl's Paper Corset.—The corset is constructed of paper and linen, on a cast of the patient's trunk which is obtained in the usual way. The cast should be as smooth as possible, and may be either solid or hollow.

The paper employed is known as pulp paper, such as is used for obtaining the matrix for stereotyping forms in newspaper offices.

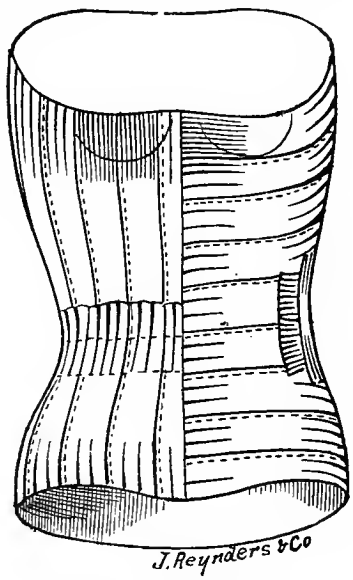

FIG. 564.—Showing Manner in which Layers are Lapped and Waist Strengthened.

The proper manipulation of the paper is an essential feature. It should be saturated with water and the excess removed by placing it between towels or cloths. It is then cut in strips of suitable width and length, according to the size of the jacket to be made. The details in making the jacket are substantially the same as those of the wood corset, Fig. 567, the difference being in the material used and the method of finishing.

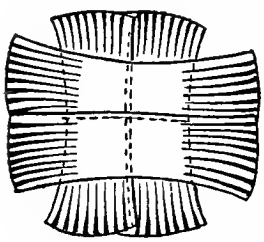

FIG. 565. — Arrangement for Strengthening Corset over Hips.

The various steps are as follows: A piece of the linen thoroughly dampened is smoothly stretched on the

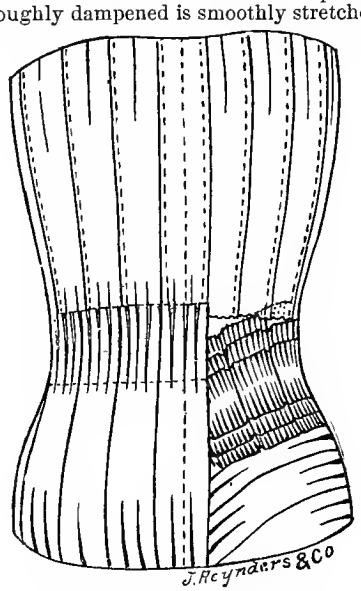

FIG. 566.—Rear View of Fig. 564.

cast and secured by tacking it along a line drawn in the centre of the cast, in front and around the top and bottom of the cast. In subjects with well-developed breasts and hips, the application of the linen will be much facilitated

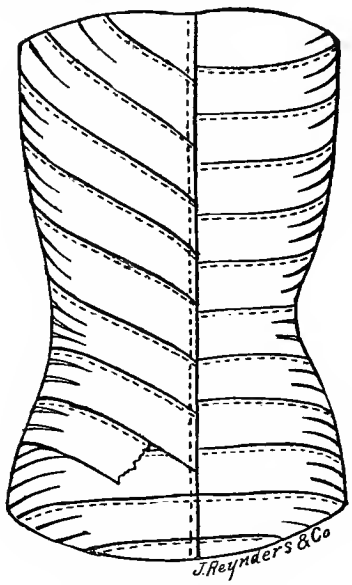

FIG. 567.—Showing Oblique Layers.

by approximately fitting it to the cast by sewing seams of proper shape along the axillary lines, after the manner of fitting dress waists to the form. The first layer of paper is now pasted on this foundation, in vertical strips, the strips overlapping each other about three-eighths of an

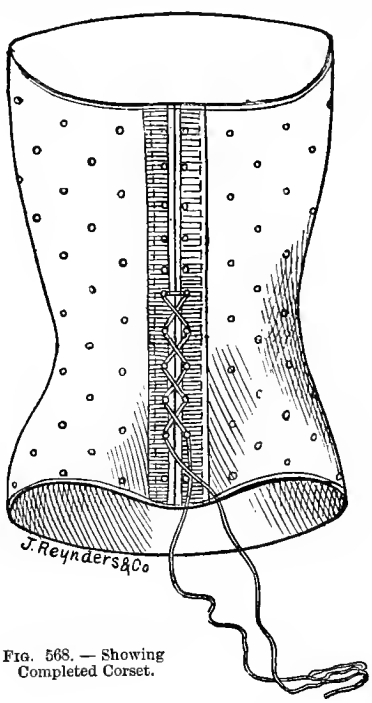

FIG. 568. — Showing Completed Corset.

inch. The paste most suitable is that known as Boston steam paste, such as is used by paper-hangers, bill-posters, etc. The second layer of paper is applied horizontally. Next a layer of linen is put on, which may be in strips

of any width. Two layers of paper strips are now applied obliquely, followed by another layer of linen, and finally two more of paper, one horizontal and the last vertical. If desired, a layer of linen may be put on as a finish, but it is not essential. Any individual points may be strengthened by applying short strips crossing each other, or built up like a wagon spring. The jacket is allowed to dry thoroughly on the cast before removing it. This secures freedom from warping. The drying may be hastened by resorting to artificial heat, as the jacket is unaffected by even a high temperature. When dry the jacket is removed from the cast by taking out the tacks which secured the first layer of linen, and trimmed as may be necessary. It is then perforated by a drive-punch. To render the corset thoroughly waterproof, it is enamelled inside and outside with about two coats of Devoe's white enamel paint, applied with an ordinary flat brush. When this is thoroughly dry and hard, the edges are bound with soft leather, alum-tanned sheep skin being the best. The easiest way to bind the corset is to glue the leather on with a liquid glue. The straps with lacing hooks are sewed on. Shoulder straps, steel strips, head-rests, etc., may be readily riveted to the jacket.

Forcible Correction and Permanent Retention. — The third plan of treatment, that of forcibly correcting the deformity and retaining the correction by a permanent plaster jacket, owes its recent development to Hoffa, of Würzburg, and Bradford, of Boston. The apparatus illustrated in Figs. 569 and 570 is Bradford's modification of Schede's apparatus for forcible correction, and is used as an exercise for stretching the shortened parts, or as a means for gaining an improved posture preliminary to the application of a permanent plaster jacket. The appliance is a standing frame made of steel rods. The whole is furnished with arrangements for vertical traction, for fixation of the pelvis and shoulders, and for direct screw pressure upon any part of the thorax which may project abnormally.

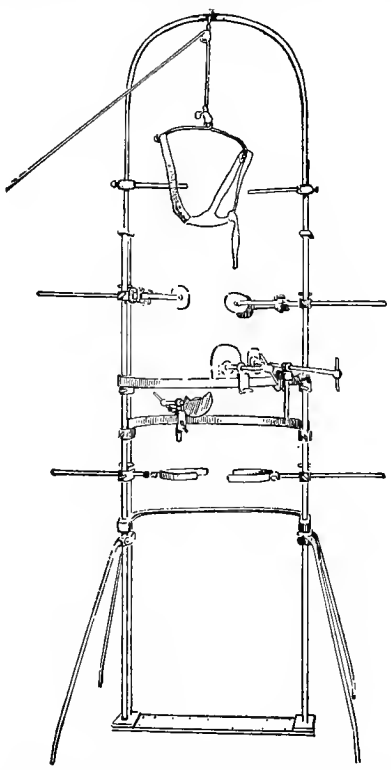

FIG. 569.—Bradford's Modification of Schede's Apparatus.

The frame is eight feet high and three feet wide, and consists of two side pieces, six feet high, connected above by an arched rod of steel, and below by a flat plate which serves as a standing basis. Each side is formed of two parallel rods, three-quarters of an inch in diameter and four inches apart, firmly secured to each other above and below. Upon these two parallel rods run blocks of steel,

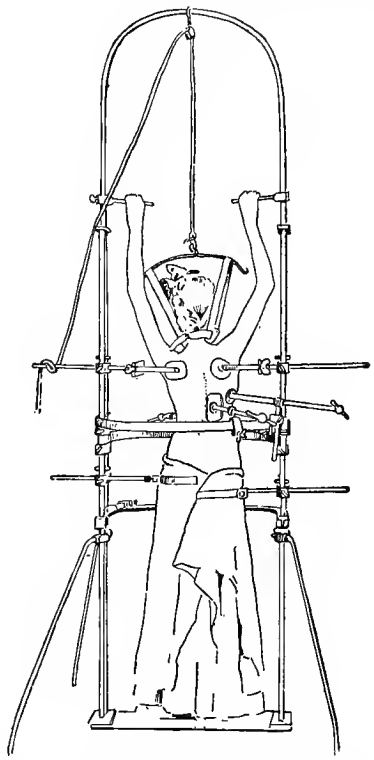

FIG. 570.—The Same Apparatus, with Patient in Position.

which may be set at any height by means of a thumb-screw. The lower of these on either side is perforated for a sliding, horizontal, square bar of steel, one-half an inch in diameter, on the inner extremity of which are fastened two curved pieces of steel, so arranged as to firmly grasp the pelvis. The upper block on either side is also perforated by a horizontal steel bar, and to this is fastened an attachment giving pressure on the shoulders in front and behind. These blocks, bars, and fixation-plates slide smoothly and can be fixed as may be required to hold the pelvis and shoulders securely.

The steel bars which carry the pressure-screws together form a half-circle, one in front and one behind, both together encircling the patient. These are attached at the sides to sliding steel blocks, and can be set at any height which is desired. The anterior bar is secured firmly at both sides; the posterior is hinged upon one side, and is then so arranged that it can be swung open in order that the patient may be put into the machine, and then be swung back and secured by a clamp to the steel block upon the other side. On the semicircular bars slide small steel blocks which can be secured at any point. Each of these blocks carries (at right angles to the bar) a rod cut with a screw-thread. At the inner end of each rod is a flat plate (made to play freely within a small arc) and at the outer end is a handle. Twisting the screw-rod regulates the pressure, which can be adjusted to any desired point by shifting the blocks. It would at first seem that it was impossible to place a plaster jacket on a patient whose thorax has been corrected by forcible pressure. It will be found, however, that if this is done with care, the pressure being increased gradually, a marked improvement in the distortion of the

thorax may be made. The patient should be placed in as nearly the corrected position as possible by means of the appliance already described, and the plaster jacket applied in the usual way, except that the bandages are wound about the trunk, avoiding the screw-pressure rods. The patient's skin is protected under the points of pressure by pieces of saddlers' felt, and even pressure is secured by thin steel plates which are incorporated in the bandages. The plaster corset is worn for a week or a fortnight, when another can be applied in a similar way with a slight increase of pressure, if practicable. It is, of course, possible to apply enough pressure to render the jacket unendurable; but short of this, it will be found that a substantial amount of pressure can be borne without more discomfort than that attending any jacket. If the jacket is split and removed the amount of correcting pressure is diminished, even though the split jacket be well laced afterward. If the greatest amount of correction is sought for persistently, the fixed bandage is to be preferred.

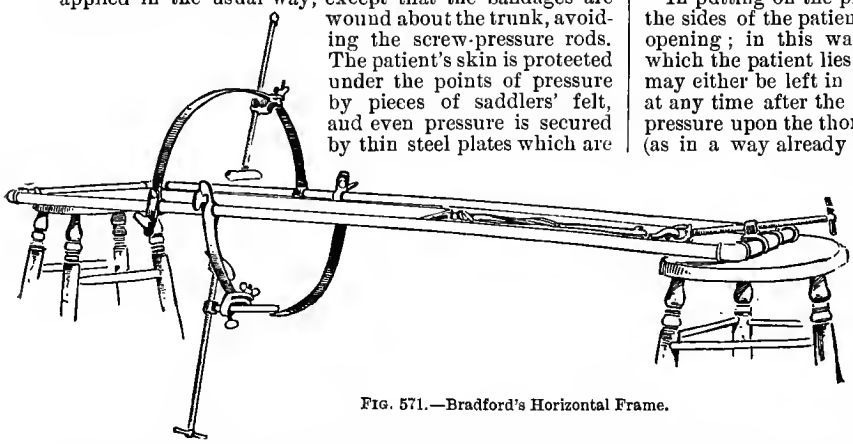

FIG. 571.—Bradford's Horizontal Frame.

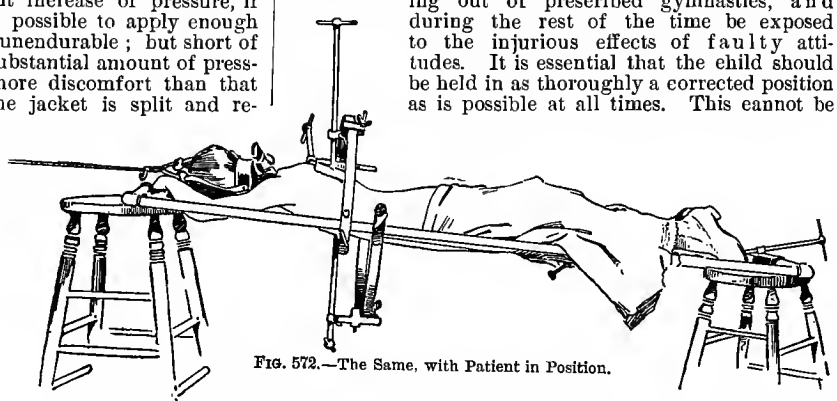

FIG. 572.—The Same, with Patient in Position.

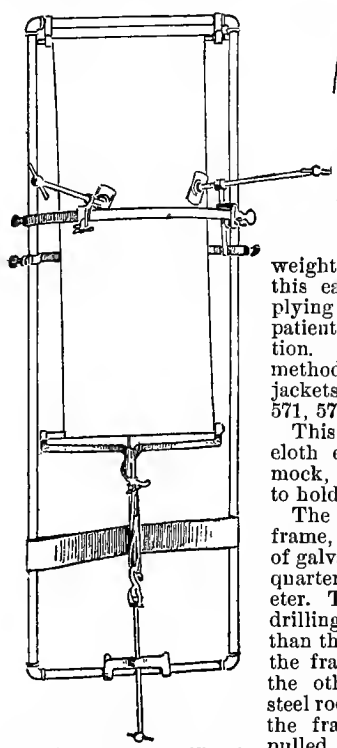

FIG. 573.—The Same, Viewed from Above.

A certain amount of discomfort is experienced by a patient who is suspended so as to entirely remove the super-incumbent weight. In many instances this can be avoided by applying the jacket with the patient in a recumbent position. For this a modification method for applying plaster jackets can be used. (Figs. 571, 572, and 573.)

This consists of a sheet of cloth constituting the hammock, and a frame arranged to hold the cloth taut.

The frame is an oblong frame, six feet by two, made of galvanized iron pipe, three-quarters of an inch in diameter. The cloth is stout sheet-drilling, somewhat wider than the patient, folded over the frame at one end, and at the other stretched over a steel rod which reaches across the frame. If this rod is pulled upon strongly, the sheet is kept tight, and sagging so prevented. This is done by connecting the rod by means of a cord to a screw staple fastened to the other end of the frame. Screwing the rods regulates the tension.

In putting on the plaster jackets, the cloth is cut along the sides of the patient, and the rolls passed through the opening; in this way the part of the hammock upon which the patient lies is incorporated in the jacket, which may either be left in permanently or may be withdrawn at any time after the jacket is hard. To secure direct pressure upon the thorax, the screw force can be adjusted (as in a way already described), and semicircular bands of steel adjusted on the upper and on the under side of the frame. (Fig. 573.)

This appliance can also, like the other, be used as a means of daily exercise. Actual experience has shown that the curved spinal column can be straightened in this way as much as by vertical suspension, and with much less discomfort to the patient. In the thorough treatment of severe lateral curvature the patient should be under treatment continuously, that is to say, it is not sufficient for the patient to devote an hour or more a day to the carrying out of prescribed gymnastics, and during the rest of the time be exposed to the injurious effects of faulty attitudes. It is essential that the child should be held in as thoroughly a corrected position as is possible at all times. This cannot be done by purely muscular exertion, for when muscular fatigue comes the faulty attitudes are liable to be resumed. Even in recumbency children often take faulty positions.

The objects of treatment are first to increase flexibility of the parts of the spine where flexibility is abnormally limited; secondly, to secure the maintenance of an improved attitude by the use of the retention apparatus, until the improved attitude has, by the alteration in the structure of the tissues, become habitual.

Forced correction and the permanent jacket should always be followed by a removable jacket, or corset, and exercise; and this by exercises alone; and the patient should be under observation for some years, at least until the full stature has been attained. Anything short of this is quite sure to be attended by a relapse.

John Ridlon.

SCOPOLAMINE. A new alkaloid, which is attracting attention on account of its chemical and therapeutic resemblance to hyoscine, hyosciamine, and atropine. It may be obtained in small amounts from plants of the order *Solanaceæ*, such as henbane, duboisia, stramonium, and belladonna, but its chief source is *Scopolia carniolica* Jac. (*Scopolia atropoides*). This plant, named after Scopoli, an Austrian naturalist of the last century, is a perennial spring-flowering plant, with dull, purple flowers, closely allied to hyosciamus niger. The flowers are solitary, placed on axillary pendulous stalks, arising from the axils of the leaves which are in pairs, one being larger than the other. Corolla. funnel-shaped, tra-

versed by fifteen nerves, the limbs divided into five very short lobes; stamens equal in length, the filaments short, dilated and hairy at the base, cylindrical above; ovary surrounded by a five-lobed fleshy disk; fruit similar to that of the henbane. The rhizome is very similar to the belladonna root, both in appearance and structure; it was introduced as a cheap substitute for belladonna root and called belladonna scopola. It is a native of the mountainous districts of Austria and Hungary, where it grows plentifully in a wild state. *Scopolia Japonica* is another species which grows in Japan and is known as Japanese belladonna. This plant is less known than the European plant, but its constituents are the same.

Scopolamine has been fully studied by Professor Ernest Schmidt (*Druggists' Circular*, December, 1892), in connection with his researches upon the composition of the various alkaloids common to the members of the night-shade family. The conclusion that he arrives at is that scopolamine and hyoscine are identical alkaloids, or rather, that the hyoscine of commerce is really scopolamine, with the chemical formula $C_{17}H_{21}NO_4$. The alkaloid grows in large, transparent crystals, containing one molecule of water; it is but slightly soluble in water, readily in alcohol, ether, and chloroform. The general characters also resemble those of atropine and hyosciamine, so much so that no difference between them is to be recognized by ordinary reactions. Physiological experiments by Professor Kobert, proved the action of this alkaloid and hyoscine to be the same; from atropine, however, some important differences were pointed out. Upon the pulse, atropine produces an acceleration in the rate, while scopolamine, even in maximum doses, fails to produce this effect Atropine in larger doses acts upon the brain by producing delirium and, at times, attacks of mania; the other alkaloid does not produce any excitement, but operates generally in an opposite manner. Scopolamine rather tends to paralyze the functions of the cerebral cortex and to retard the heart's action. Its mydriatic action in common with that of all the alkaloids is very marked.

Its value in ophthalmic practice has been very carefully studied and reported. Rählmann (*The Therap. Gaz.*, May, 1893) used, upon normal and diseased eyes, for over half a year, samples sent to him by Professor Kobert. He concludes that scopolamine as a mydriatic and antiphlogistic surpasses all other tropines, including atropine. The great advantage that he found it to possess over atropine, was the absence of any disagreeable effect upon the secretions and the appetite, so common to the use of atropine. He never observed this action to follow its use. In several cases of iritis and episcleritis, when the powers of the body were depressed by the want of appetite, the new alkaloid not only produced an improvement in the condition of the eye, but also maintained the general health of the body. It also does not seem to influence the intra-ocular pressure, which would indicate it to be of great value in the treatment of glaucomatous eyes. The hydrochloride of scopolamine, the salt generally employed, he found to operate about five times as powerfully as atropine. It paralyzes the sphincter of the iris and the accommodation. The duration of the effect of one-fifth per cent. is about the same as a one per cent. atropine solution. He advises its use in one-tenth to one-fifth per cent. solutions; of the former, six or seven drops may be administered daily, or used every fifteen minutes during one and a half hour. The hydrochloride is a colorless, transparent crystalline powder, readily soluble in water and alcohol.

Scopoline is the name given to another product by Schmidt, which is formed from the decomposition of scopolamine by the action of baryta water. The following equation represents the chemical change that is produced:

$$\underset{\text{(Scopolamine)}}{C_{17}H_{21}NO_2} = \underset{\text{(Scopoline)}}{C_8H_{15}NO} + \underset{\text{(Atropic acid)}}{C_9H_8O_2}$$

This alteration is analogous to that of atropine or hyoscyamine under similar circumstances.

$$\underset{\text{(Atropine)}}{C_{17}H_{23}NO_3} = \underset{\text{(Tropine)}}{C_8H_{15}NO} + \underset{\text{(Atropic acid)}}{C_9H_8O_2}$$

The physiological action and therapeutic properties of scopoline have yet to be investigated.

Beaumont Small.

SENECIO MARITIMA. This plant, also known as *Cinereria maritima*, has acquired some notoriety on account of its supposed value as a remedy in ophthalmology. The plant has a reputation in Venezuela as possessing the property of removing the blindness of cataract, and two cases are reported[1] by Thomas Christy, in which improvement followed the use of the juice; two or three drops were placed in the eye three times a day. The treatment requires to be continued for several months. Further reports[2] have been made of its successful use in Calcutta, by a Dr. R. P. Banerjee. No details of the cases treated are furnished.

The genus *Senecio*, of the order *Compositæ*, is one of the most extensive genera in regard to the number of species, some nine hundred being known to botanists. They are scattered all over the globe, but are especially found in mountainous districts of South America and South Africa. *Senecio maritima* is also found in Southern Europe, on the shores of the Mediterranean Sea. It is a hardy perennial, its foliage being covered with a short white down which gives the plant a silvery appearance. It is cultivated and grown extensively in gardens as a foliage plant, for the sake of contrast with scarlet and other colors. The plant is rich in a gummy secretion, and the fresh leaves are quite glossy and glutinous.

Beaumont Small.

[1] Notes on New Remedies, August. 1890.
[2] Ibid., December, 1892.

SERUM. The blood-serum of various animals has been experimented with, during the past few years, as a means of treating tubercular disease and removing the cachexias of syphilis, malaria, and anæmia. Its use for this purpose is based upon the immunity of certain animals to certain specific poisons. It is well known that rats cannot be inoculated with the virus of anthrax, and goats and dogs are almost proof against the bacillus of tubercular disease. It has been shown by experiment, that if a few drops of the blood-serum of the rat be injected into a mouse, it is also protected against anthrax; likewise, when the serum of a goat or dog is introduced into the blood of a rabbit it, only with great difficulty, can be infected with tuberculosis. The following are the conclusions of MM. Richet and Héricourt, in announcing their discoveries to the French Academy of Sciences: 1. A rabbit having been inoculated with a culture of the tubercle bacillus, the evolution of tuberculosis can be arrested by injecting dog's blood afterward when the bacillus culture is not too virulent, but this evolution is only delayed when the culture is very virulent. 2. The effective substances of the blood, which have not yet been identified, reside in the serum, and a small dose of the latter is sufficient ($\frac{1}{2}$ c.c. per kilogramme of the rabbit). 3. The serum of dog's blood has a prophylactic action—that is to say, when injected into a healthy rabbit it prevents the development of experimental tuberculosis at a later period. 4. The serum of a dog which has been previously inoculated with tuberculosis seems to be more efficacious in a healthy rabbit, but, on the contrary, seems to aggravate the disease when injected into a rabbit already tuberculized.

These experimental researches led to the employment of serum in human subjects. MM. Bernheim and Lépine used the serum of the goat, but this has been replaced by that procured from the dog, which is now most generally used. Dr. Beretta, describing the results of this method of treatment (*British Medical Journal*, November 14, 1891), states that in two-thirds of the cases in which it had been used a real improvement, more or less marked, was observed. "The patient quickly recovered his strength, appetite, and power of movement, while his weight gradually increased. As a rule, after a few injections the patient sleeps better, the digestive functions become more regular; in some cases the

coughing, expectoration, sweating, and hæmoptysis are diminished." The patients were in the first stage, or early in the second stage. In more advanced cases a marked improvement was noticed at first, but did not continue. He sums up: "Dog's serum, in men as in animals, does not seem to have a special curative action against tuberculosis, but it possesses a powerful action, if not against the microbe, at least against its effects. It seems to act as a powerful tonic, and indirectly, by improving the general nutrition, puts the patient in a better condition to overcome his terrible disease."

The preparation of the serum, or *hæmocyne*, as it is termed, is made with great care. The blood is taken from the carotid artery of a healthy dog and received in a vessel, under strict antiseptic precautions. The serum separates, and on the following day is drawn into glass pipettes and the ends closed, all the vessels and appliances being sterilized. A careful examination of the blood and organs of the dog is made before the serum is used. The serum is injected subcutaneously in the cellular tissue of the trunk or limbs, one or more cubic centimetres being used every two days. No ill effects have been traced to this method of employing the remedy.

This method of treating tuberculosis in man has not proved the success its authors seemed to expect, but it has opened a wide field of experimental work with a promising future. The object now is to render an animal immune by inoculation and utilize the serum, not only as a protective against the disease, but also to counteract the poison when present in the system, and produce a cure. The result of this work upon animals has proved encouraging, but time alone can tell of what practical benefit it may prove to man.

Beaumont Small.

SHADOW-TEST.* "Keratoscopy," "Retinoscopy," "Retino-skiascopy," "Korescopy," and other names. An objective method of determining the refraction of the eye.

When, from a certain distance, an observer throws light into an eye by means of a perforated mirror, on looking through the hole in the mirror he sees the entire pupil illuminated with a reddish light. If, now, the mirror is slightly rotated, a dark segment ("shadow") comes into view and, increasing as the mirror is rotated, presently extends over and darkens the entire pupil. The direction in which the "shadow" grows, *i.e.*, the direction in which the border of the shadow moves, whether in the same or in the opposite direction to that in which the mirror is rotated, depends, with certain limitations, on the refraction (hypermetropia, emmetropia, or myopia) of the observed eye, and affords a means, when the necessary conditions are fulfilled, of measuring its refraction.

The perforated mirror used in the shadow-test may be either plane or concave.

1. We will assume that a plane mirror is used, and that the observer's eye, which is immediately behind the perforation, is stationed at a distance of one metre from the observed eye. The mirror is now adjusted to reflect light, preferably from an Argand burner, directly upon the observed eye, whose pupil is seen filled with a uniform red light. On rotating the mirror to the right (*i.e.*, turning the left side of the mirror forward) a dark "shadow" appears at the left side (*i.e.*, to the observer's left) of the pupil and passes over it, increasing from left to right, until the entire pupil is darkened. Similarly, on rotating the mirror to the left, the shadow appears at the right side of the pupil and passes over it from right to left.

This movement of the border of the shadow in the direction of the rotation of the mirror, occurs whenever the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls elsewhere than between the observer's and the observed eye. When, as we have assumed, the observer's eye is stationed at a distance of one metre, the observed eye may be either hypermetropic, emmetropic, or myopic in any degree less than 1 D.

2. Rotating the (plane) mirror to the right, the "shadow" appears at the right side of the pupil and passes over it from right to left; or, rotating the mirror to the left, the shadow appears at the left side of the pupil and passes over it from left to right.

This movement of the border of the shadow in a direction opposite to that of the rotation of the mirror, occurs when the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls within the distance at which the observer's eye is stationed. In our assumed case this distance is taken equal to one metre; the observed eye is therefore myopic in some degree greater than 1 D.

3. Rotating the (plane) mirror in any direction, no "shadow" is seen, but the illumination of the pupil fades gradually into darkness. This fading out of the illumination of the pupil in its totality, without any appearance of a moving shadow, occurs only in the case in which the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls at the exact distance at which the observer's eye is stationed, which in our assumed case has been taken equal to one metre; the observed eye is therefore myopic, and its myopia is equal to 1 D.

4. Substituting for the plane mirror a concave mirror of short focus, in which case a real image of the flame is formed between the observer's and the observed eye, the "shadow" is seen to move in a direction opposite to that in which it moves when the plane mirror is used.

These facts have been utilized for the practical determination of the refraction in several different ways, two of which have been especially cultivated.

I. The observer, stationed at a distance of one metre, and using a concave mirror preferably of about twenty centimetres focus, throws light from an Argand burner placed beside or above the patient's head, into the eye whose refraction is to be investigated. If on rotating the (concave) mirror in any direction, he sees the "shadow" moving in the opposite direction, he concludes that the eye is either hypermetropic, emmetropic, or myopic in some degree less than 1 D. Convex glasses, of progressively increasing strength, are then placed, one after another, in a trial-frame before the observed eye, until a glass is found through which no shadow-movement is discernible in the transition from the illuminated to the darkened state of the pupil. The combination of the observed eye and this convex glass represents myopia of 1 D., and the subtraction of 1 D. from the value of the glass gives the refraction of the eye. For example, if the convex glass measures 3.5 D., the refraction is H=2.5 D.; if the convex glass measures just 1 D., the eye is emmetropic; if without a glass no moving shadow is seen, the refraction is M=1 D.

If, on rotating the (concave) mirror, the shadow is seen moving in the same direction, the presence of myopia of a higher grade than 1 D. is established; concave glasses, of progressively increasing strength, are then placed, one after another, in front of the observed eye, until a glass is found through which no shadow-movement is seen. The combination of the observed eye and this concave glass represents myopia of 1 D., and the addition of 1 D. to the value of the glass gives the actual myopia.

This is the method advocated by Cuignet, Parent, and others.

II. The observer uses a plain mirror, and does not keep at a fixed distance from the observed eye. We will suppose that he first stations himself at a distance of one-half metre, and sees the "shadow" moving in the same direction as that in which the mirror is rotated, thus establishing the fact that the eye is either hypermetropic, emmetropic, or myopic in some degree less than 2 D. A convex glass of sufficient strength to render the observed eye myopic in excess of 2 D. is then placed before it in a trial-frame, thus causing an image of its fundus to be formed in front of the eye of the observer. The observer next approaches the observed eye until he reaches

* See foot-note at bottom of page 701.

a point at which no moving shadow is discernible—*point of reversal.* The observer's eye is now at the far-point of the observed eye as modified by the convex glass, and the distance from eye to eye is measured by means of a rule or a tape-measure. The reciprocal of the fractional part of a metre thus measured represents, in dioptries, the refraction of the observed eye plus the convex glass, and the subtraction of the value of this glass gives the refraction of the eye.

When the observed eye is myopic in excess of 2 D., so that its far-point lies within the distance of one-half metre at which the eye of the observer is stationed, the movement of the shadow is in the direction opposite to that in which the mirror is rotated, and the distance of the point of reversal from the observed eye gives the measure of the myopia.

When the myopia of the observed eye is in excess of 4 D. or 5 D., the point of reversal falls too near the eye for an entirely trustworthy measurement of its distance. In such a case a concave glass, of sufficient strength to carry the far-point back to a distance of from one-quarter metre to one-half metre, is placed before the observed eye, and the value of this (concave) glass must be added to that obtained by measuring the distance of the point of reversal.

This is the method advocated by Chibret, Schweigger, and others.

In emmetropia, and in simple ametropia (hypermetropia and myopia), the movement of the mirrored image of the flame, whether virtual or real, and that of the "shadow" are always in one and the same plane passing through the observer's and the observed eye. The same is true also in astigmatism whenever the plane in which the image moves, as determined by the direction in which the mirror is rotated, passes through either of the two principal meridians of the observed eye. The shadow-test is, therefore, perfectly adapted to the measurement of the refraction of an astigmatic eye in each of its two principal meridians. If, however, the shadow is seen to move in a plane other than that determined by the direction of the rotation of the mirror (see Fig. 574), it is certain both

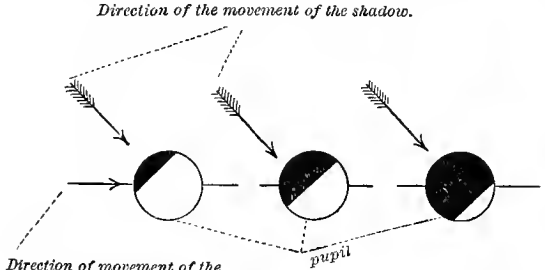

FIG. 574.

that the observed eye is astigmatic, and that the plane in which the mirrored image moves does not pass through either of its principal meridians. To find a principal meridian, whether of greatest or least refraction, it is then only necessary to vary the direction in which the mirror is rotated, until the shadow is seen to move in the same or in the opposite direction. The statement made by different writers, that the direction of the obliquely moving shadow corresponds to that of one or the other of the two principal meridians, is erroneous.

The idea of utilizing the direction of the movement of the "shadow" in the pupil for the practical determination of the refraction originated with Cuignet (1873), but he gave a wrong explanation of the phenomenon and so was led to give to the procedure the very unsuitable name, "keratoscopy." Landolt (1878) was the first to propose a nearly correct theory, and his and Parent's descriptions have contributed largely to the popularization of the method. Credit must also be given to Chibret (1882) for the important modification of the procedure in which the plane mirror is used at a varying distance. Leroy and Monoyer have further developed the theory, which, strange to say, had been erroneously, or at best inadequately, stated during a good number of years.

The theory of the shadow-test will be best understood if we consider a few special cases :

I. We will assume that the observed eye is emmetropic, and that the test is made with a plane mirror at a distance of one-half metre. An image of the source of light (Argand burner) is formed at the fundus of the observed eye, which, within the limits of this image, is strongly illuminated so that every point gives out rays of light as if it were self-luminous. The details of this illuminated area at the fundus are, however, indistinguishable, or at best imperfectly distinguishable, inasmuch as, by the conditions of the test, the observer's eye is accommodated, not for the fundus, but for the pupil of the observed eye. The illuminated area is seen, therefore, in circles of confusion, consequently as a more or less diffuse red light shining through the pupil.

How much of the illuminated area is, in any case, visible to the observer, is determined in part by the diameter of the pupil of the observed eye, and in part also by the size of the hole in the mirror, or, if this is rather large, by the diameter of the pupil of the observer's eye. Let $a\,a'$ (Fig. 575, *I*) represent a portion of the illuminated area (image of the flame) at the fundus of the observed eye, which we assume to be directed upon the hole in the mirror, consequently upon the pupil of the eye of the observer. Let $a\,P\,p\,\pi$ represent a limiting ray passing out of the pupil of the observed eye to enter the pupil of the observer's eye ; similarly, let a' represent the origin of another limiting ray, as determined by the points P′ and p', meeting the retina of the observer's eye at π'. Now P P′ and $p'\,p$ represent, respectively, the diameters of the two (circular) pupils, consequently $a\,a'$ and $\pi\,\pi'$ must also represent diameters of circles. We will call the circular area $a\,a'$ the *visible circle.* Inasmuch as the illuminated area (image of an Argand burner when the distance of the mirror is taken anywhere between the limits of one metre and one-quarter metre) is considerably larger than the visible circle, the entire pupil P P′ will be lighted up, and the visible circle $a\,a'$ will coincide throughout with the two pupils, P P′ and $p\,p'$, and with the circle $\pi\,\pi'$ at the fundus of the eye of the observer. But we have already seen that the visible circle $a\,a'$ is pictured at $\pi\,\pi'$ in circles of confusion ; hence the impression made on the observer is rather that of the illuminated pupil P P′ than of the circle $a\,a'$.

To explain the phenomenon of the moving "shadow" we will suppose that the observer, whose attention is fixed on the illuminating pupil PP′ of the observed eye, now rotates the mirror a little to the right (see Fig. 576), thus displacing the mirrored (virtual) image of the flame to the left, consequently displacing the real image of the flame at the fundus of the observed eye to the right. The displaced image of the flame, as it passes over the visible circle, presently leaves a segment of the latter without illumination, consequently a segment of the pupil P P′ darkened (see Fig. 577). As already explained, the border of this dark segment is seen somewhat imperfectly defined, thus suggesting a shadow with its penumbra, and accounting, in a way, for the name "shadow-test."

It will be observed that in this case (emmetropia of the observed eye) the growth of the darkened segment of the pupil (movement of the shadow) is in the same direction as that in which the (plane) mirror is rotated, the reversed movement at π, or at π', being perceived as a direct movement at a or at a', consequently at P or at P′.

II. We will now assume that the observed eye is hypermetropic, the other conditions remaining as before (see Fig. 575, *II*). Comparing *I* and *II*, Fig. 575, it is evident that nothing essential has been changed, as regards either the formation of the "shadow" or the direction of its movement. The illuminated area (image of the flame) is, however, smaller, and the visible circle larger, than in the case of emmetropia of the observed eye. The dark border of the illuminated area will therefore pass the limit of the visible circle more quickly (the rate of rota-

tion of the mirror being assumed to be unchanged), but more time will be required for its transit. We have seen that the apparent diameter of the visible circle is the same as that of the pupil; the rate of passage of the shadow across the pupil is therefore slower in hypermetropia than in emmetropia.

In hypermetropia of the observed eye the conditions for obtaining a clearer view of the details of the fundus, when the eye of the observer is accommodated for its

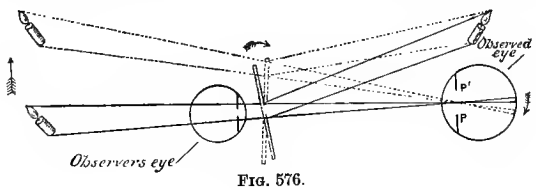

Fig. 576.

pupil, are more favorable than in emmetropia, and the higher the grade of the hypermetropia (*i.e.*, the less the distance at which the virtual image, $h\,h'$, of the visible circle lies behind the plane of the pupil) the more clearly will the retinal vessels, etc., be seen. On the other hand, hypermetropia of the observed eye is unfavorable for the accurate focussing of the image of the flame on its retina, and for this reason the outlines of this image are less sharply defined than in emmetropia. The advantage, to the observer, of the clearer view which he obtains of the image of the flame is, however, greater than the disadvantage resulting from its less perfect definition; hence the free border of the shadow, as it traverses the pupil, appears more sharply defined in hypermetropia than in emmetropia, and the higher the grade of the hypermetropia, the more distinct, on the whole, does the shadow appear.

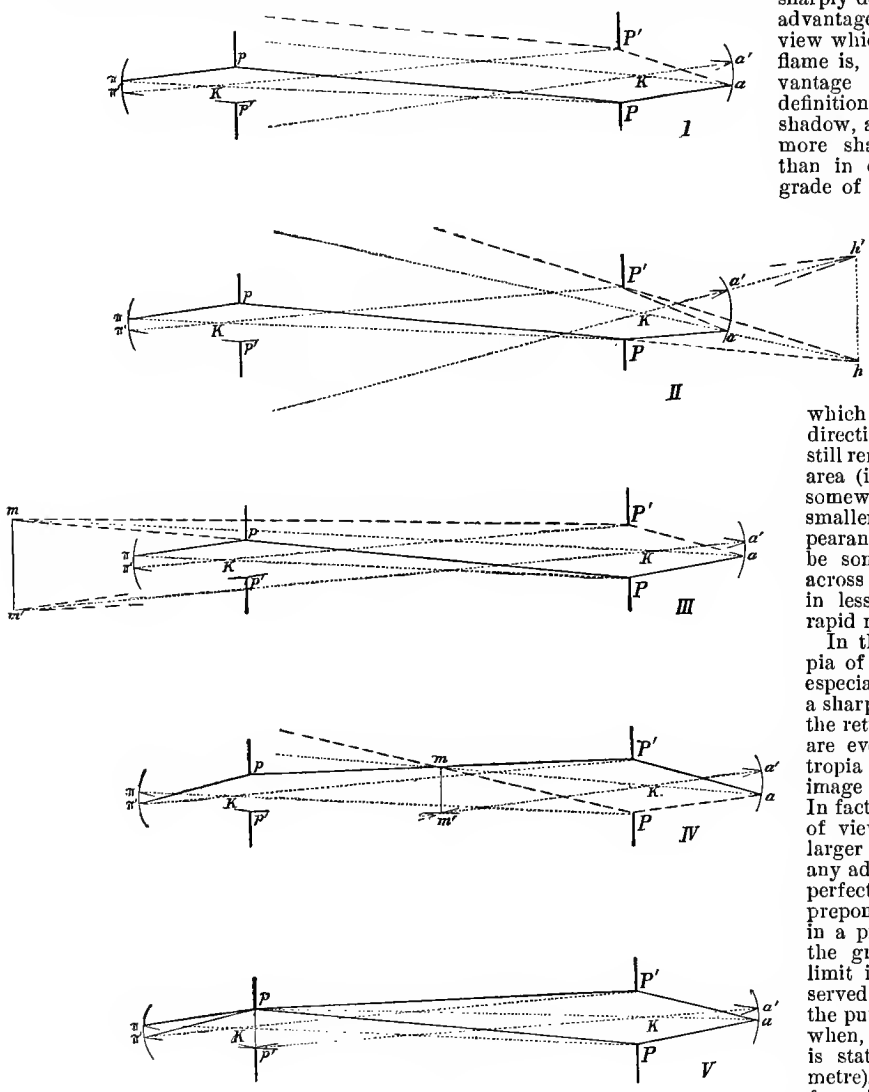

Fig. 575.

III. The observed eye is assumed to be myopic in some degree less than 2 D., the observer being stationed, as before, at a distance of one-half metre (see Fig. 575, *III*). Comparing *III* with *I* and *II*, Fig. 575, we see by inspection that the conditions which determine the formation and the direction of movement of the "shadow" still remain unchanged. The illuminated area (image of the flame) is, however, somewhat larger, and the visible circle smaller than in emmetropia. The appearance of the shadow will therefore be somewhat retarded, but its transit across the pupil will be accomplished in less time, consequently at a more rapid rate of movement.

In the case under consideration (myopia of less than 2 D.) the conditions are especially favorable for the formation of a sharply defined image of the flame on the retina of the observed eye, but they are even less favorable than in emmetropia for the accurate picturing of this image on the retina of the observer's eye. In fact, the disadvantage to the observer of viewing the image of the flame in larger circles of confusion outweighs any advantage accruing from the more perfect definition of this image, and this preponderance of disadvantage increases, in a progressively augmenting ratio, as the grade of myopia approaches the limit in which the far-point of the observed eye lies exactly at the distance of the pupil of the observer's eye (*i.e.*, 2 D., when, as we have assumed, the observer is stationed at a distance of one-half metre). In this limiting position of the far-point of the observed eye (point of reversal) no shadow-outline, consequently no shadow-movement, is discernible.

IV. The far-point of the observed eye is assumed to lie in front of the eye of the observer (myopia of the observed eye in excess of 2 D., when the observer is stationed at the assumed distance of one-half metre—see Fig. 575, *IV*). A new condition now comes into play.

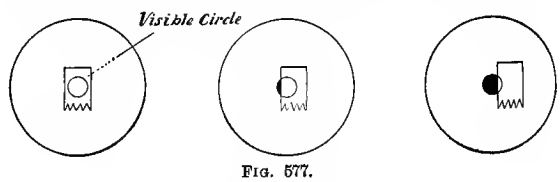

Fig. 577.

A real image, $m'm$, of the visible circle $a\,a'$ is formed at the far-point of the observed eye. Of this image a second image $\pi\pi'$ (which is a twice-inverted, therefore an erect image of $a\,a'$) is pictured on the retina of the eye of

the observer, who sees the image of the flame at $a\ a'$ inverted, and the direction of its motion, consequently the direction of the shadow-movement, reversed. The higher the grade of the myopia, the larger is the illuminated area (image of the flame), and the larger, also, is the visible circle, the latter increasing, however, at a greater rate than the former. Conversely, the lower the grade of the myopia within the assumed limit of 2 D. (*i.e.*, the nearer to the plane $p'\ p$ of the pupil of the observer's eye the real image $m'm$ falls), the smaller is the portion of the fundus at $a\ a'$—*i.e.*, the visible circle—from which rays of light can enter the eye of the observer. Again, the higher the grade of the myopia (*i.e.*, the nearer to the plane P P' of the pupil of the observed eye the real image $m'm$ falls), the sharper will be the definition of the shadow-outline. Conversely, the lower the grade of the myopia (*i.e.*, the nearer to $p'\ p$ the real image $m'\ m$ falls), the less advantageous will be the conditions for seeing it distinctly; consequently the more imperfect will be the definition of the shadow-outline, until, in the assumed limit of 2 D., no shadow-outline, consequently no shadow-movement, will be seen.

V. The far-point of the observed eye is assumed to lie at the exact distance of the pupil of the observer's eye (myopia of 2 D., when the observer is stationed at the assumed distance of one-half metre—see Fig. 575, *V*). In this case the real image of the visible circle (*cf. V.*, with *III* and *IV*, Fig. 575) is formed at and fills the pupil $p\ p'$ of the eye of the observer, the point p corresponding to a, and p' to a'. Now the outermost rays, a P p and a P' p, of the limiting pencil originating at a to pass out of the pupil of the observed eye and enter the pupil of the observer's eye, are refracted to π and π', respectively, at the retina of the observer; and, in like manner, all intermediate rays belonging to the same pencil are refracted each to its own point intermediate between π and π'; hence every point in the circle $\pi\pi'$ is faintly illuminated by rays emanating from a. Similarly, the limiting pencil originating at a', likewise all pencils originating at points lying between a and a', contribute each its own share to the general illumination of the circle $\pi\pi'$, consequently to the illumination of P P', the pupil of the observed eye, in its totality. The effect of the rotation of the mirror is manifested, therefore, by a gradual fading out of the light in the pupil, and not, as in cases I. to IV. by the appearance of a moving "shadow." It will be further observed (*cf. I, II, III, IV*, and *V*, Fig. 575) that in this case the diameter of the visible circle (*i.e.*, of the area at the fundus of the observed eye from which rays of light can pass out through its pupil to enter the pupil of the observer's eye) is at its minimum.

Comparing these several cases, we draw the following deductions:

a. Appearance and direction of movement of the shadow. Whenever a "shadow," appearing at the side of the pupil of the observed eye, is seen to move in the same direction as that in which the (plane) mirror is rotated, the eye is either hypermetropic, emmetropic, or myopic in such (lower) degree that its far-point lies behind the eye of the observer—cases I to III.

When the "shadow" is seen to move in the direction opposite to that in which the (plane) mirror is rotated, the eye is myopic in such (higher) degree that its far-point lies in front of the eye of the observer—case IV.

When no shadow-outline is discernible, the illumination of the entire pupil fading gradually into darkness whatever may be the direction in which the mirror is rotated, the eye is myopic in such degree that its far-point lies at the distance of the eye of the observer—case V.

b. Distinctness of the shadow-outline. The definition of the shadow-outline is always less perfect than that of the image of the flame at the fundus of the observed eye, for the reason that the (virtual or real) image of this image, which we may regard as the object actually viewed by the observer, is formed either at an infinite distance from the pupil of the observed eye (in emmetropia), at a finite and always considerable distance behind the pupil (in hypermetropia), or at a finite and always considerable distance in front of the pupil (in myopia). In no case, therefore, can this image be perfectly focussed by the eye of the observer, when, in accordance with the requirements of the test, the latter is accommodated for the pupil of the observed eye. Nevertheless, in high grades both of hypermetropia and of myopia, the difference in the distance (from the observer) of the pupil and the image is not so great as to prevent a fairly distinct view of both at the same time. In hypermetropia (case II.) of decreasing grade, passing through emmetropia (Case I.) and myopia of relatively low grade (Case III.), to the limiting grade of myopia (Case V.), in which the image of the visible circle at the fundus of the observed eye lies at and fills the pupil of the eye of the observer; likewise in myopia of relatively high grade (Case IV.), decreasing to approach the same limit (Case V.), the distinctness of the shadow-outline diminishes at a rapidly increasing rate, until, in the limiting case (Case V.), the shadow-outline and the shadow-movement vanish together.

Again, the image of the flame at the fundus of the observed eye is itself imperfectly defined, except in the particular case in which the far-point of the observed eye lies exactly at the distance of the (virtual or real) image of the flame as formed by the mirror. When the test is made with a plane mirror—see Fig. 576—this particular case implies myopia of low grade, which, as already stated, is a condition unfavorable for obtaining a distinct view of the image of the flame at the fundus of the observed eye. When, on the other hand, the test is made with a concave mirror, the higher grades of myopia offer the most favorable conditions both for the sharp definition of the image of the flame at the fundus and for seeing the outlines of the real image of this image, consequently for good definition of the shadow-outline.

Narrowness of the pupil, whether of the observed eye or of the eye of the observer, is favorable to the definition both of the image of the flame, at the fundus of the former, and of the image of this image, as pictured on the retina of the latter. But narrowness of either pupil, and still more of both pupils, involves a notable limitation of the area of the visible circle—see Fig. 575—and narrowness of the pupil of the observed eye involves also a diminution (in the ratio of the square of its diameter) of the brightness of the image of the flame at its fundus. Furthermore, a narrow pupil is unfavorable for observing the passage of the shadow. For these reasons, it will readily be comprehended that the preponderance of advantage may be greatly on the side of a large and well-lighted pupil, and this is in practice found to be the case. To this end the diameter of the hole in the mirror should be somewhat greater than that of the pupil of the observer's eye, and the pupil of the observed eye, unless naturally rather wide, should be dilated by instilling a solution of one of the weaker-acting mydriatics.

c. Brightness of the pupil. We have given the name "visible circle" to the circular area, at the fundus, from which alone any ray of light can both pass out of the observed eye and enter the eye of the observer. Under the conditions of the shadow-test the visible circle is simply that portion of a larger illuminated area (image of the flame) which, seen always in circles of confusion, is visible through the pupil of the observed eye. The image formed on the retina of the observer's eye is, therefore, an indistinct image of the visible circle, but by reason of its indistinctness, together with the fact that its outline is the same as that of the pupil of the observed eye, the impression made on the observer is rather that of an illuminated pupil than of the portion of the fundus behind it. As the size of the image on the observer's retina is independent of the actual size of the visible circle it follows that the larger the visible circle (its brightness being assumed to be constant), or the brighter the image of the flame (the size of the visible circle being assumed to be constant), the stronger will be the illumination of the pupil.

The area of the visible circle is larger, (α) the wider the pupil of the observed eye, (β) the wider the pupil of the observer's eye, (γ) the greater the myopia of the observed eye in excess of the critical grade (case V.), in

which the far-point of the eye lies at the distance of the pupil of the observer's eye, (δ) the less the refraction of the observed eye measured from the same critical grade of myopia, and (ε) the less the distance of the observer's from the observed eye.

The brightness of the image of the flame at the fundus of the observed eye is greater (α) the wider the pupil of the observed eye; and, when the test is made with the concave mirror, the greater the apparent area of the mirror, that is, (ε) the less the distance of the observer's eye (looking through the hole in the mirror) from the observed eye, or (ζ) the larger the concave mirror.

The conditions favorable to a strong illumination of the pupil of the observed eye are then, (α) wideness of its pupil, (β) a fairly large pupil on the part of the observer, (γ) a high grade of myopia of the observed eye, (δ) a high grade of hypermetropia of the observed eye, (ε) a short-observing distance, and (ζ) the use of a large concave mirror. Of these conditions, the first (α) may be secured when necessary by resorting to artificial mydriasis; the second (β) is best attained by observing with relaxed accommodation, the observer correcting the far-point of his own eye for the distance of the pupil of the observed eye by means of a suitable lens mounted behind the hole in the mirror. A short observing distance (ε) may be tried whenever the condition of the observed eye (*e.g.*, exceptionally dark pigmentation of the fundus, narrowness of the pupil from extensive synechiæ; imperfect transparency of the media, etc.) is unfavorable to good illumination of its pupil. The use of a concave mirror of large diameter (ζ) is also a possible resource in cases of exceptional difficulty.

d. The rapidity of the shadow-movement (other things being equal) varies inversely with the diameter of the visible circle, over which the image of the flame passes as the mirror is rotated; the smaller the visible circle, the less will be the time occupied in this passage, consequently the more rapid will be the movement of the shadow across the pupil. The darkening of the pupil occurs most quickly in myopia of the particular grade in which the far-point of the observed eye lies at the distance of the pupil of the observer's eye—Case V.; the passage of the "shadow" is progressively slower in higher grades of myopia, also in lower grades of myopia passing through emmetropia and the lower and medium grades of hypermetropia to hypermetropia of high grade.

e. The form of the "shadow" is determined by the form of the image of the source of light. If this is approximately circular the shadow-outline will be correspondingly curvilinear, and the shadow will have the form of a crescent. When an Argand burner is used the shadow-outline appears as a somewhat ill-defined straight line—see Fig. 577.

When the shadow-test is made with the concave mirror, the direction of the shadow-movement is in every case the opposite of that observed when the plane mirror is used. But with this exception there is no essential change in the reactions. When the observer is stationed at a fixed distance, of say one metre, the concave mirror has the advantage of affording a stronger illumination; when the test is made at a shorter and varying distance, the plane mirror is to be preferred.

The complete theory of the shadow-test as applied to the investigation of astigmatism is too complicated to be adequately presented in an elementary paper.

The shadow-test is, on the whole, the most exact method which we possess for the objective determination of the refraction of the eye. As compared with the determination of the refraction with the ophthalmoscope by the direct method, it is both more accurate and easier of execution; and this is especially true in the higher grades of myopia, in which measurements made with the ophthalmoscope are always very unsatisfactory. In the measurement of astigmatism it has an advantage over the ophthalmometer of Javal-Schiötz, in that it reveals the total astigmatism of the eye and not merely the corneal asymmetry. On the other hand, the shadow-test affords almost no information regarding the condition of the fundus of the eye under examination, and none as regards its acuteness of vision. The true value of the shadow-test is therefore as supplementing, not as superseding, other methods of examination.

The technique of the shadow-test is comparatively easy to acquire, and it calls for almost no special apparatus; an ophthalmoscope furnished with a concave and a plane mirror and a Rekoss disk, or a clip for holding a correcting glass, and a short tape-measure graduated to fractional parts ($\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, etc.) of a metre make up the list of essentials. *Carl Koller.*

SINUSES RESULTING FROM ABDOMINAL SECTION.—These are sequelæ in abdominal surgery which are by no means uncommon, and unfortunately they have failed in very many cases to receive such efficient treatment as would be desirable. In other words, an efficient technique for this form of injury has not yet been devised. Of course, the persistent sinus after injury to, or operation upon, deep-lying tissues, has been recognized ever since men have observed the phenomena which follow injuries, ever since surgery has been practised as an art which is far from infallible. The sinuses following bone injuries, glandular abscesses, etc., are lesions which are in some cases but too familiar. But the sinuses which attend abdominal surgery are, of course, a matter of recent observation, because abdominal surgery itself is but a development of yesterday. Furthermore, it is only since the development of pelvic surgery that these lesions have become comparatively frequent—which means that the number of operators is far greater now than formerly, as is also the number of cases to be operated upon; and I suspect the average ability of the operators is not as great as in the days when abdominal surgery was rarely attempted except by men of mature experience and keen powers of observation. On the other hand, all who operate now have the benefit of the accumulated experience of three-quarters of a century of abdominal surgery, and the wonderful advantages which have accrued from the antiseptic theory.

A sinus may be regarded in all cases as an illustration of a perverted or a perverse inflammatory process, an accumulation of wasted energy, a prodigal effusion of vital force, and a sinus of the abdomen is no exception to this statement. It is at once an evidence of the prodigality of nature in the expenditure of her resources, and of her conservatism in her constant attempts to repair injuries, the *vis medicatrix naturæ*. An extreme illustration which will serve as a type is the following case, which was seen in the autumn of 1891.

The patient was a young Irish woman about twenty years of age, who had been operated upon, several months prior to the time when I saw her, for tubercular peritonitis, the abdominal wound having been left open for drainage. The peritoneum had secreted freely, but instead of agglutination of the visceral and parietal surfaces, the parietal surfaces remained free, while a wall of new tissue gradually formed over the omentum and intestines, completely isolating them from the parietal peritoneum. This wall or sheath had its upper limit several inches above the umbilicus, extended well into the flanks laterally, and apparently had its lower limit at the brim of the pelvis, though the bladder and uterus were wholly outside of it in the great sinus between the layer of new tissue and the abdominal wall. This latter circumstance may have been due to the fact that the drainage-tube dipped into the pelvic cavity behind the uterus. The new membrane was not very vascular, dark brown in color, and friable. It showed no tendency to adhere to the parietal peritoneum, secreted more or less abundantly, and apparently showed little tendency to contract. In fact, this was an example on a colossal scale of a persistent sinus resulting from abdominal section. The wonderful power of the peritoneum as a secreting organ is shown in such processes. Instead of a sinus, it frequently throws out bands and adhesions in various portions of the abdominal and pelvic cavities. It suggests the cuttle-fish throwing out ink, obscuring the water, and then swimming away from its pursuers. That is, this seems like an effort at conservatism on the part of nature, though it

may prove deleterious, perhaps destructive. The exudate which is thrown out becomes organized with connective tissue and blood-vessels like other tissues which are the result of an inflammatory process, but the organization is a low one, and though it may contract, it may not contract enough to obliterate the newly formed channel, if a channel has been newly formed, and though retrograde metamorphosis may be established, the process may not be vigorous enough to dispose of the viscera which have suffered from its attachment. So there may be a persistent and annoying opening in the belly with a discharge of pus, or of gas and fæces if the intestine has been perforated, a constant dribbling of urine if the corroding process penetrates the bladder. The consequences are discomfort and disgust to the patient, possibly pain and prolonged invalidism, and a tax upon the ability and ingenuity of the surgeon which he may be unable to fully satisfy.

The causes of the condition in question may be considered as constitutional, irritative, and septic.

1. Predisposing may be a better term than constitutional. Cases in which the peritoneum, from any cause whatsoever, has contracted a habit, as it were, of throwing out excessive secretion are by virtue of that habit favorable cases for the formation of sinuses after abdominal section. This is notably true in connection with tuberculosis of the peritoneum, although it is also true that the effect of opening the peritoneal cavity in such cases is frequently curative, and that if sinuses are formed the necessary and desirable retrogressive changes occur with greater relative frequency than in non-tuberculous cases. Predisposition to sinus formation is also present in connection with syphilis, malignant disease of the peritoneum, or disease of any of the abdominal viscera in which the visceral or peritoneal circulation is seriously interfered with. In cases in which an abundance of adhesions, either recent or ancient, is found in the abdominal or pelvic cavity, as the result of an inflammatory process, we are in the presence of an irritable peritoneum, with a predisposition to sinus formation under favoring conditions. The mere agglutination of coils of intestine to each other may be the first step in this process, and should these become adherent to the parietal peritoneum in the vicinity of the abdominal wound, and the latter fail to close, or be reopened by a force from above or below, the sinus would be complete.

2. The cause which seems more fruitful than all others in the production of sinuses, I have termed irritative. Perhaps it would be better to speak at first of mechanical irritation, for septic causes are also irritative, but act chemically as well as mechanically. Drainage and suture or ligature material, of whatever substance composed, is the principal means by which this irritative action is caused. At present I am considering only its irritative action as a foreign body, without reference to the septic elements which are frequently associated with it. Chief among these irritative agents are glass drainage-tubes. It matters little whether their calibre be large or small, when used too long in some cases, and when used at all in others, whether properly or improperly adjusted, the result will be a sinus. Their presence is an irritant to the sensitive peritoneum of the intestines and omentum, which snugly embrace them. The exuding secretion in a short time (Tait says in seventy to eighty hours) forms a mould around the tube, the intestines are agglutinated to the mould and to each other, and thus a cavity is formed which is walled off from the abdominal viscera. When the drainage-tube is removed the concentric pressure of the surrounding structures upon the walls of the sinus may cause them to collapse, and disintegration and absorption may gradually accomplish their complete removal. But in the unfavorable cases these results do not ensue, but the sinus walls become more completely organized and the consequent phenomena of granulation may continue indefinitely. Sinuses may also be caused by the irritation of too many or too large sutures or ligatures around tissues which have shrunk or atrophied. Such an irritation may be an aseptic one, as has been shown by Bumm. Such sinuses are without the well-marked wall which occurs when a drainage-tube has been the irritating cause. They are formed by the agglutination of coils of intestine, the exudate varying in thickness, of course, with the intensity of the process and the sensitiveness of the peritoneum to irritation. The track of such sinuses may be long, irregular, and intricate, and they may contain pockets of considerable capacity, which will give rise to no end of uncertainty and surmising in attempts at exploration and treatment. That ligatures are the cause of sinuses was long since observed by the earlier ovariotomists, and this fact induced some of them to endeavor to dispense with them as far as possible, especially the large ligatures which are required for pedicles. Thus Keith substituted the actual cautery for the pedicle ligature, and Peaslee devised a method for cutting and removing the pedicle ligature after it had been adjusted long enough to insure freedom from hæmorrhage. These methods have never been improved upon, though they have been forgotten or ignored by many abdominal surgeons. The use of gauze as a means of drainage within the abdomen is a step in the direction of progress. The irritation which it causes is probably less intense than results from the use of any solid material. The gradual withdrawal of the gauze is probably more favorable to the breaking up of newly formed plastic material than the withdrawal of the drainage-tube, and the entrance and development of poisonous germs within the peritoneal cavity is certainly as little facilitated by this as by the use of any drainage material which has as yet been suggested. These and other considerations have induced some surgeons to discard the drainage-tube in favor of gauze, especially in view of the fact that drainage with gauze seems to be quite efficient. The matter is of so much importance that it is worthy of more extensive study and discussion than it has yet received. The same objections which have been urged against glass drainage-tubes are applicable to tubes of rubber, bone, or other more or less firm material. It is assumed that the subject of drainage of the abdominal cavity is intrinsically so important that it will be universally admitted that substances should be used which will be certain to provoke the least possible irritation.

3. The subject of sepsis as a cause of abdominal sinuses is as yet too obscure to admit of careful and exact statements. Sinuses not infrequently occur when no drainage-tube has been used. The abdominal wound may have been carefully sealed, but sinuses have resulted. It has already been stated that ligatures, by their very presence as foreign bodies, excite more or less irritation, but in how many instances there are also foci of irritation in the form of blood, pus, or serum, within the abdomen or pelvis, or poisonous material which has been introduced from without, which the peritoneum cannot or does not absorb or successfully isolate. The gonococcus may be instanced as a form of infection from without, though Bumm affirms that the gonococcus alone will not cause septic peritonitis, that it is infectious only upon mucous membranes, and that its injurious effects cease after it has traversed the mucous membrane of the Fallopian tube ; also that when it reaches the peritoneum it becomes harmless, and is encapsulated. Possibly Bumm is correct in his statement that cases of septic peritonitis in which the gonococcus is found are illustrations of mixed infection, the streptococcus which is often associated with the gonococcus being the efficient cause of the peritoneal injury. However this may be, the investigations and observations with reference to the question immediately at issue have been mainly clinical. I have found no record of autopsies bearing upon the question, and as Sänger has observed (*Deutsche med. Wochen.*, xvii., 1891, p. 145), experiments like those of Heinricius, Loebker, and Delbet upon cadavera and animals furnish no convincing argument. We are still very much in the dark as to the rôle which is played by micro-organisms in the matter. The results which attend the formation of abdominal sinuses are bad enough. The condition is that of a granulating wound which is both annoying to the patient and destructive of

vital force, like persistently granulating processes in any situation. There is more or less interference with the functioual activity of the intestines and danger to vital organs such as results in all cases from prolonged suppuration.

Consequences with which all are familiar in such cases, are fistulæ of the intestines and bladder, prolonged vesical irritation and cystitis, inflammatory diseases of the kidneys, anæmia, and intensification of pre-existing tubercular or syphilitic processes. Whatever benefit may have been derived from the performance of the original operation, and the removal of diseased structures, is neutralized by the morbid condition which has been engrafted, and a very important problem is furnished for consideration, for which no satisfactory means of treatment has as yet been devised. Treatment is rendered the more difficult by reason of the fact that it is frequently impossible to explore the cavities with sufficient thoroughness, on account of their sinuosities, on account of the large areas which are frequently involved, and on account of the danger of wounding the intestines or the peritoneum, if active measures of treatment are adopted. The alternatives with which one is confronted in the matter of treatment are simple expectancy, palliative measures, or radical ones—that is, the reopening of the peritoneal cavity, extensive and difficult dissection, and possible inability, even after such efforts, to treat the condition successfully. Expectant treatment means doing nothing, throwing the responsibility of the situation upon the natural reparative forces. This may be the method of laziness, or of despair, but it is astonishing how frequently nature is equal to the emergency, if suitable measures are adopted for maintaining the general nutrition. With a fair degree of vitality of the tissues and functions a spontaneous cure not infrequently results, and it is not improbable that many cases which pass from the surgeon's observation, and are no longer heard of, are cured in this way. But there are many others which remain uncured, the patients suffering varying degrees of annoyance, but not sufficient to compel re-entrance into a hospital and submission to radical procedures.

The palliative method of treatment offers a choice of many measures, the degree of success varying with the vitality of the patient, the area of the sinus, and the adaptability of the measures to the given condition. A prerequisite to success is cleanliness, which means not only cleanliness of the surface of the body contiguous to the opening of the sinus, but cleanliness of the walls of the sinus, its secretions being removed with sufficient frequency and thoroughness. This may not be easily accomplished, and a freqnent cause of persistent sinuses is the retention and decomposition of secretions. Irrigation should be practised at least once a day with hot Thiersch solution, hot solution of carbolic acid, creolin, or any other suitable astringent. It is unnecessary to say that the abdominal opening should be kept sufficiently large for the ready exit of discharges. Applications of strong solution of nitrate of silver will sometimes sufficiently stimulate the sluggish granulation process. Trypsin will corrode and digest the new tissue, but it is very dangerous, unless used with sufficient circumspection. In one case, in which it was recommended by me, it produced an opening into the bladder, and in another into the intestine. The former was cured by persistent drainage of the bladder, the latter by resection of the intestine. In a number of cases I have seen good resnlts from packing the sinus with iodoform gauze; in sinuses which are extensive in area, I have seen it fail. Tbrough drainage into the vagina may be efficient, and it may result in failure, as I have experienced. A pedicle ligature may be the cause of a sinus, but the sinus may not heal even after the ligature has been extruded. For obstinate cases, there remains only radical treatment, that is, reopening the abdomen, breaking up adhesions, and dissecting away all adventitious tissue. This may be an operation of great magnitude, and I have known it to fail even with the most skilled operators. It seems to me, however, that it is the true method for the treatment of obstinate cases, and I doubt not that increased experience in technique will make it successful, even in such cases. In all cases it must be remembered that violence in exploration, in injection, or in irrigation, are to be rigorously avoided. We must not forget that we are in intimate contact with the thin and often friable wall of the intestine, and that too much manipulation will almost inevitably resnlt in a more serious condition than that from which the patient is already suffering.

Andrew F. Currier.

SIRADAN. A small spa, in the Department of Hautes-Pyrénées, Fraunce.

Location.—Siradan is a little village, long noted for its calcareo-sulphated and chalybeate springs. It is devoid of scenic attractiveness, being situated in an arid valley, about twelve miles from Bagnères-de-Luchon.

Access.—By way of Bordeaux and Solichan on the South of France Railroad.

Analysis.—According to Filhol, one thousand grammes of the principal spring contain:

	Grammes.
Bicarbonate of lime	0.2000
Bicarbonate of magnesia	0.0255
Sulphate of lime	1.3600
Sulphate of magnesia	0.2800
Sulphate of soda	0.1090
Chloride of calcium	0.0500
	2.0255
Carbonic acid, free	18 c.c.

Traces of chloride of potassium, sodium, calcium, magnesium, oxide of iron, silica, iodine, phosphate of lime, and organic matter.

The chalybeate springs are cold, and supply a water of moderate ferruginous strength and average composition.

Indications.—The waters of this spa are employed in gastralgia, abdominal plethora, gravel, and vesical catarrh, as well as chlorosis and anæmia.

Accommodation.—The thermal establishment is modern and satisfactory, but the boarding-houses are of an inferior order.

E. C. Wendt.

SKULL, FRACTURES OF THE BASE OF. As in fractures of other portions of the skull, the fracture itself is of comparatively minor importance, and the extreme gravity of these injuries lies in the injury to the base of the brain which is very certain to accompany them. In order to fnlly understand the subject it is essential to consider some peculiarities of the base of the skull and its relation to the portions of brain overlying it.

If we view the skull as a whole from either side, and especially from the rear, it will be noticed that while the upper and posterior surfaces have a dome-like arch, the shape of which is well calculated to resist any ordinary violence, the base or under surface, especially viewed from the rear, is nearly flat. This is more strikingly apparent if we make a transverse and vertical section just back of the foramen magnum. This will show that the base of the skull at that point is almost exactly flat, and lacks the arched contonr calculated to withstand blows or pressure. This will be made evident by reference to the accompanying illnstration (Fig. 578) of a transverse vertical section just back of the foramen magnum.

A glance at the under surface from without will show that it is weakened, not only by the large foramen magnum, but by the numerous foramina on either side and in front of it. If the base be viewed from within, being held between the observer and a moderately strong light, a considerable portion of the entire base will be found to be quite translucent, and some portions almost transparent, owing to their extreme thinness. The posterior fossa of a skull before me is thinner than at any other portion of its entire contour. In this specimen it is easy to distinguish through the posterior fossa small objects held on the other side of it, the bone here being as thin as the thinnest paper.

While it would appear that the thicker portions of the

base, as, for instance, the condyles on either side of the foramen magnum, the mastoid portions of the temporal, the median portion of the sphenoid, and the elevated ridges on the occipital bone, add considerable strength, in reality they do not furnish as much addi-

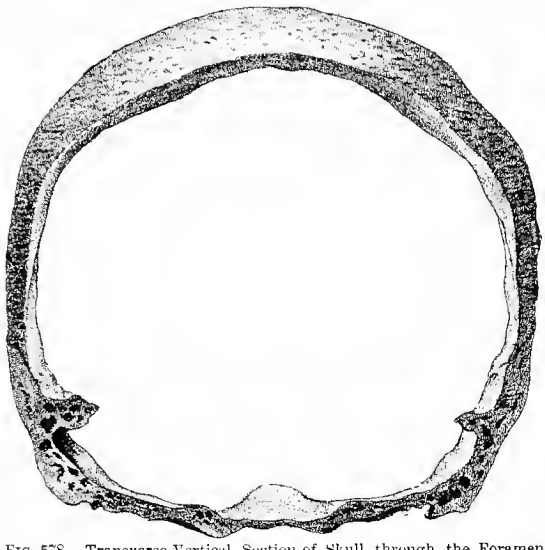

FIG. 578.—Transverse Vertical Section of Skull through the Foramen Magnum, at Junction of its Middle and Posterior Thirds; showing thinness and flatness of the base in contrast with the thickness and convexity of the vertex. (Author's Specimen.)

tional support as would at first appear; for if we make sections of these above-mentioned thicker portions, we shall find that they have only an extremely thin layer of outer and inner table or solid bone, and that almost their entire thickness is made up of diploë. They do not nearly compensate for the extreme thinness of the greater portions of all the fossæ and for the numerous foramina. It will therefore appear evident that the base

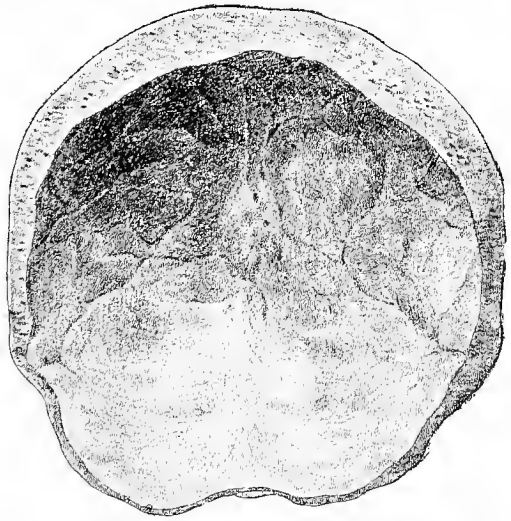

FIG. 579.—Transverse Vertical Section of the Skull, Three-quarters of an Inch Posterior to Foramen Magnum, contrasting the thinness, flatness, and consequent weakness of the base with the thickness, convexity, and strength of the vertex. (Author's Specimen.)

of the skull is relatively weak, and not calculated to withstand more than a moderate amount of violence. The greater portion of the base has little or no diploë. No diploë is to be found in the posterior fossa and in the orbital plates of the frontal bone.

If it were not that the base of the skull, from its less exposed position and from its being to a great extent protected from direct violence by being enclosed by the structures of the neck beneath, and by the fact that its great mobility upon the cervical vertebræ lessens the danger from any direct violence, it would be much more frequently fractured.

Viewed from within, the contour of the entire base is remarkably irregular, containing many ridges, angles, and sharp edges of bone which might, therefore, when fractured, cause severe injury to the portions of brain overlying them.

In this respect, however, we are liable to some misconception in examining skulls from which all the soft parts have been removed, for during life these sharp angles and ridges are somewhat rounded off and protected by being overlaid by dura mater and by the large venous sinuses and other blood-vessels.

The under surface of the brain, that contiguous to the base of the skull, is of greater importance, and any in-

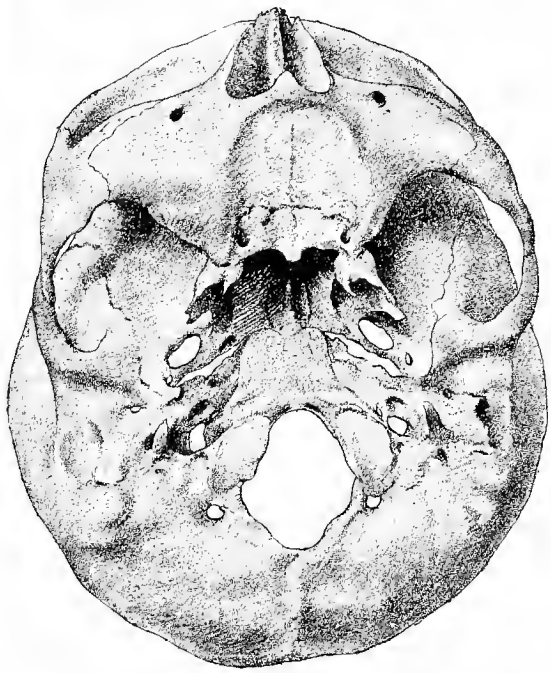

FIG. 580.—View of Base of the Skull, showing as far as possible to what extent it is weakened by foramina. (Author's specimen.)

juries of it much more serious than those of its upper surface, and it is principally for this reason that fractures of the base are more disastrous than those of the vertex.

Hilton has drawn attention to the extremely important manner in which the cerebro-spinal fluid protects the base of the brain from injury. He has shown that almost the only part of the base of the brain which is in close apposition with the base of the skull is the inferior portion of the anterior lobes of the cerebrum, where they rest upon the orbital plates of the frontal bone, and that all the other portions of the base of the brain, including those parts most essential to life, do not rest upon the bones at all, nor even touch them, but that under these portions of the brain there is such an abundant accumulation of cerebro-spinal fluid that it forms what he aptly terms a water-bed. No other portions of the brain are thus protected by an abundant supply of cerebro-spinal fluid to break the force of any violence. The contour of the two posterior lobes of the brain does not, therefore, correspond to that of the portions of the skull over which they float on this water-bed.

CAUSES.—Fractures of the base of the skull may result either from direct or from indirect violence. Cases

are recorded in which the orbital plates and the ethmoid or sphenoid bones have been perforated by slate pencils, scissors, canes, swords, pieces of stick, tobacco pipes, bayonets, umbrellas, and points of foils used in fencing, thrust through the orbit, nose, or mouth, and in one instance by a fall against a meat hook.

The most remarkable case which I have been able to find recorded is described in the *American Journal of the Medical Sciences* for July, 1850, by Dr. Bigelow. A solid bar of iron, three feet seven inches long and one and one-fourth inch in diameter, was driven by a premature explosion of a blast, entirely through the skull of a man twenty-five years of age, high into the air, and fell several rods distant. The bar passed upward beneath the zygomatic process on the left side, and through the floor of the anterior fossa of the base of the skull, and emerged near the centre of the frontal bone close to the coronal suture. A considerable portion of brain-substance was

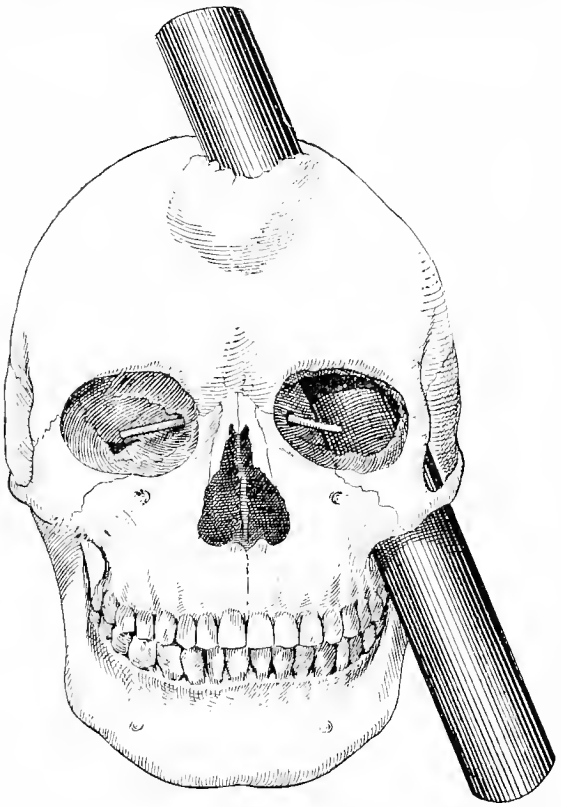

FIG. 581.—Case Reported by Dr. Bigelow, of an Iron Bar (43 inches long and 1¼ inch in diameter) driven upward through the skull. Recovery.

lost. The patient was almost immediately able to converse rationally, and rode three-quarters of a mile, sitting erect in an ox-cart, and after alighting from the cart without aid, walked up a long flight of stairs. His recovery was complete in all respects, excepting the loss of sight in the left eye.

Perforations have also occurred in various parts of the base of the skull from gunshot wounds. Wounds from direct violence of this kind are much more common in the anterior fossa than in other portions of the base, its floor being so thin that but little force would be required to thrust any of the above-mentioned foreign bodies through into the brain. Punctured wounds through the anterior portion of the orbit by small slender instruments or weapons, leave but very little external evidence of injury. If slender weapons be introduced under the upper lid, nothing is visible but a slight amount of ecchymosis of the conjunctiva. If the wound be external to the lid there will be nothing visible but the small wound in the region of the eyelid or eyebrow; and as the brain symptoms from such a wound of the anterior portion of the brain may not appear for several days, the gravity of the case or the nature of the injury may be entirely overlooked.

Nancrede has called attention to the fact that murderous wounds leaving no trace that can be detected, except

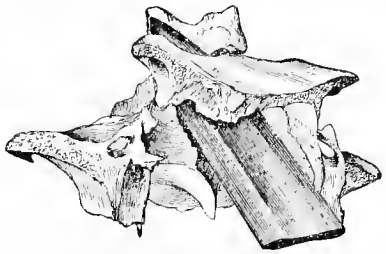

FIG. 582.—Fracture of Clinoid Process by Sword Thrust. (From Surgical History of War of Rebellion.)

upon a very careful examination, could be readily effected by passing a small pointed instrument through the retro-tarsal conjunctival fold, and then penetrating the delicate orbital roof and superjacent brain. While this would not be difficult in an adult, it would be especially easy in children.

The ethmoid bone has been fractured by a blow upon the nose driving it upward against the brain.

The squamous portion of the temporal bone has been fractured by a blow upon the chin driving the condyle of the lower maxilla through the glenoid fossa.

It is easy to appreciate how, if a man fall from any considerable height, and especially if, falling upon his head, he strikes upon any soft surface, thus distributing the force of the blow over a considerable area of the vertex, the weight of the body being projected like a blow from a hammer, with the momentum gained by a descent of many feet, against the base of the skull, an extensive fracture of the base would easily be produced. These fractures should be considered as caused by direct violence. As the entire weight of the individual's body, projected from a height of a number of feet, constitutes the fracturing force, it would seem very easy for extensive fissure of the base to occur.

The base may also be fractured by an individual falling a considerable distance and alighting upon the knees, pelvis, or feet, the skull being driven so forcibly against the cervical vertebræ as to produce fracture of the base.

The above-mentioned fractures, although considered by some as illustrations of contre-coup, are the result of direct violence by impact of the base of the skull against

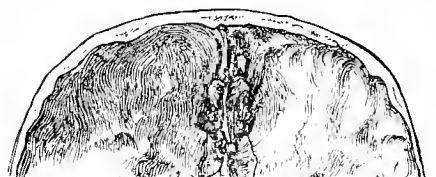

FIG. 583.—Fracture of Anterior Fossa from a Blow on the Nose. (Bryant.)

the cervical spine, and not properly from contre-coup, as formerly considered by Chopart and others, who have recorded their cases of contre-coup. Counter-stroke, as a factor in the production of fractures of the base, probably very rarely occurs, and is much less often referred to in modern medical literature. A fracture by contre-coup is one in which the fracture is produced on the side of the head opposite to that on which the blow is received. Grima's definition of contre-coup is: "A lesion produced

by a blow in another place than that which received the blow." The fracture is caused by the violence being transmitted through and around the skull. In a considerable proportion of cases the fracture at the base is a result of the extension of a fissure from a fractured vertex. In those cases in which there is fracture of both vertex and base, the direction of the fracture is from the vertex toward the base. The theory of Aran, who made numerous experimental investigations, was that fractures of the base are always connected with fractures of the vault from which they radiate, following a line within the zone in which the former occurred, and taking a course which corresponds with the shortest route to the base. Aran based his theory upon numerous experiments with dead bodies, and upon old dried skulls.

Fractures of the base are generally, if not in all cases, only fissured and without marked depression, as in fractures of the vertex.

Symptoms.—The symptoms are often obscure, and the diagnosis may not be made out with certainty at the outset. Symptoms usually appear early, but may be long delayed, and all may be absent until three or four hours before death, as in a case recorded by Jackson. Hilton mentions an interesting case of a gentleman who was

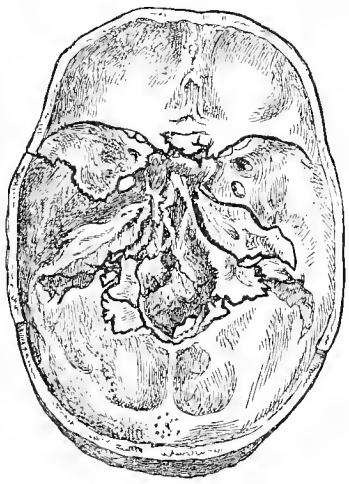

Fig. 584.—Fracture of the Base by a Fall on the Vertex, which was fissured. (Erichsen.)

thrown from his horse, striking upon the back of the head, and he was dragged by his foot catching in the stirrup. He subsequently disentangled his foot, mounted his horse again, and rode several miles home. He occupied himself about his usual duties for the following thirteen days, driving, walking, and attending to various business matters, previous to coming under Hilton's care. He then began to suffer from indications of paralysis and subsequently died, and an examination of his skull showed that he had suffered a fracture at the base. Yet during the thirteen days following the injury, there was not the slightest evidence of any brain lesion.

Owing to the location of a fracture of the base, and to the fact that such fractures are only fissured and with little or no depression, it is not possible to make out by inspection or palpation the lines of fracture, as can be done in those of the vertex. The manner in which the violence has been inflicted would guide us very much in our diagnosis, and the symptoms will depend upon the portion of the base which is fractured.

Hæmorrhage from the ears alone is of only moderate importance, for it may occur without fracture, simply from any laceration of the small vessels of the external auditory meatus, or the membrana tympani; but if the hæmorrhage be prolonged and copious, and especially if it be evidently arterial, as shown by pulsation, and if it be accompanied by other symptoms, or the nature of the accident be such as would be likely to produce fracture of the base, it is a symptom of considerable importance, but is not alone quite conclusive. Severe hæmorrhage from the ear has occurred without fracture of the base. This symptom does not occur even in all fractures of the middle fossa, but only when a fracture through the petrous portion of the temporal bone establishes a communication between the injured intra-cranial vessels and the cavity of the tympanum, the membrana tympani being also ruptured. If, in such cases, the membrana tympani was not ruptured, the blood would escape through the Eustachian tube into the throat.

Serous discharge from the ear is the most important and almost characteristic symptom of fracture of the base. This discharge is sometimes very copious, so much so that it is recorded that as much as a tumblerful has been discharged in a short time. It has been pretty conclusively proven that this consists of cerebro-spinal fluid, for its composition, whenever examined, has proved to be the same, and there would appear to be no other possible source for such a copious discharge of fluid corresponding in chemical composition. It was at one time erroneously supposed that it was the serum of the blood, or the fluid secreted by the internal ear. The cerebro-spinal fluid is a perfectly clear fluid of a very pale yellow color, and having a specific gravity of about 1.010. It has a saltish taste and its reaction is alkaline. It contains a substance which, according to Foster, although not sugar, acts like dextrose when tested with Fehling's solution. Five cases have been recorded by Wilder (*Medical News*, Philadelphia, 1885, vol. xlvi., pp. 625–627), in which brain-substance escaped through one ear. Of these, three were fatal and two recovered. The discharge of cerebro-spinal fluid is only possible when there has been a fracture of the petrous portion of the temporal bone, with rupture of the dura mater and arachnoid, and of the membrana tympani. Cerebro-spinal fluid has rarely been discharged through the nose, when the line of fracture extends through the anterior fossa. In a case recorded by Cameron in *The Lancet*, London, 1884, vol. i., p. 205, there was copious discharge of cerebro-spinal fluid through the nostril and one ear; but the patient, although seventy-five years of age, recovered. Erichsen reports a case (fatal) of a boy who received a wound on the back of the head, with depressed and comminuted fracture of the skull, through the wound in whose scalp a large quantity of cerebro-spinal fluid escaped. This discharge of serous fluid by itself is a very characteristic symptom, and when taken in connection with an accident the nature of which would be likely to produce fracture of the skull, would constitute almost positive proof. A very noteworthy case has, however, been reported by Page (London *Lancet*, 1888, vol. i., p. 774) of a sailor who, after a fall of twenty feet, had ptosis of right eye, partial loss of vision in left eye, and hæmorrhage from left ear and nose, followed by copious, clear serous discharge from left ear, and insensibility. Nearly complete recovery soon followed, but he died seven weeks after the accident, and at the autopsy no fracture could be found, but only purulent meningitis. Paralysis of one or several cranial nerves has occurred as a result of fracture of the base. Hæmorrhage from the nose and mouth, and subsequent vomiting of blood, may arise in many cases where there is no fracture. But if the hæmorrhage be considerable, and if the nature of the accident were such as was likely to cause a fracture of the base, it may be supposed that the source of the hæmorrhage is probably from rupture of an intra-cranial vessel, the blood escaping from a fracture of the sphenoid or ethmoid bones forming the roof of the nasal fossa. Vomiting of blood in considerable quantity, without hæmorrhage from nose and mouth, has occurred from fracture of the base, the blood having been previously swallowed. I have at present under my care a boy ten years of age, who seven days ago fell fifteen or twenty feet upon a bare wood floor, striking upon the right side of the occipital bone. Vomiting of blood continued frequently for at least twenty-four hours. There was slight hæmorrhage from the right nostril and right ear, followed by serous discharge from the right ear. He is improving.

Hæmorrhage into the orbit may occur to a very noticeable extent when a fracture implicates the orbital plates, the blood then escaping from the intra-cranial vessels into the areolar tissue of the orbit, and appearing very noticeably under the ocular or palpebral conjunctiva. The discoloration of the lids from such a cause would not usually make its appearance as promptly after the injury, nor be accompanied by as much swelling, as when due to contusions of the lids from direct violence.

Loss of vision from hæmorrhage into the orbit may occur, as recorded by Rohrbach.

The only objective evidence of hæmorrhage from fracture of the base may be the appearance, after a number of hours, of extravasated blood beneath the skin on the back or side of the neck. In such cases the blood flowing from the broken skull finds its way down along the cellular-tissue until it appears beneath the skin, in the neck. Such extravasations beneath the skin are of considerable diagnostic importance, if there has been no direct violence at the location of such extravasations to account for them.

Vertigo, deafness, otorrhœa, hemiplegia, impairment of vision, and priapism have also been recorded as symptoms. There is no one symptom constantly present in all fractures of the base.

Prognosis.—Fractures at the base are not as invariably fatal as was formerly supposed. There can be no doubt that recovery occasionally occurs. The prognosis as to the injury of this portion of the skull itself, if there were no accompanying lesion of the brain, would not differ from fractures of other portions, for repair may take place here as in other portions of the cranium. If the patient survived long, union would probably take place, although slowly. According to Hewett, in some cases, even after months and years, no trace of union of the fragments could be found. In others the line of fracture was found partly united by dense fibrous tissue and partly by a thin layer of inlaid bone, while in others bony union was perfect. In some instances of bony union there was an excessive formation of porous bone, it being heaped up along the line of fracture. Usually, however, the injury to the brain results fatally. It is hardly possible for an amount of violence sufficient to produce fracture of the base to fail to produce concussion, laceration, or compression of this, the most delicate part of the brain. As in fractures of other portions of the skull, the prognosis depends almost entirely upon the amount of injury to the brain. Bryant, however, reports a series of thirty cases, with twelve recoveries. In these twelve the injury to the brain consisted of simple concussion.

Charles Phelps has collected a series of seventy cases of fracture of the base with twenty-one recoveries, or thirty per cent.

J. A. Lidell has called attention to the fact that the prognosis is more favorable in fractures caused by the impact of gunshot projectiles, and has collected from the Medical and Surgical History of the War of the Rebellion, one hundred and thirty-five examples of more or less complete recovery from such injuries. Of these cases thirty-five recovered sufficiently to go back to duty permanently or enter the Veteran Reserve Corps, or be mustered out of service without pension. He shows that in many of the cases of recovery the disability from cerebral lesions subsequently increased with lapse of time. Thus apparent recovery may not be permanent. He ascribes these results to the fact that in such compound fractures extravasated blood and inflammatory products can readily escape from within the skull through the wound, and thus cerebral compression be avoided. It would be fair to consider that the same would be true to some extent of punctured wounds by canes and swords, etc., provided no portion of the foreign body remained within the skull. Lidell states that in about half of the one hundred and thirty-five cases the fracture occurred in the anterior fossa, and, therefore, infers that such injuries of the anterior fossa and anterior lobes are less fatal than those of other portions of the cerebral base.

Even though recovery may appear to take place, it may not be permanent, for there is danger of development of epilepsy or paralysis, or death from secondary brain disease subsequently. The prognosis would be especially unfavorable if, in cases of any direct violence by sticks, canes, gunshot, or other foreign bodies, any portion of the missile remained unextracted.

Recovery may occur in patients of almost all ages. Rouse records the recovery of a boy aged seven. In a series of twenty-two cases of all ages (twelve fatal), four of the patients who recovered were boys under ten years of age. (St. George's Hospital Reports, London, 1879, vol. x., pp. 125–128.) Even very prolonged coma does not render the case hopeless. W. J. Barkas reports the recovery of a girl, seven years old, under very adverse hygienic conditions, after twenty-one days' partial or complete unconsciousness. Parsons reports the recovery of a man, aged forty-eight, after being twelve days in a semi-comatose condition.

Recovery may be incomplete, and there may remain or be subsequently developed otorrhœa, headache, loss of hearing or taste or smell, unsteadiness of gait, local paralysis, and mental impairment, or epilepsy.

Treatment.—In those fractures caused by canes, swords, and other missiles penetrating the skull, the indications would be to remove the foreign body as completely and quickly as possible, and if the point of injury be accessible to the trephine, that instrument would furnish better access for the removal of foreign bodies than would any operation by cutting forceps. Aside from the removal of foreign bodies where possible, and the employment of strict antisepsis to the wound, little can be done. In all other fractures of the base, it is impossible generally to detect any depression of fragments, or to remove or elevate them where there is such displacement, and therefore the treatment would resolve itself into the simple measures for antisepsis and for insuring perfect quiet to the patient, and such measures as would be resorted to for the prevention and relief of the intra-cranial inflammation which would result from fractures of other portions of the skull. An ice-cap should be applied, and due attention given to the condition of the patient's bladder, and bowels, and diet. The head should be kept as immovable as possible, and in some severe cases it would be advantageous to secure immobility by a plaster cast.

It would rarely happen that in fractures of the base any operation would be indicated.

In all punctured fractures of the base caused by weapons or missiles, and in all other fractures in which the lines of fracture open communication with the air, as through the nasal passages or ear, and thus render the fracture compound, thorough antiseptic measures should be employed. If the nasal passages be involved, these should be frequently and thoroughly subjected to the spray of a solution of peroxide of hydrogen, and occasionally irrigated with a solution of the same from a Thudicum nasal douche apparatus. It would seem barely possible that if solutions of bichloride of mercury were used, absorption might take place to an injurious extent, considering the great extent of the nasal mucous membrane; or that some of the solution might be swallowed by the patient. The anterior nares should be plugged with sublimated gauze after each irrigation or use of spray. It would be difficult or impossible to keep aseptic any compound fracture communicating with the nasal passages.

If the communication be through the ear, this should be thoroughly cleansed and its interior irrigated with peroxide of hydrogen, and all the surrounding surfaces made clean by shaving off the hair and washing with ethereal or other soap, and made thoroughly aseptic with solution of carbolic acid, four per cent., or bichloride of mercury, 1 to 1,000. A dressing of sublimated gauze should then be applied.

It should be remembered that in syringing solutions into the ear in these cases, it may not be impossible to inject the fluid within the skull against the brain, through the same route by which the cerebro-spinal fluid escaped; and this would indicate that our antiseptic liquids

should not be strong enough nor of a kind to act as irritants.

Roswell Park (*Medical News*, December 1, 1888) has demonstrated the efficiency of boric-acid solution, 1 to 100, as a germicide; and it would therefore (as endorsed by Keen) be a very good substitute for the hydrogen peroxide.

In compound fractures of the posterior portion of the occipital bone, the scalp should be shaved and thoroughly cleansed, and antiseptic dressings be applied, and depressed fragments be elevated when accessible. In every case of possible fracture of the base, it is of extreme importance to insist that the patient be kept absolutely quiet, and on no account be allowed to get up for a considerable length of time, even though he feel quite able to do so. Hilton calls attention to the great fatality which results from failure to rigidly restrain the patient in a recumbent position, even though he feels perfectly well, for a prolonged period. *Thomas H. Russell.*

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SNOW-BLINDNESS (Ger., *Schneeblindheit;* Sw., *Snöblindhet*). Hunters and trappers in the Arctic regions, as well as mountain climbers in southern latitudes, often suffer from an affection of the eyes, to which, from its supposed causation by the glare of the sunlight reflected from the snow, the term snow-blindness has been applied. It is encountered occasionally during the winter season in the northern and western parts of this country, but is a common complaint only in the far north, and there only during the spring or summer, when the sun is well above the horizon. It follows very closely, in its degree of greatest prevalence, the isothermal lines in the three continents bordering upon the north pole, being observed much further south in America than in the continents of the eastern hemisphere.

The affection begins usually with a feeling of irritation of the conjunctiva, as if there were fine sand in the eye, and there is usually also a slight cloudiness of vision, objects appearing to the observer as if seen through a mist. This is followed by sharp burning pain in the eyeball, extending thence around the orbit into the temple. Photophobia and lachrymation are usually marked, and blepharospasm, independent of the photophobia, is not uncommon. The sight becomes at times markedly impaired, and this failure of vision may come on so suddenly and be so pronounced, that the sufferer cannot distinguish the landmarks, and, if alone, may be unable to find his way back to camp.

Examination of the eye at an early stage shows merely a slight hyperæmia of the conjunctiva, with moderate contraction of the pupil. When the condition is further advanced we find increased hyperæmia and chemosis of the conjunctiva, the latter being usually confined to that portion of the cornea which is exposed to the direct rays of light when the eye is open. In the more severe cases cloudiness, or even ulceration of the cornea has been observed. Examination of the fundus of the eye reveals, as a rule, nothing beyond a slight redness of the optic nerve.

There are two theories concerning the production of snow-blindness. The older one is that the affection is the result of a molecular change in the retina, caused by over-stimulation by the glare of the sun shining through an atmosphere containing but little moisture, and reflected from the glistening snow. This retinal affection causes pain and photophobia, and excites reflexly an irritation and inflammation of the conjunctiva. The main objections which have been urged against this theory are, first, that there are no changes in the retina, visible upon ophthalmoscopic examination, sufficient to account for the symptoms, and, secondly, that recovery of vision and relief of the discomfort follow very rapidly when the eyes are protected from the action of direct sunlight.

The second, and more plausible theory is one recently advocated by Dr. A. Berlin ("Om Snöblindhet," *Nordiskt Medicinskt Arkiv*, No. 3, 1888). This writer, who studied the affection during an Arctic expedition which he made with Nordenskjold's party, regards it as primarily an erythema of the conjunctiva due to the direct action of the ultra-violet chemical rays of the sun upon this membrane. It occurs, he says, in regions characterized by an intensely cold atmosphere and low humidity. As it is the particles of moisture in the atmosphere that absorb the sun's rays, the latter ought to exert a more intense action here than they do in lower latitudes, where the humidity is relatively much greater. And this, in fact, is the case, for Arctic travellers and mountain climbers speak frequently of the burning heat of the sun even when the temperature of the atmosphere is very low, and it is well known that the unprotected portions of the skin are more affected by the action of the sun in the far north and at great elevations than in other regions, a painful dermatitis being the result of even short exposure. Dr. Berlin believes that snow-blindness, or conjunctivitis erythematosa, as he prefers to call it, and dermatitis from sunburn are due to the one and the same cause, viz., the direct action of the sun's rays, and that the process in the two affections is the same, consisting of first hyperæmia and then exudation and the formation of blebs, attended by an intense burning sensation. He compares this to the other condition, also called snow-blindness, which is caused by the irritation from fine particles of snow blowing against the eyes during a blizzard. The latter is manifestly a traumatic conjunctivitis, but the symptoms are nearly identical with those of the first form. Another fact which the author cites in support of his view is that often only one eye is affected, and that the one exposed to the sun. For example, he observed that when the members of Nordenskjold's Greenland exploring party were marching westward, they suffered from snow-blindness confined to the left eye, but that the right eye was the one attacked when they were walking in the opposite direction. Dr. Rosendale, who agrees with Berlin as to the nature and cause of the affection, also reports several cases occurring in hunters, in whom snow-blindness began in the eye most exposed to the direct rays of the sun ("Fall af Snöblindhet," *Hygeia*, 1891, p. 299).

Among the older writers, who looked upon the affection as one due to retinal changes, strychnine was a favorite remedy. Soothing applications were also made to the eyes, and the patient was kept in a dark room until all signs of irritation had subsided. It is claimed, however, by recent authorities, that the affection will subside readily in a few days if the patient avoid the direct sunlight. It is not even necessary for him to be confined to a dark room.

As a prophylactic measure Berlin recommends the wearing of goggles made of a moderately fine wire network, without glass, fitting closely around the eyes. The

Esquimaux use "snow-eyes," which are simply goggles made out of a thin disk of wood having a minute transverse slit. A mode of protection frequently employed by trappers and hunters in the far North is the smearing of the nose, cheeks, and eyelids with a gunpowder or other dark paste. It is a curious fact that this manner of protecting the eyes from the glare of the sun is in use over very widely separated parts of the globe, and is by no means confined to the inhabitants of the polar regions. In *Nature*, vol. xxxiii., 1885, Mr. Ralph Abercromby writes that nose and face blackening is in use by the natives of Morocco as a preventive against the effects of sand glare, by the Fijians to shield themselves from the water glare, and by the inhabitants of Likkim to prevent the effects of snow glare. The efficacy of this measure as a preventive of dermatitis from the action of the sun and of snow-blindness also serves to strengthen Dr. Berlin's view that the latter is nothing more than a sunburn of the conjunctiva. *Thomas Lathrop Stedman.*

SODIUM DITHIOSALICYLATE. This is the sodium salt of an acid formed by the reaction that occurs when salicylic acid and sulphur chloride are mixed together in molecular proportions at a temperature of 120° to 150° C; the decomposition of the sulphur supplying the elements for the formation of dithionic or hyposulphuric acid, which combines with the salicylic acid. A large isomeric series is possible, but only two are utilized, the sodium salts of which are known as sodium dithiosalicylate I., and sodium dithiosalicylate II. The acids themselves are not employed for any therapeutic purposes, the sodium salts only being used. No. I. has not been used to any extent except in veterinary practice, in which two and a half and five per cent. solutions are used in the treatment of foot-and-mouth disease. No. II. is the salt usually employed. It is a grayish-white powder, very hygroscopic and entirely soluble in water. On the addition of acids a precipitate of yellow viscid drops is formed consisting of dithiosalicylic acid.

This salt is a powerful antiseptic, and is said to be superior to the salicylates in the treatment of acute and gonorrhœal rheumatism. It is given in doses of three grains, twice a day in mild cases, and more frequently when the attack is severe. It may be repeated as frequently as every hour. It is said to cause the pain, fever, and swelling to disappear in from two to six days. It has the advantage of a smaller dose and freedom from disagreeable effects. It does not irritate the gastric mucous membrane, nor cause nausea, tinnitus, or any sense of depression and collapse.

Locally it is used as an antiseptic lotion, its germicidal action being much more marked than that of salicylic acid. A twenty per cent. solution is said to destroy the spores of the anthrax bacillus within forty-five minutes.
Beaumont Small.

SODIUM TETRABORATE. Introduced for the purpose of replacing boric acid on account of its greater solubility and more active antiseptic properties. The kolyseptic or development-arresting action of boric acid on bacterial life is very marked, but being soluble only to the extent of four per cent. in water, its action is not very certain, especially where the solution may be diluted by the secretions and discharges. Tetraborate of soda is soluble to the extent of sixteen per cent., and forms a much more active antiseptic solution.

It is formed by heating together equal parts of boric acid, borax, and water; when the solution cools the compound separates as neutral crystals. It is recommended for use whenever boric acid is indicated, and is perfectly unirritating, harmless, and stable. *Beaumont Small.*

SOLUTOL AND SALVEOL. Are two patented disinfectant fluids, their active ingredient being cresol. These solutions differ from other cresol solutions, as creoline and lysol, by being free from the objectionable property of soapiness which is characteristic of these excellent disinfectants. In solutol the cresol is rendered soluble by the action of sodium cresylate. It is said to contain in every three and a half ounces, two ounces of cresol, one-fourth free and three-fourths combined as sodium cresylate. Salveol holds the active ingredient in solution by the aid of sodium cresolate in the place of sodium cresylate.

Both solutions possess all the disinfectant properties of cresol, but the former being an alkaline and caustic solution, is not applicable to ordinary work. It is very suitable for all household purposes, as it effectually disinfects closets, sinks, infected bed clothing, utensils, etc. It is very soluble in water, and may be diluted as desired. Salveol is a neutral solution, and may be used for all medical and surgical purposes for which a disinfecting fluid is required. A one-half per cent. solution is used for surgical dressings and for ordinary surgical work. It is not at all irritant, and is said to be more active than a two per cent. carbolic-acid solution. It is perfectly soluble in water, forming a clear solution.
Beaumont Small.

SOMNAL. (Ethyl-chloral-urethane.) Introduced as an hypnotic by Radlauer, of Berlin, in 1889. He described it as a true chemical compound formed by the direct combination of chloral alcoholate with urethane. By some it is said to be simply chloral-urethane or ural under another name.

It is properly a clear, colorless crystalline powder, with a hot burning taste, and very deliquescent, but is supplied in the form of a liquid on account of its instability. It is an alcoholic solution, one part in three.

It is used solely as an hypnotic, the dose being from twenty to thirty minims for adults. It resembles chloral in the rapidity of its action, but there is no depression produced. No unfavorable after-effects follow its employment, the appetite remains good, and its action on the pulse, respiration, and temperature is negative. In a great number of cases it produced sleep within fifteen minutes to an hour, and the sleep lasted from three to six hours to the whole night. The sleep is not profound. The action of the drug is sedative, and it has proved most satisfactory in the insomnia and restlessness of chronic diseases, and in convalescence from acute diseases. In delirium tremens it is not very certain in its action, nor has it proved satisfactory in acute inflammatory diseases.
Beaumont Small.

SOZOIODOL. (Di-iodo-para-phenol-sulphonic acid.) An acid base which was introduced in 1887 as an antiseptic. It contains forty-two per cent. of iodine, twenty per cent. of carbolic acid, and seven per cent. of sulphur. It is prepared by treating dio-iodo-benzol with fuming sulphuric acid and adding sulphuretted hydrogen. It is also said to be formed by adding two parts of crude carbolic acid to one part of strong sulphuric acid; the reaction raises the temperature for about two days, and when this has subsided, any excess of carbolic acid is removed and iodine added. The acid itself is not employed, but it forms salts which possess all the properties of the acid. The potassium and sodium salts are the ones most employed. They resemble one another in physical characters, forming in colorless, well-defined prisms, soluble in water, the potassium compound in fifty parts, and the sodium in fourteen. The sodium salt is the more efficacious of the two. A two per cent. solution entirely prevents the development of pus cocci.

The use of these compounds is in all those conditions in which iodoform is likely to be proved useful. It is said to be preferable, as it is soluble in water and glycerine, does not decompose when exposed, readily combines with other substances, and is free from irritating action and disagreeable odor. The salts are used as a dusting powder, either pure or mixed with French chalk, or lycopodium powder, or in the form of an ointment of the strength of two per cent. It is particularly serviceable in parasitic skin diseases. A one or two per cent. solution is used to irrigate the bladder when antisepsis is wished for, and as a wash in ozæna and other purulent catarrhal discharges. The zinc salt has been specially recommended for gonorrhœal discharges. In acute forms a half to one per cent.

aqueous solution is used with two and a half per cent. of laudanum added. In chronic forms salicylate of bismuth is added in the place of the laudanum. It is best used when the inflammatory action is beginning to decline, it then rapidly checks the secretion and hastens a cure. The zinc salt is also used in all conditions in which the sodium and potassium salts are employed. It is soluble, one part in twenty of water. All the solutions should be freshly prepared and not exposed to the light, as they are decomposed and free iodine liberated.

The mercurial salt is a lemon-yellow powder, soluble in about five hundred parts of water. It is mainly employed in the treatment of syphilitic affections. A powder or ointment of twenty per cent. strength is employed for ulcerations of the surface in disease of the nasal and other cavities. A wash when used should not exceed five per cent. It has been recommended as the most suitable form of mercury for hypodermic injections. The injections should be made in the gluteal regions, alternately on the right and left side. It causes a little pain, but the local effects are said to be much less than with any other mercurial salt. The dose is one and a half grain, and one injection a week is equal to three of other forms of mercury. The absorption of the drug is rapid, and the gums have to be carefully watched, as its action is very marked. *Beaumont Small.*

SOZOL. Is the name applied to the paraphenol-sulphonate of aluminium, one of the latest antiseptics. It occurs in crystalline granules of a strong astringent taste and faint carbolic odor. It is very soluble in water, glycerine, and alcohol, and forms very stable solutions.

It is not a powerful antiseptic or bacteriacide, but has been found to be a very serviceable application to wounds, ulcers, etc., as it possesses an astringent action in addition to its antiseptic properties. In cystitis it has been used to irrigate in a one per cent. solution. Not much is yet known of the therapeutic properties of this drug, and its value cannot now be estimated. *Beaumont Small.*

SPARTEINE. Is the alkaloid obtained from broom, *Cytisus scoparius*. It is a volatile oily liquid, very unstable, allied to coniine in appearance, chemical composition, and action. It is only used in the form of the sulphate of sparteine, which occurs in colorless, odorless, transparent needles, very soluble in water and alcohol.

Sparteine was introduced as a tonic for the heart, and proposed as a substitute for digitalis in the treatment of heart diseases and dropsy, by Laborde and Germain Sée. Although it has been employed for a number of years, it has not proved to be of very much service, nor can its action be said to be thoroughly understood. Although very contradictory reports concerning its action have been furnished, it is now very generally recognized as being much weaker than digitalis, but more rapid in producing its effect. It appears to be indicated in the cases in which there is lack of compensation without any organic lesion, and in the early stages of valvular disease. In cases of long-standing disease it is not of any benefit. Another class of cases in which it is indicated are those in which a rapid action is required and where delay would be dangerous. It is thought to have a cumulative action. On the heart it acts as a tonic to the muscular tissue, rendering the beat more slow and powerful, and correcting any irregularity in its action. This is followed by diuresis, due to the effect on the kidneys and blood-pressure. The dose is from one-half to one-third grain repeated three or four times a day; this may be increased to much larger quantities, as much as three or four grains daily. It may be given as a pill or in solution, and has also been used hypodermically.

The sulphate of sparteine is also reported (*Therap. Gaz.*, June, 1892), to have been used with marked success in the treatment of various forms of tremors. A number of cases are reported, in all of which rapid relief was obtained by taking one-fourth to one-half grain doses three times a day. The patients were both young and aged, and the tremors were due to the effect of paralytic strokes, syphilitic disease, and other causes. This effect is probably explained by its action on the motor nerves, which it depresses from the periphery to the centre, and to its tonic action on the heart and system generally. Its action, other than on the heart, has not been studied to any extent. *Beaumont Small.*

SPINAL CORD, SURGERY OF. I. SPINA BIFIDA.—In Volume VIII. of the REFERENCE HANDBOOK OF THE MEDICAL SCIENCES, p. 471, is an excellent account of Spina Bifida, by Dr. Robert W. Lovett. The only point necessary to be discussed here is the question of treatment. In the four years that have elapsed since that article was published, the operative treatment by excision has found more and more favor. Excision has now been done in a considerable number of cases with encouraging results.

Undoubtedly, in a large proportion of cases the injection of Morton's fluid (iodine, gr. x., iodide of potassium, gr. xxx., glycerine, ℥ j) will effect a cure. Powers (New York *Medical Record*, July, 16, 1892, p. 64) has tabulated 15 cases collected since the Clinical Society's Report, with 4 deaths, giving a mortality of 26.66 per cent. He has also tabulated 34 cases of excision, from which he deducts 3, which were indefinite as to the cause of death, leaving 31 cases, with 24 recoveries and 7 deaths, a mortality of 22.58 per cent.

Were all the cases collected the probabilities are that the mortality would be about the same as, or possibly a little less than that of the method by injection of Morton's fluid; but as the technique improves it is fairly certain that the percentage of recoveries after excision will increase, and thus make this the favorite method of treatment. The age at which excision has been done has varied from immediately after birth (Walther, *Revue de Chirurgie*, April, 1892, 371) up to adult life, of which there have been collected in Powers' table 3 over twenty years of age, the oldest being Powers' own successful case at thirty years of age. Of course, but few cases survive to adult life.

Technique of Excision.—In case the tumor is a simple meningocele, an elliptical incision is made, preserving enough skin on each side to cover in the defect; the sac is then dissected down to its base, the serous membrane at the neck of the sac being sutured with the two serous surfaces apposed; or if very small, the neck of the sac may be ligated and the wound closed in the ordinary way. It is important to prevent the escape of the cerebro-spinal fluid, not so much on account of the immediate danger to life from its escape as to prevent a fistula, which may eventually become infected and be followed by meningitis; and to do this it is advisable that the lines of suture of the sac and of the skin be not opposite each other. How successful the treatment by excision may be in an apparently almost hopeless case is well shown in Robson's third case. She was a girl of sixteen, with a temperature of 102° F., restless, and moaning with intense headache and dilated and sluggish pupils. In twenty-six days, eighty-five ounces of cerebro-spinal fluid were removed from the sac by eight aspirations, with temporary relief, but finally, as she was evidently failing and must soon die, the excision was done, and in thirteen days she was entirely well.

Should the case be one of meningo-myelocele, the nerves will more commonly be found attached to the posterior surface of the sac, from which they should be dissected loose and replaced in the canal, the operation being completed as before. Whether the nerves are present in the sac and adherent to its walls or not, can sometimes be told by examination of the tumor by means of transmitted light from a candle held upon its opposite side, and while the surgeon looks through a cylinder of paper, the end of which must be closely applied to the skin. They are more commonly adherent on each side of the middle line, in which line sometimes a furrow exists. Their presence, which is found to be a fact in about sixty or seventy per cent. of the cases, is, as a matter of course, an added danger.

The firmer closure of the opening in the defective spine, however, is the direction in which the chief improvement has taken place from operative interference. Bayer (*Prager*

med. Wochenschr., 1890, p. 49) has loosened the muscles on each side of the spine and brought them together in the median line. In 1883, Robson, Jessop, and Hayes, of Rochester, N. Y. (*Trans. Clinical Soc. of London*, vol. xviii.), sought to close the cleft by using a strip of periosteum from a rabbit, the osteogenetic surface being turned undermost and the piece being sutured to the neighboring periosteum. Perrier (*Semaine Médicale*, May 18, 1892) refers to a case in which Berger inserted a plate of bone from the scapula of a young rabbit. The case was reported five months after the operation, the cure having persisted, though it was thought likely that the bone had become absorbed.

The most important modification, however, has been introduced by Dollinger, Senenko, and Bobroff, of Moscow (*Centralblatt für Chirurgie*, 1892, No. 22, p. 465). Dollinger, with bone forceps, divided the rudimentary portions of the arches of the fourth and fifth lumbar vertebræ, close to their bases, and pushed them close to the middle line, where he secured them by suture. Senenko did a similar operation in a sacral case, chiselling loose from each side a piece of bone two centimetres broad, leaving them, however, in connection with the soft parts at the upper and lower ends. After four months the posterior border of the sacrum showed a continuous bony surface. Bobroff, in October, 1891, operated in the following manner: After removing an elliptical portion of the skin covering the sacrum, several nervous cords of the cauda equina, and the lower end of the spinal marrow were dissected loose from the sac, and replaced in the vertebral canal. The opening was sufficiently large to admit the index-finger. Two incisions were next made along the upper border of the ilium, and the glutæus magnus was dissected from the bone. Bobroff then chiselled from the iliac crest a piece of bone, three centimetres wide, two centimetres long, and a little less than one centimetre thick. The piece of bone was not chiselled loose, but was turned over on a hinge formed by the erector spinæ muscle, so that the periosteal surface was next the cord, and the chiselled surface presented posteriorly. The edges of the defect were freshened, two bone sutures were placed in position, the wound being then closed as usual and the patient laid upon the abdomen. A drainage-tube was used. The cerebro-spinal fluid continued to escape for several days and then the flow ceased. After two months consolidation of the transplanted bone had taken place and the patient ceased to lie upon the abdomen. Five months after the operation he was in good condition.

This case is not only noteworthy by reason of the method of operating, but also on account of its results. From birth the boy had had incontinence of urine and fæces; after the operation for three months, first faradism was used, and later the galvanic current, to arouse the sphincters, which then began to act so that the boy was able to retain the contents of the rectum, not only when lying down, but in walking and running. The sphincter of the bladder, however, only served to retain his urine during the night or when he lay down in the day-time. As soon as he stood up the urine began to escape.

Bobroff proposes, in spina bifida of the lumbar and dorsal region, to fill the defect from adjacent ribs, chiselling off the outer lamellæ, but leaving them attached to the soft parts next the spine, and then to transplant them through a slit in the thickness of the erector spinæ instead of over its surface.

As a rule, as Powers points out, excision should be resorted to "in selected cases only—cases in which the general condition of the patient is good; in which paraplegia is absent; in which the vertebral fissure is of moderate extent and the communication between the sac and the canal is narrow." In other cases the injection of Morton's fluid would be the operation of preference, if any operation whatever is deemed wise. In *International Clinics* for October, 1891, I have reported two cases, one of cervical and one of sacral spina bifida, in which recovery from operative treatment followed, but the children died of enteritis.

II. Spinal Drainage for Tubercular Meningitis and Hydrocephalus.—In consequence of the uniformly fatal course of tubercular meningitis, and especially of the rapidly fatal intercurrent coma produced by dropsy of the lateral ventricles, and of the fact that there is often but little development of tubercle present, Wynter (*Lancet*, 1891, i., 931) proposed to drain away the cerebro-spinal fluid, not by tapping the ventricles, but by indirect drainage by puncturing the membranes of the cord in the lumbar region. He has reported four cases, all of which, however, resulted fatally. The first case operated on, in February, 1889, was a boy three years of age, who was comatose and with Cheyne-Stokes respiration. No anæsthetic was needed. The child was placed in a sitting position, a small incision was made in the skin, and a Southey tube and trocar were inserted until the lamina of the second lumbar vertebræ was reached. The point was then directed downward and pushed through the ligamentum subflavum, and then through the theca of the spine, when clear fluid at once welled up in the tube. A piece of rubber tubing was attached to the tube to carry off the fluid, the boy's breathing became regular, his color good, and he could swallow. Cessation of escape of the fluid was followed by death. The prick of the trocar could not be found. In the second case, a year later, Mr. Hulke removed the spine and right lamina of the second lumbar vertebra; punctured the theca with a knife and inserted a drainage-tube into the canal. The temperature dropped from 102° F. to the normal, but on the third day, when the aperture was closed and fluid ceased to escape, coma and strabismus set in and the child died the next day. In the third case Mr. A. Pearce Gould drained from the subdural space and stitched the margins of the theca to the edges of the wound. The child improved immediately on the escape of the fluid, but died four hours afterward. The fourth child also died in three hours.

Quincke (*Berliner klin. Woch.*, 1891, Nos. 38 and 39) reports ten similar operations for hydrocephalus, pressure being made upon the skull at the same time. One case was cured, in two the results were probably due to the other measures employed, in three there was temporary improvement; none of them died. In the *British Medical Journal* (Epitome, 1893, p. 81) he is said to have done twenty-two punctures. Quincke calls attention to the fact that the cord in infants extends to the third lumbar vertebra, and hence the puncture should be made in the third or fourth intervertebral space. In infants the cauda equina is in two lateral bundles separated by a space about five millimetres broad. The third and fourth lumbar spaces measure eighteen to twenty millimetres transversely, and ten to fifteen vertically; the depth of puncture to reach the cord in infants is about two centimetres, in adults about four to six centimetres.

III. Intra-spinal Division of the Posterior Nerve-roots for Inveterate Neuralgia.—In the New York *Medical Record* for February 9, 1889, Dr. Robert Abbe reports the case of a man forty-four years of age, who, about eighteen months before, began to suffer from neuralgia of the brachial plexus, for which first the nerves of the arm were stretched and later the arm amputated. Dr. Charles L. Dana proposed to the patient that the spinal cord should be exposed with a view to the removal of a tumor, or to remedy any inflammatory processes, if either of these lesions should be found present; and if neither of them was found, then for the purpose of cutting the posterior roots of the nerves involved. On December 31, 1888, Dr. Abbe carried out the suggestions of Dr. Dana, and removed half the posterior arch of the fourth and all of the arches of the fifth, sixth, and seventh cervical vertebræ. The dura was exposed over an extent of two inches, but no tumor was found. The intervertebral foramina were then explored with a curved hook; the sixth and seventh cervical nerves were hooked up gently so that a short loop of each was raised. This was done outside the dura, but inside the vertebral canal. The fifth nerve could not be raised without exciting hæmorrhage. The sixth and seventh nerves were then cut across just outside the dura, dividing in this manner both the motor and sensory roots. The wound was left open but packed with iodoform gauze. The pain, however, soon returned. Two days after the

operation, without ether, the wound was exposed and the dura slit up. It is noticeable that "the dura was scarcely at all sensitive to cutting," though Mr. Horsley has stated that in spinal operations profound anæsthesia is necessary during this step on account of its extreme sensibility. The posterior roots of the seventh and eighth nerves were divided within the dura, which was then sutured with catgut and the entire wound closed. His pain changed in character but soon returned, and Dr. Abbe writes me (January, 1893) that he "still has considerable neuralgia, if his statements can be taken for truth." Since then Abbe has reported a second case (New York *Medical Record*, July 26, 1890), in which, within the dura, he excised the posterior roots of the sixth, seventh, and eighth cervical and the first dorsal nerves. As in the former case, temporary relief was obtained. But though in each case the anæsthesia of the parts supplied by these nerves was persistent, the pain has returned. The condition of the second case, Abbe writes me, is practically the same as in that of the first. This is the more curious, inasmuch as we know that in nerves of sensation the Wallerian degeneration proceeds centrally and should have destroyed the central diseased ends of the nerve-fibres. Abbe suggests that the cutting of the fifth nerve root might have done more good. It has seemed to me that the "pain habit," if I may so call it, may be so established in these cases that an earlier rather than a more extensive operation would promise better results. Abbe's own opinion, as expressed in his note to me, is that "the operation is a safe one, and if the hysterical element can be eliminated from any proper case it should be tried still further, inasmuch as it cannot disable the arm in the slightest degree," the motor roots being left intact—an opinion in which I fully concur.

Dr. W. H. Bennett ("*Medico-Chirurgical Transactions*," 1889, lxxii., p. 329) also reports the case of a man, the subject of syphilis, who had suffered agonizing pain in the left leg, and later in the latissimus dorsi and erector spinæ muscles, with violent spasms. An incision had first been made over the tibia, later the leg was amputated at the knee, followed by stretching, and finally, excision of the sciatic nerve, all to no purpose. Mr. Bennett, by an incision six inches long, with its centre at the eleventh dorsal spine, removed the laminæ of the ninth, tenth, and eleventh dorsal and first lumbar vertebræ. The nerves divided were the lower four lumbar, division of the nerves causing arrest of the pulse, which returned upon gentle pressure on the cord with a warm sponge. Then the first two sacral nerves were divided, followed by a similar effect upon the heart. Bennett discovered later that he had not divided the second lumbar, as he had thought at the time of operation. On the fifth day the patient was comfortable, no pain existing, though the spasms recurred. By the tenth day the wound was healed. On the eleventh day the man suddenly died from cerebral apoplexy. The post-mortem showed sclerosis of the posterior root zone and of the columns of Goll.

Division of the posterior nerve-roots for inveterate neuralgia will probably take the same position as resection of the fifth nerve in trigeminal neuralgia. The operation is one of considerable difficulty, but not of excessive danger. It is, however, doubtful whether it will permanently remedy the disease, at least in some cases. As in trigeminal neuralgia, the peripheral operations are less dangerous, and at least for a time are efficacious, and it is probable that stretching or resection of the nerves involved, and sometimes amputation, would be justified before recourse is had to division of the nerve-roots, but the pain is occasionally so horrible that the patient will be willing to undergo any operation, no matter what its magnitude or danger, in order to get relief. Such an operation should manifestly be reserved for such cases, which fortunately are extremely rare, but, as already suggested, it should not be so long delayed after recurrence that the pain habit has become firmly established.

IV. Spinal Hæmorrhage.—Spinal hæmorrhage may be either a hæmato-myelia, *i.e.*, hæmorrhage into the spinal cord itself; or hæmato-rhachis, that is, hæmorrhage in connection with the spinal membranes.

Hæmato-myelia sufficient to cause symptoms is, according to Gowers, a very rare disease and does not admit, of course, of surgical treatment. Mr. Thorburn, however, ("Surgery of the Spinal Cord," p. 62), has pointed out the fact that, especially in the cervical region, hæmatomyelia unaccompanied by any evidence of injury to the spine itself is relatively frequent, having been found in six out of the twenty-one cases of injury to the spine he reports. "The symptoms will depend upon whether the lesion is a 'destroying' or a 'compressing' one, the former being permanent, the latter more or less temporary. A 'destroying' hæmorrhagic lesion produces atrophic paralysis, and possibly persistent anæsthesia in the distribution of some of the roots of the brachial plexus. The 'compressing' lesion may cause more or less complete paralysis and anæsthesia below its level, with retention of urine and fæces, priapism, contraction of the pupil, and other symptoms, which as a rule soon subside, probably leaving only some spastic symptoms in the lower limbs" (Thorburn). Thorburn attributes the lesion not to concussion, but to a diastasis with recoil. The region in which hæmato-myelia is found is between the fifth cervical and first dorsal nerves, corresponding to the bodies of the fourth, fifth, and sixth cervical vertebræ—that is, the summit of the arch formed by the cervical curve and the point at which acute flexion of the neck would produce its worst results.

In *hæmato-rhachis* the blood may be found outside of the membranes (extra-dural hæmorrhage), under the dura (subdural hæmorrhage), or under the arachnoid (subarachnoid hæmorrhage). In the extra-dural or extra-meningeal form the amount of blood is rarely sufficient to produce compression. In subdural hæmorrhage it may be quite extensive, and may pass almost from one end of the cord to the other. Neither form of hæmorrhage is, as a rule, amenable to surgical intervention, though Mills has suggested the possibility of trephining at two points to secure suitable drainage.

V. Gunshot Wounds of the Spinal Cord.—As a rule, modern surgery is so far in advance of that of the past that gunshot wounds involving the cord should be operated on, unless, as Vincent (*Rev. de Chir.*, February, 1892, p. 89) states, other lesions of a probably fatal character would forbid interference. As he states, gunshot wounds of the cord may be divided into three classes:

1. Those in which the cord is compressed by extravasation of blood, by fragments of bone, or by the projectile lying outside of the medullary canal. In this class, by removal of the source of compression we shall at least do no harm, and shall probably improve the condition of the patient.

2. If the projectile has passed through the spine, injuring the cord in its track, as the diagnosis of the amount of injury cannot be made without an operation, it would be best, as a rule, to explore, unless other fatal and especially visceral lesions are present.

3. If the projectile lodge in the spinal canal, an operation should certainly be done on account of the almost absolutely certain meningitis and myelitis, followed by cystitis, bed-sores, and death.

VI. Laminectomy for Pott's Disease.—The first laminectomy for Pott's disease seems to have been done by Jackson, of Sheffield (*Brit. Med. Journ.*, 1883, i., p. 812); but the modern surgery of Pott's disease really dates from the case of Macewen (*Lancet*, 1885, i., 881), when he operated on a case of paraplegia with incontinence of urine and fæces, due to a connective-tissue tumor at the seat of angular curvature of the spine. In this boy, nine years of age, between the theca and the bone was found a fibrous neoplasm one-eighth of an inch in thickness, firmly attached to the theca and covering two-thirds of its circumference. After this was dissected away the cord was able to expand backward, and pulsation, which had been absent, showed itself, especially opposite the fifth dorsal vertebra. Twenty-four hours after the removal of the pressure the limbs had lost their livid color and were warm; the spastic rigidity was greatly lessened; the perception of tickling the soles had returned, and that of touch was improved. Movement was first observed eight

days later, and soon after this he had perfect control over the sphincters. After six months he was able to go about without support. Five years afterward he could walk three miles; he attended school regularly, joining in all the games, including even foot-ball.

A second and more aggravated case (*Brit. Med. Journ.*, 1888, ii., 308), operated on in 1884, by the same surgeon, showed a slight tumor with organic changes in the cord, which had shrunk to about half its normal dimensions. In ten hours after the operation the limbs had lost their lividity and felt warm. From the fourth day the patient obtained control over her bladder and rectum; six weeks after the operation she could move her limbs freely, and two months after, she walked a quarter of a mile and was able to perform light duties in the house.

Three other similar cases were operated on, one of which was successful, but the other two died. Besides these cases Macewen reported the evacuation of an abscess in the posterior mediastinum, which was pressing on the heart and bronchi. This case was also completely successful. Another similar and striking illustrative case is reported by Southam (*Brit. Med. Journ.*, 1892, i., 655), in a child three and a half years old, all four extremities being so paralyzed that the patient lay helpless in bed with incontinence of both urine and fæces. In this case, at two operations three months apart, he removed the laminæ from the fourth cervical to the first dorsal vertebra inclusive, and removed a quantity of granulation-tissue. But little improvement was noticed for nine months after the second operation; then—a most important point of encouragement—the child began to improve, and, when reported two years later, could walk without assistance and had control over the sphincters.

The source of the nervous symptoms seems not generally to be the mere curvature of the spine, nor an acute myelitis, but the pressure caused either by fungous masses of granulation-tissue over the bodies of the vertebræ by inflammatory swelling, but oftenest by a chronic pachymeningitis, or by the accumulation of pus. For instance, W. Arbuthnot Lane (*Lancet*, 1891, ii., 989), reports eleven cases of Pott's disease in which the compression in all but one was caused by an abscess. In none of these were there any fibrous neoplasms such as are described by Macewen. In such cases death follows either as the result of pulmonary complications, or more frequently from cystitis and renal complications, bed-sores, pain, sleeplessness, etc. In all of Lane's cases the large amount of disease would have precluded a cure by anchylosis. He urges, therefore, that "every case of paraplegia due to spinal caries should be operated on with as little delay as possible." In view, however, of published clinical results, especially as shown by Lloyd (*Annals of Surgery*, October, 1892, 289), who has tabulated seventy-five cases of laminectomy for Pott's disease, this opinion seems too sweeping if taken without reservation. Thus Meyers has reported recovery from paraplegia without operation in fifty-five per cent. of 218 cases; Gibney, fifty per cent. in 58 cases; Taylor and Lovett, ninety per cent. in 19 cases; and Sayre, ninety per cent. in 38 cases. The views of Burrell and Bullard and of Kraske seem to be the more reasonable. "So long as we have reasonable or even moderate chances of recovery without operation," say the former authors, "we do not believe it advisable or justifiable, in the present condition of spinal surgery, to perform so serious an operation as the resection of the laminæ." Kraske's rule for interference is well expressed. "It is necessary before operating to have exhausted all other methods of treatment. I would say, interfere when a paralysis of the bladder is established; this is the one symptom which is so serious as to justify everything" (Lloyd), to which Lloyd adds that "the first sign of degeneration of the cord should indicate immediate operation." It will be especially observed that ordinary cases of mere curvature from Pott's disease are excluded, and only those in which paraplegia with all its dire evils has resulted from the caries, should be considered suitable for operation, and then only with the limitations already stated. If there are other tubercular complications, operative interference of course is contra-indicated.

It will be observed that the cases above referred to fall into two categories: First, the cases of paraplegia from pressure, either by masses of granulation-tissue which may arise from the vertebræ within the spinal canal, or by the thickening which results from pachymeningitis—a thickening which, for instance in Macewen's case, amounted practically to a tumor so far as pressure on the cord is concerned; secondly, cases of paraplegia as a result of pressure on the cord from abscesses resulting from the breaking down of the granulation-tissue. Cases of paraplegia from either of these lesions, provided they fulfil the conditions already mentioned, may be treated by laminectomy, with removal of the neoplasm, the granulation-tissue, the pus, the carious bone, etc., by the usual means employed in such cases. (*Vide infra, Technigue*, p. 824.)

Besides these there are many cases of abscesses in Pott's disease in which modern surgery has of late achieved notable improvements in the way of preventing the later lesions which they induce in the cord, lesions to which we may properly here make brief allusion. Until within a few years surgical interference has been limited to evacuation and drainage of these abscesses at their lowest point—*e.g.*, usually on the thigh below Poupart's ligament—with or without curetting, or injection of iodoform in ether, or an emulsion of iodoform in olive-oil. This left the source of the evil—the carious vertebræ—untouched, and also very imperfectly treated the abscess. Mr. Treves, in June, 1884 (*Med.-Chir. Trans.*, vol. lxvii.), urged the evacuation of psoas abscess in the loin, combined with the removal of the carious and necrosed bone by the usual means employed elsewhere. In his "Manual of Operative Surgery," vol. ii., p. 731, 1892, he has described his improved method.

In the cervical region such retro-pharyngeal abscesses are usually accessible through the mouth, and the bone can also be treated by the same route. Burckhardt (*Centralbl. f. Chir.*, 1888, No. 4) has advocated an external incision at the inner border of the sterno-cleido-mastoid, reaching the abscess by the inner side of the sheath of the vessels, and Kramer (*Centralbl. f. Chir.*, 1892, No. 12) has successfully carried out Burckhardt's proposed operation with ease. Chiene, as early as 1877, advocated a similar operation on the outer border of the sterno-cleido-mastoid. These operations have the advantage, of course, of permitting more thorough antisepsis than the oral route, but the mortality of the latter has been very small. In abscesses in the cervical region, accessible with difficulty by the mouth, however, these methods of operating will prove of greater value than that by the mouth.

In the dorsal region the methods of Vincent (*Rev. de Chir.*, April, 1892, 273) and Schaefer (*Journal of the Amer. Med. Assoc.*, December 19, 1891, 943) are applicable.

VII. Fractures and Dislocations of the Spine.—Of the many distressing, painful, and fatal accidents to the human body, fractures and dislocations of the spine are among the most pitiful. Though either may occur independently, they are often combined, when the compound name of fracture-dislocation is appropriately used. The injury to the bone, though it may be extensive, is really the least important element in the case. It is the injury to the cord which is of such vital importance, since this interferes with motion and sensation, causes loss of control of the bladder and the rectum, and is followed very frequently and very speedily, often within twenty-four or forty-eight hours, by large bed-sores, especially over the sacrum; these bed-sores not only leading to extensive exposure of the bones, but often to septic complications, which of themselves would terminate life, even though no other lesions existed. The amount of injury of the cord varies very greatly. Sometimes, especially in the lower part of the cervical region, the bending of the neck may be so extreme as to produce mechanical destruction of the cord without any fracture, and with only temporary diastasis of the bones, which spring back into place after having injured the cord. In other cases the displacement may persist, and be so severe that the cord may be reduced to a pulp or even torn into shreds. The extent of the injury cannot be

ascertained with accuracy in many cases, until either an exploratory operation or the post-mortem reveals it. In dislocation, of course, the lesion will be at the intervertebral cartilages. In fracture there may be fracture and displacement of the laminæ which may produce compression of the cord, and fragments of bone may be driven into the cord; or there may be fracture of the vertebral bodies, which may be greatly displaced and produce direct pressure on the cord, or the articular and transverse processes may be broken. It is especially to be observed that the external deformity may be very slight, and yet the injury to the cord may be very great. This, of course, is due to the fact that the external deformity only shows the lesions of the laminæ and spinous processes. The lesions of the bodies and articular processes are so deep that their extent cannot be determined by an examination of the back. The reparative powers of the spinal cord are often surprisingly great, so that even after severe crushing it may to some extent, and occasionally to a large extent, recover its functions; hence the encouragement for surgical interference in order to place the cord in the most favorable conditions for recovery.

The distinction between total and partial transverse lesions of the cord is a very important one, and has been studied by Bastian (*Med.-Chir. Trans.*, 1890, lxxiii., 151), Thorburn (*Manchester Med. Chron.*, 1892, xvi., 73, and "Surgery of the Spinal Cord"), Herter (*Journ. of Nerv. and Ment. Dis.*, June, 1891), and others, especially with reference to the condition of the reflexes as an index to the extent of the lesion, whether it be partial or total, and therefore whether it be advisable to operate or not. The generally expressed opinion of the authors named is that in complete transverse destructive lesions of the cord there will be complete paralysis of the muscles, complete anæsthesia, and also complete and permanent abolition of the knee-jerk and other deep reflexes on both sides; but that in partial destructive transverse lesion of the cord the paralysis of the muscles and also the anæsthesia will be incomplete, and the deep reflexes will be either normal or exaggerated. The visceral reflexes, especially those of the bladder and rectum, obey the same rule as the deep reflexes, but the superficial reflexes do not follow the same rule as absolutely. Hence, Thorburn, Herter, and others would condemn an operation if immediately after an accident the knee-jerk on both sides is absent. This disapproval, in the light of experience, certainly seems to be too positive. Thus Schede (*Ann. of Surg.*, Sept., 1892, 231) reports the case of a man who had fallen from a height and fractured the fifth and sixth dorsal vertebræ, with complete paraplegia and anæsthesia of the lower extremities. The patellar reflexes were absent. The next day bed-sores were beginning over the gluteal region. Sixteen hours after the accident Schede operated and removed the fragments which were pressing on the cord, the dura being uninjured, but the cord being soft and fluctuating. In two days the patient's symptoms began to improve. The knee-jerks became increased, with ankle clonus on the right side, and the superficial reflexes scarcely increased, excepting those of the footsole. When reported the functions of the bladder and rectum were normal, and the patient was able to walk about without support or pain. His nutrition was excellent, and two months after his discharge he was in first-rate health. Had the rule stated above been adhered to, not to operate when the knee-jerks immediately after the accident are abolished, unquestionably this patient would have died from the myelitis following compression and injury of the cord.*

Thorburn ("Surg. of Sp. C.," p. 94; *Brit. Med. Jour.*, '88, ii., 881) also reports a case of recovery after traumatic paraplegia, with absence of knee-jerks and superficial reflexes, from dislocation of the second lumbar vertebra, in which sensation returned and movements of the knee-jerks were normal, those of the ankle being limited to extension; he had perfect control over the bladder, and nearly two years after the operation was able to walk three miles, with short intervals of rest, and was generally improving. It is true that in this case the very upper limit of the cauda equina was compressed, but this was not known to a certainty until the operation revealed it, and, moreover, the blunting of sensation over the genitals showed that the lower two segments of the cord had been at least to some extent injured. Very recently, at the Jefferson Hospital, I assisted my colleague, Prof. Forbes, in a laminectomy for an old fracture-dislocation in the dorso-lumbar region, in which the knee-jerks had been absent for eighteen months and returned within a week after the operation.

If no operation is done and the pressure still remains, the cord will not only degenerate, a process which begins as early as the third or fourth day, but a traumatic myelitis will follow without any possible doubt. Even if the pressure be removed myelitis will occur in the majority of cases, but the cases quoted and others show that an unexpectedly good result may sometimes be obtained, even in apparently hopeless cases.

A sharp distinction must be drawn between lesions of the cord itself and of the nerve-roots, which are practically peripheral nerves. The nerves, as is well known, resist trauma remarkably well, and recover from it to a surprising extent. This especially emphasizes the wisdom of operation in such lesions in the region of the cauda equina (that is to say, fractures below the level of the first lumbar vertebra), which are followed by paralysis of these nerves. These are entirely peripheral nerves, and their lesions should be treated precisely like lesions of peripheral nerves in other parts of the body. If they are merely contusions or bruises the symptoms will be immediate but temporary, and recovery follows; but if the symptoms persist the cause must be a permanent one and should be removed, whether it be pressure from a displaced bone or from cicatricial tissue, resulting from such an injury. The rule which has received the widest commendation of surgeons is that of Lauenstein (*Centralbl. f. Chir.*, 1886, No. 51, p. 888), that if after from six to ten weeks there is incontinence of urine and fæces, with cystitis and bed-sores, little is to be hoped for from nature's efforts, and an operation is justifiable. Horsley (*Brit. Med. Journ.*, December 6, 1890), however, is much more emphatic, and says: "In all cases where displacement or crepitus indicates compression, and where extension directly after the accident fails to reduce the displacement," we should operate if there are symptoms showing interference with the functions of the cord. In view of the early degeneration of the cord if the pressure be not relieved, of the great mortality in such cases, and of the rare but undoubted instances of good results following early operation, the tendency of modern surgeons is toward earlier rather than later interference. Schede's case already cited is a good example, and Golding Bird (*Brit. Med. Journ.*, 1891, i., 1124) has reported another of operation on the second day after a fracture of the eleventh and twelfth dorsal laminæ, causing almost complete paraplegia from compression of the cord by the displaced laminæ, and in eighteen days the patient seemed quite well. Moreover, it must be remembered that a definite conclusion should not be reached nor the cases be reported too early. Not only after operations in fracture-dislocations, but in any operations on the spine, improvement may begin late and continue slowly but surely for many months (cf. p. 823). Hence no case should be despaired of until at least a year has elapsed after the operation.

The determination of the level at which the lesion exists is a very important one, and to some extent is not yet capable of so exact a solution as we could wish. Three means exist for ascertaining this level: first, the determination of the extent of the motor paralysis; secondly, of the area of the sensory paralysis; and thirdly, the presence or abolition of the reflexes connected with each segment. From these three phenomena we can judge what nerves, and therefore what spinal segments, are involved. For this purpose the spinal cord may be considered as a series of segments placed one on top of another like a pile of checkers, these segments corresponding to the nerves which arise from them. Thus the fifth cervical segment would correspond to that segment of the spinal cord from which the fifth cervical nerve-roots originate,

* See a similar case by Phelps and Hammond (Jour. Nerv. and Ment. Dis., July, 1893, 472 and 478).

the sixth segment to the source of origin of the sixth nerve-roots, and so on. The following table of localization of the functions of the segments of the spinal column gives in the first column the various segments of the spinal cord which have been investigated; in the second, the muscles supplied by the nerve or nerves arising from each segment; thirdly, the reflex which has its origin in such a segment; and fourthly, the area of sensation, that is, the area of skin supplied by such nerves.

LOCALIZATION OF THE FUNCTIONS OF THE SEGMENTS OF THE SPINAL CORD.

Segment.	*Muscles.*	*Reflex.*	*Sensation.*
Second and third cervical.	Sterno-mastoid. Trapezius. Scaleni and neck. Diaphragm.	*Hypochondrium* (?) (third to fourth cervical). Sudden inspiration produced by sudden pressure beneath the lower border of ribs.	Back of neck and of head to vertex. (Occipitalis major, occipitalis minor, auricularis magnus, superficialis colli, and supraclavicular.)
Fourth cervical.	Diaphragm. Deltoid. Biceps. Coraco-brachialis. Supinator longus. Rhomboid. Supra- and infraspinatus.	*Pupillary* (fourth cervical to second dorsal). Dilatation of the pupil produced by irritation of neck.	Neck. Shoulder, anterior surface. Outer arm. (Supraclavicular, circumflex, musculo-cutaneous or external cutaneous.)
Fifth cervical.	Deltoid. Biceps. Coraco-brachialis. Brachialis anticus. Supinator longus. Supinator brevis. Deep muscle of shoulder-blade. Rhomboid. Teres minor. Pectoralis (clavicular part). Serratus magnus.	*Scapular* (fifth cervical to first dorsal). Irritation of skin over the scapula produces contraction of scapular muscles *Supinator longus* (fourth to fifth cervical). Tapping the tendon of the supinator longus produces flexion of forearm.	Back of shoulder and arm. Outer side of arm and forearm to wrist. (Supraclavicular, circumflex, musculo-cutaneous or external cutaneous, internal cutaneous, radial.)
Sixth cervical.	Biceps. Brachialis anticus. Subscapular. Pectoralis (clavicular part). Serratus magnus. Triceps. Extensors of wrist and fingers. Pronators.	*Triceps* (sixth to seventh cervical). Tapping elbow tendon produces extension of forearm. *Posterior wrist* (sixth to eighth cervical). Tapping tendons causes extension of hand.	Outer side and front of forearm. Back of hand, radial distribution. (Chiefly musculo-cutaneous or external cutaneous, internal cutaneous.)
Seventh cervical.	Triceps (long head) Extensors of wrist and fingers. Pronators of wrist. Flexors of wrist. Subscapular. Pectoralis (costal part). Serratus magnus. Latissimus dorsi. Teres major.	*Anterior wrist* (seventh to eighth cervical). Tapping anterior tendons causes flexion of hand. *Palmar* (seventh cervical to first dorsal). Stroking palm causes closure of fingers.	Radial distribution in the hand. Median distribution in the palm, thumb, index, and one-half middle finger. (Musculo-cutaneous or external cutaneous, internal cutaneous, radial, median.)
Eighth cervical.	Triceps (long head) Flexors of wrist and fingers. Intrinsic hand muscles.	.....	Ulnar area of hand, back, and palm, inner border of forearm. (Internal cutaneous, ulnar.)
First dorsal.	Extensors of thumb Intrinsic hand muscles, Thenar and hypothenar muscles.	.....	Chiefly inner side of forearm and arm to near the axilla. (Chiefly internal cutaneous and nerve of Wrisberg or lesser internal cutaneous.)
Second dorsal.	.....	.....	Inner side of arm near and in axilla. (Intercosto-humeral.)
Second to twelfth dorsal.	Muscles of back and abdomen. Erectores spinæ.	*Epigastric* (fourth to seventh dorsal). Tickling mammary region causes retraction of the epigastrium. *Abdominal* (seventh to eleventh dorsal). Stroking side of abdomen causes retraction of belly.	Skin of chest and abdomen, in bands running around and downward corresponding to spinal nerves. Upper gluteal region. (Intercostals and dorsal posterior nerves.)
First lumbar.	Ilio-psoas. Rectus. Sartorius.	*Cremasteric* (first to third lumbar). Stroking inner thigh causes retraction of testicle.	Skin over groin and front of scrotum. (Ilio-hypogastric, ilio-inguinal.)
Second lumbar.	Ilio-psoas. Sartorius. Quadriceps femoris	.....	Outer side of thigh. (Genito-crural, external cutaneous.)
Third lumbar.	Quadriceps femoris Anterior part of biceps. Inward rotators of thigh. Abductors of thigh.	*Patellar* (third to fourth lumbar). Striking patellar tendon causes extension of leg.	Front of thigh. (Middle cutaneous, internal cutaneous, long saphenous, obturator.)
Fourth lumbar.	Abductors of thigh Adductors of thigh Flexors of knee. Tibialis anticus. Peronens longus.	*Gluteal* (fourth to fifth lumbar). Stroking buttock causes dimpling in fold of buttock.	Inner side of thigh, leg, and foot. (Internal cutaneous, long saphenous, obturator.)
Fifth lumbar.	Outward rotators of thigh. Flexors of knee. Flexors of ankle. Peronei. Extensors of toes.	*Achilles tendon* (fifth lumbar to first sacral). Over-extension causes rapid flexion of ankle, called ankle clonus.	Back and outer side of leg; sole; dorsum of foot. (External, popliteal, external saphenous, musculo-cutaneous, plantar.)
First and second sacral.	Flexors of ankle. Extensors of ankle. Long flexor of toes. Intrinsic foot muscles.	*Plantar* (fifth lumbar to second sacral). Tickling sole of foot causes flexion of toes and retraction of leg.	Back and outer side of leg; sole; dorsum of foot.) (Same as fifth lumbar.)
Third, fourth, and fifth sacral.	Glutens maximus. Perineal. Muscles of bladder, rectum, and external genitals.	Vesical centres. Anal centres.	Back of thigh, anus, perineum, external genitals. (Small sciatic, pudic, inferior hemorrhoidal, inferior pudendal.)
Fifth sacral and coccygeal.	Coccygeus muscles.	.....	Skin about the anus and coccyx. (Coccygeal.)

This table I have taken from Mills (*Therap. Gaz.*, 1889, p. 314). It is founded on one by M. Allen Starr (*Am. Journ. of the Med. Sci.*, May, 1888, p. 464). It must be understood, however, that further observations will very likely necessitate changes in some of its details. Similar tables for the different regions may be found in Thorburn's "Surgery of the Spinal Cord," pp. 77 and 111.

Mr. Thorburn has called especial attention to what he terms the "fifth root group" of muscles, and to the almost pathognomonic postures assumed by the patient who has had the fifth cervical nerve crushed and its muscles paralyzed, in contrast to the different position of the arms assumed in cases of lesion below this point. The fifth cervical nerve supplies chiefly the biceps, the brachialis anticus, the deltoid, and the supinators. If these muscles are not paralyzed, that is, if the fifth cervical nerve is uninjured and the lesion exists at a lower level, even so close as the sixth nerve, the deltoid will abduct the elbow, the infra-spinatus (supplied by the fourth nerve) will rotate the humerus externally, and the biceps, brachialis anticus, and supinator longus will flex and supinate the forearms, so that the patient will lie with his arms in the characteristic attitude shown in Fig. 585 and, in the right arm, in Fig. 586. That is to say, if the fracture be below the fifth cervical nerve

there will be abduction of the arm, elevation and external rotation of the humerus, with flexion of the elbow and supination of the hand. If, however, the lesion involves the fifth cervical nerve, the deltoid being paralyzed, the elbow will lie next the body, the biceps and brachialis and supinator longus being paralyzed, the

FIG. 585.—Peculiar Attitude of a Patient in whom the Fifth Cervical Nerves had been Crushed. (Thorburn.)

forearm and hand will lie prone on the chest, as is well shown in the left arm in Fig. 586, in which the fifth cervical nerve has been injured on the left side only. At other levels than these there will be no characteristic posture, but the site of the injury can be ascertained by determining what muscles are paralyzed, and therefore what nerves are involved. It is of great importance that in future cases, therefore, both surgeons and neurologists should not merely use general terms, but mention in detail the individual muscles which are paralyzed. In this way only can we hereafter determine the exact value of each spinal segment. We must remember also that the muscular paralysis will vary at different periods after the accident, and that it is of the greatest importance to determine, not only the initial paralysis, but also from day to day the alteration of such paralysis, due to either recovery, or, in destructive cases, to the upward march of the myelitis.

Secondly, the lesion can be determined to some extent by the anæsthetic cutaneous area. In the cervical region the table just given will enable us to arrive at a moderately accurate determination of the nerves involved from the area of anæsthesia found clinically, but it is to be regretted that as yet there are no charts, constructed from well-recorded cases, to guide us in this determination of the level of the lesion from the anæsthesia. In a general way, as Mr. Thorburn indicates, the outer parts of the limb correspond to the upper nerve-roots, and the inner to the lower. When we reach the dorsal region of the cord, the area of anæsthesia is as a rule nearly horizontal, and encircles the trunk if the lesion be bilateral.

It is important to remember, however, that the foramina of exit of the spinal nerves and the level of the segments of the cord from which they arise do not correspond. A reference to the well-known cut of Dr. Gowers (Fig. 587) shows how far, especially as we go down the cord, the individual nerves pass downward within the spinal canal before making their exit. Thus the fifth dorsal nerve originates opposite the body of the fourth dorsal vertebra, the twelfth dorsal nerve opposite the eleventh dorsal vertebra; while the second lumbar nerve originates opposite the body of the twelfth dorsal vertebra. In fact, the five sacral and the coccygeal nerves are all crowded together at their origins in the small region opposite the bodies of the twelfth dorsal and first lumbar vertebræ. As a consequence of this difference of level of the segment from which it originates and the parts supplied by the nerve, the region of anæsthesia as a rule will be considerably below the level of the nerve involved. In addition to this, between the area of complete normal sensibility and the area of anæsthesia there is a region of varying breadth in which the sensibility is perverted, called the region of paræsthesia or dysæsthesia.

FIG. 586.—Instance of a Case where the Fifth Cervical Nerve had been Injured on the Left Side only. (Thorburn.)

Starr (*Am. Journ. of the Med. Sci.*, July, 1892, p. 15) has made a most careful study of the condition of local anæsthesia as a guide to the diagnosis of lesions of the lower spinal cord, that is, from the second lumbar to the fifth sacral segments of the cord; and has combined the observations into two diagrams (Figs. 588 and 589) which will prove of the greatest value as a foundation for future studies. His conclusions may be summarized as follows:

In the spinal cord the centres of control of the bladder and rectum are always affected together, and must therefore be adjacent. Control over these sphincters is lost when the lower three sacral segments are involved, and probably the centres which control them lie in the lowest two segments. Loss of control over the sphincter ani is best determined by the introduction of the finger, which will meet with no resistance when the sphincter is paralyzed. The sphincter of the bladder is not permanently relaxed, for constant dribbling does not take place, but there is only intermittent though unconscious dribbling as soon as a few ounces of urine collect. Retention of urine is much more liable to occur when the lesion lies at a higher level. If, therefore, in a case of paraplegia the mechanism of the bladder and rectum is not interfered with, it is a proof that the lesion has not destroyed the lower sacral segments of the cord. This fact, with a careful

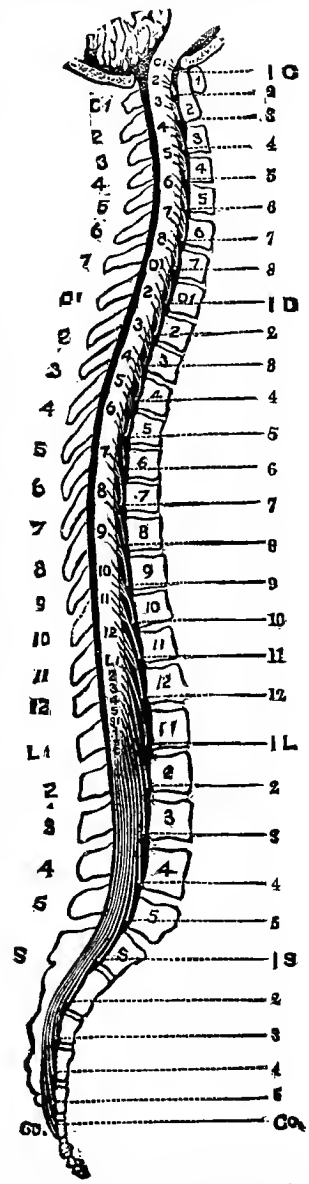


FIG. 587.—Diagram Showing the Relations between the Different Levels of the Segments of the Spinal Cord and the Nerves Originating from them, and the Levels of the Spines and Bodies of the Vertebræ between which they Emerge. (Gowers.)

determination of the area of anæsthesia, may enable us to make an exact diagnosis.

Figs. 588 and 589 show the cutaneous areas of anæsthesia which are caused by lesions of the nerves indicated. Each area of anæsthesia includes the smaller ones within it. The different zones are numbered in the illustrations, as follows:

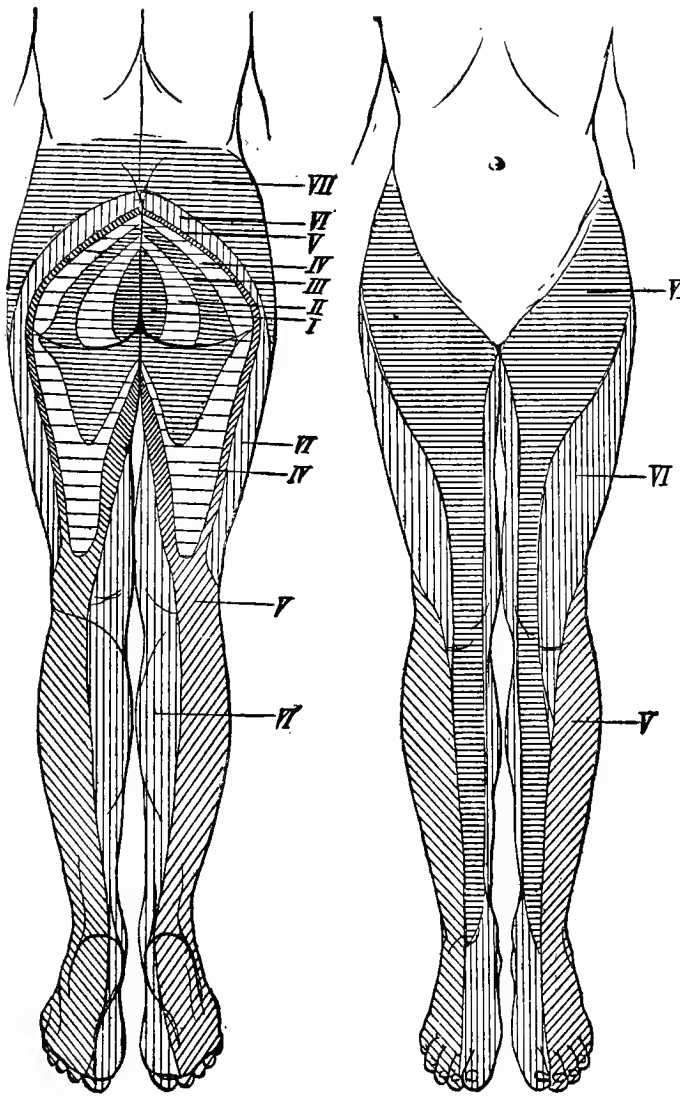
I. The first zone is supplied by the fifth sacral segment and includes the perineum, the posterior part of the scrotum in males, the vagina in females, and also the mucous membrane of the rectum.

II. The second zone, supplied by the conus medullaris and the fifth and fourth sacral segments, is heart-shaped, with the point up, and includes the entire scrotum and the posterior surface of the penis, the mucous membrane of the urethra in males, the entire genitals of the female except the outer surface of the labia majora and the mons veneris.

If the genital organs escape the case is one of functional and not of organic paraplegia.

III. The third zone is supplied by the fifth, fourth, and third sacral segments, and involves not only the buttocks, but extends down the back of the thighs. This has been named the "saddle-shaped" area, as it coincides with that part of the body which is in contact with the saddle in riding.

IV. This corresponds to the first and second sacral segments and is similar to the third, except that it is larger in extent.



Figs. 588 and 589.—Areas of anæsthesia resulting from lesions at various levels of the spinal cord, from sacral V, to lumbar II. (After Starr.)* I, Sacral v.; II, Sacral iv.; III, Sacral iii.; IV, Sacral i.; V, Lumbar v.; VI, Lumbar iii.; VII, Lumbar ii.

V. The fifth zone corresponds to the fifth lumbar segment.

VI. The sixth zone corresponds to the third lumbar segment. This may hereafter be separated into two parts corresponding to lesions of the fourth and third lumbar segments. As yet the number of recorded cases is insufficient for this distinction.

VII. The seventh zone involves the four lower lumbar segments. It will be observed that the abdominal wall is not anæsthetic in lesions of this segment. It is only when the first lumbar segment of the cord is involved that the anæsthesia extends to the abdominal wall.

Above the level of the second lumbar segment the zone of anæsthesia extends around the body in a girdle.

It is impossible at present, by the area of anæsthesia, to distinguish the lesions of that part of the cord from which the nerves of the cauda equina arise from lesions of the cauda itself. If the fracture or dislocation, however, is below the first lumbar vertebra, at which level the cord ends, the lesion must be of the cauda itself.

The muscular paralysis is very slight in lower cord lesions, being confined to the perineal muscles when the lesions are at or below the second sacral segment. It involves the anterior and posterior tibial muscles when all the sacral segments are involved, and only involves the movement of the hip-joint when the entire lumbar region is affected. In lesions of the cauda, on the other hand, pressure on nerve-roots is often sufficient to produce widespread paralysis when sensation is but slightly affected (Starr).

It has been thought that sensations of touch, temperature, and pain not being equally destroyed, was an evidence of lesions of the cord as distinguished from one of the cauda, but Starr has shown that this point is not well taken.

The table on page 819 shows the origin and distribution of the reflexes; these should be exactly observed and recorded in each case.

Eye Symptoms.—Only in lesions at and above the second dorsal would we expect any pupillary trouble, the cilio-spinal centre being involved. The sympathetic or radiating fibres of the iris being paralyzed, the pupil will then be smaller and immobile. Mr. Thorburn has shown that the eye-ground gives but little information so far as we now know. There may be a haziness of the disk, with want of definition of its margins and slight distention of the retinal veins, coming on the third or fourth day, and persisting for three or four weeks. Atrophy of the optic nerve does not take place.

Dangers of Operation.—Mr. Horsley has called attention to five of these: 1. Hæmorrhage. 2. Difficulty in clearing the neural canal. 3. Physical difficulties in treating the fractured vertebræ. 4. The hopeless nature of the damage to the spinal cord; and 5, septic infection; to which White has added 6, the danger of anæsthesia in the prone position, with paralysis of the abdominal muscles. The last is a real danger, and one of my own cases

* M. Allen Starr: Am. Journ. M. Sci., July, 1892.

came near dying from apnœa in consequence of anæsthesia even in the dorsal position, before I began the operation. He bore the operation, however, very well in spite of this. Sepsis is also a real danger which ought to be overcome by modern antiseptic methods. Whether the damage to the spinal cord, if extensive, makes the case hopeless or not is really the most important question, especially as the operation itself involves to a certain extent some additional disturbance and damage to the cord. Thorburn does not approve of operation, as a rule, inasmuch as he does not believe that it holds out much prospect of improvement. In those cases—and they constitute a majority—in which there is not found any serious narrowing of the vertebral canal, he says the operation is useless, as the whole mischief is already done. If the displacement of the bones is maintained, and the cord is permaneutly compressed, the damage to the cord is greater than in those cases just mentioned. Yet even in the more favorable conditions recovery rarely follows, and it is highly improbable that those in which the pressure persists will do any better after trephining. In other words, the damage done by the acute compression of the cord is usually irremediable, whether the pressure still remains or has been removed. On the other hand, Mr. Horsley says: "So far from its being unjustifiable to operate on the spine owing to the possibility of the cord being hopelessly damaged, it seems to me to be criminal not to operate." As is so often the case the truth seems to lie between these two extreme and diametrically opposite views.

The other three dangers already alluded to may be practically disregarded, for, by the modern technique, there is little if any trouble with them.

The question whether the operation should be done or not, depends chiefly upon the results. The vast majority of fractures and dislocatlons of the spine are certainly incurable without operation. For example, Gurlt records two hundred and seventeen deaths out of a total of two hundred and seventy fracturcs, and in many of the fifty-three who recovered life was scarcely worth the living.

On the other hand, the cases already quoted, in which even the absence of knee-jerk seemed to show a total transverse lesion of the cord, but which nevertheless recovered after operation, show that much is to be accomplished in a few cases. The remarkable improvement in the bed-sores, which not uncommonly are arrested in their ravages after operation, would alone make the operation sometimes advisable, and the improvement in the urine sometimes noticed would also be encouragement in the same direction. In addition to this, Thorburn has collected sixty-one cases in which an operation was done. Only thirty-five (fifty-seven per cent.) died. In Gurlt's two hundred and seventy cases not operated on, eighty per cent. died. The mortality after operation, therefore, is much less than when no operation has been done.

For the present, then, until a larger experience has given us grounds for a more precise conclusion, it would seem proper to give patients suffering from such almost hopeless injuries the small but reasonable chance which an operation affords, and that the operation should be done at an early rather than at a late period.

VIII. Fixation by Silk or Wire.—In a former brief paper on the "Surgery of the Spinal Cord" (Reference Handbook, Vol. VIII., p. 492), I have already referred to Wilkins' case, in which he fixed the two adjacent vertebræ between which a hernia occurred, by a figure-of-eight sterilized silk ligature passed through the intervertebral notches. Since that time Hadra, of Galveston, Tex. (*Phila. Medical Times and Register*, May 23, 1891), has proposed to wire the spinous processes of the vertebræ together as a means of immobilizing them in fracture and in Pott's disease. Hadra's patient was one who had a fracture of the sixth cervical vertebra, which was dislocated forward and rotated on its vertical axis to the right. At a later time, when bending his neck too much, he was paralyzed, his head and neck being turned to the right; his right hand numb; right arm weak; girdle pains around the upper abdomen; bladder not fully under control; slight priapism. Crepitus was observed ten months after the accident. At the operation the vertebral canal was not opened, but the sixth and seventh spines were wired together by silver wire in figure-of-eight. After some weeks, thinking the wire had become loose, it was removed and a new one put in its place. This patient I saw in the winter of 1891 and 1892. He was perfectly free from any paralysis, but the inability to move his head well, and especially to do without some support, was still quite marked, and disabled him, practically, from any form of labor.

IX. Tumors of the Spinal Cord.—In the Reference Handbook, Vol. VI., p. 89, Dr. Zenner has given an admirable résumé of the chief phenomena connected with spinal tumors. A few points, however, that have been developed since his paper was written, may be of value.

Operative interference was undertaken only in one case prior to 1887. This is reported by Johnson ("Trans. Path. Soc. of London," xviii., 16). It was a congenital lipoma of the sacral region, extending to the cord. Recovery ensued after the operation, with great relief of the symptoms, but the patient (eleven months of age), died six weeks later from acute peritonitis. Practically this was an isolated case and invited no repetition until the brilliant paper of Gowers and Horsley ("Medico-Chirurgical Transactions," 1888, vol. lxxi.) appeared. In this paper Horsley has pointed out that, excluding parasites, such tumors are chiefly of the connective-tissue type. Even the intra-dural tumors are generally covered by a thin capsule derived from the pia and arachnoid, and can be easily removed without damage to the cord. In the initial stage they are ofteu mistaken for rheumatism, especially on account of the pain, which resembles rheumatic pain not a little. But the march of the symptoms is very different from that seen in rheumatism. In spinal tumors the pain is followed by muscular paralysis, and later by sensory paralysis. In a few cases Brown-Séquard's paralysis has been observed. In this, from the crossing of the sensory and motor nerves at different levels, there will be anæsthesia on the opposite side from the tumor, with hyperæsthesia, ataxia, paralysis, and exaggerated reflexes on the same side. If carefully observed this difference of the symptoms on the opposite sides of the body will enable us to localize the tumor very much more exactly than otherwise. The pain is almost always referred to a lower level than the lesion, on account of the intra-spinal course of the nerve-roots (Fig. 587), and especially on account of the as yet undetermined course of the nerve-roots after they enter the spinal cord.

Hence, if we localize the tumor by the area of pain we are very apt to locate it below its real level. In Gowers' and Horsley's case, the tumor was opposite the third dorsal body, but was referred to the fifth root, and lay at a level four inches above the zone of anæsthesia. This difference in the level of the pain and anæsthesia on the one hand, and of the tumor on the other, was within an ace of causing absolute failure in this, the most remarkable case of spinal surgery on record; for when Horsley had removed the laminæ of the third, fourth, fifth, sixth, and seventh dorsal vertebræ, nothing pathological was discovered, and it was only after removal of the lamina of the second dorsal that the tumor was discovered.

Horsley calls attention to the fact that it is necessary to define with the greatest possible accuracy the upper border of the hyperæsthetic or paræsthetic zone above the level of the anæsthesia, and that when the spine is operated on it should be explored to the very *highest* point suggested by any definite symptoms, including even *slight* paræsthesia.

Again, it is to be noted also that the favorite position of tumors is below the middle of the cervical region, and at the upper and lower ends of the dorsal region. They occasionally, however, appear in the cauda equina and other parts of the spine. In the dorsal region the tumor is, as a rule, situated higher than the point of tenderness, but not in the cervical. Stiffness and weakness of the spinal column correspond pretty closely with the position of the tumor. If the spine be curved to one side the cavity is on the same side as the growth, as a rule. Spastic

rigidity is marked in at least half the cases of intra-dural tumors; in extra-dural in but a small proportion. The reflexes are first markedly exaggerated, and then as the tumor slowly progresses they are gradually lost from below upward. Spasms occur in about sixty-one per cent. of the intra-dural and thirty-five per cent. of the extra-dural tumors. Most of the cases cover two years or more, and the paralyses of both motion and sensation are not sudden as is usual in cerebral tumors, but increase slowly. Pressure lesions in the cauda equina progress even more slowly than in the cord.

Horsley tabulates fifty-eight cases, of which only two received any benefit from treatment, and eighty per cent. died as a direct result of the tumors. All, he thinks, might have been relieved by surgical interfereuce, and probably a number even cured. In 1882 Bramwell was the first one to suggest the removal of extra-medullary tumors, and in 1887 Gowers suggested, and Horsley executed, the first really modern operation for such a removal. The man was forty-two years of age, and the tumor apparently arose from a sprain. In June, 1884, the pain was first noticed. It varied very much for two years, sometimes almost ceasing, at other times the patient was scarcely able to walk, and his irritability was such that even his sanity was questioned. Early in 1887 his legs became paretic, first the left leg, and a few weeks afterward the right, until he was completely paralyzed; sensation was impaired, and retention of urine occurred. There was anæsthesia as high as the area of skin supplied by the fifth dorsal nerve, with doubtful diminution of sensibility in the area supplied by the fourth. In the region supplied by the fifth and seventh intercostal nerves there was severe pain, much more marked on the left side than on the right, and increased to agony on any movement. The urine was purulent. Mr. Horsley, as already stated, removed the tumor with the gratifying result that in seven months the patient could walk three miles with ease, and in a year was able to do a day's work of sixteen hours, including much standing and walking about, and was entirely free from pain and discomfort.

Wright (Thorburn, "Surg. of the Spinal Cord," p. 168) has operated on a case of fibro-sarcoma of the neck, involving the brachial plexus, which invaded the cord through the intervertebral foramen for the third cervical nerve. The tumor, which was a fibro-myxoma about the size and shape of a lemon and encapsulated, was removed by an ordinary dissection. A Volkmann's spoon was then introduced into the intervertebral foramen and the growth scraped away. Recovery of the patient followed, and also immediate relief of the symptoms.

Rehn (*Archiv f. klin. Chir.*, 1891, xlii., 812) has reported a case (observed by Laquer and operated on by Rehn) of lymphangioma cavernosum, compressing the cauda equina, the removal of which was followed by recovery and relief. The patient was a young man of nineteen, who first noticed his pain in the sacral region and in the back of the thigh in September, 1888. At first this was the only symptom present, but in two years there was paralysis of the bladder and the rectum, loss of patellar reflex on the right side and weakening of it on the left, no ataxia, no disturbance of sensibility, and no atrophy of the muscles. The patient walked with a stiff leg and in a slightly stooping posture. He became exhausted after a few steps, and could only obtain sleep by narcotics. He lay in bed on his right side with the lumbo-sacral region pushed markedly backward. Every motion caused him great pain. There was, however, no decided paralysis. A tumor was suspected both by Laquer and Rehn, who operated October 14, 1890. He chiselled upward from the lower end of the sacrum, and at the upper border of the second sacral vertebra came upon a small tumor as thick as the finger, with a blue, translucent capsule. The tumor was removed partly with the scissors and forceps, and partly with a sharp spoon. The dura mater and the nerves were pushed toward the anterior wall of the canal. The patient made a good recovery and was dismissed in a month. His pain was gone, the patellar reflexes were restored, and he was able to walk without difficulty and to resume light labor.

Abbe (New York *Medical Record*, July 26, 1890) has also reported two cases of tumor of the spinal cord upon which he has operated. The first was a man aged twenty-two, who was taken with pain in the back in January, 1888. During March his sense of touch was dulled in the legs and the muscular power weakened, and a line of hyperæsthesia formed about the waist. Incontinence of urine and fæces followed, and the tumor grew so rapidly that by May 26, 1888, it seemed that he would soon die. Abbe removed the arches of the eighth, ninth, and tenth dorsal vertebræ. Outside the arches of the ninth, which were carious, and also filling up the intervertebral canal, was a quantity of inspissated pus and a tubercular neoplasm 2.5 inches long. Thorough curetting was performed, and a plaster jacket was applied. On the eighth day sensation began to return, in three weeks he could move his legs and toes, pain disappeared in three months, and he walked with crutches in eight months, being then robust and hearty. Two years later, after having remained in good health, an abscess formed in the cicatrix and the sinus which led down to the bone was curetted. The other case was that of a man forty-two years of age, who suffered from an extra-dural sarcoma. He was injured in 1887; six months later, when lifting a piano, he experienced an excruciating pain in the back. July 1, 1889, his spine was jarred severely by alighting violently on his feet, and a week later this accident again occurred. In two weeks he found it painful to rise. At the end of five weeks paresis of the legs set in; paraplegia and anæsthesia were complete by August 23d. The paraplegia was diagnosticated to arise from pressure, and it was hoped that it was from Pott's disease. His urine soon afterward showed albumin, and this was followed by chills, sweating, and vomiting, with a deep ulceration of the rectum. On April 16, 1890, Abbe operated, removing the arches of the eighth, ninth, and tenth vertebræ, and found a sarcoma filling the vertebral canal and compressing the cord to half its normal bulk. On the fifth day the patient began hiccoughing and vomiting, and finally died on the ninth day from exhaustion.

Deaver (*Amer. Journ. of the Med. Sci.*, December, 1888, p. 564) operated upon a patient of Lloyd's, who was thought to have a tumor of the cervical spine. There were paresis of the left arm, paralysis of the left leg, and exaggerated reflexes, but neither paræsthesia nor anæsthesia. He removed the laminæ of the third and fourth cervical vertebræ, but found nothing abnormal in the cord or membranes. Puncture of the cord with a needle produced exceedingly irregular respiration, which continued until her death, three days later. The post-mortem examination showed no tumor, but an old extravasation of blood and degeneration of the cord.

Dereum and White (*Annals of Surgery*, vol. ix., p. 424, 1889) have reported also one case of paraplegia thought to be due possibly to a tumor. No tumor was found, but the removal of the connective tissue outside the dura and separation of subdural adhesions were followed by marked improvement in sensation, which was still progressing when the case was reported.

X. Syringo-myelia.—So far as I know, Abbe's is the only case of this form of glioma of the spinal cord that has been operated on and reported (*Journal of Nerv. and Ment. Dis.*, July, 1892, 512). He removed the ninth, tenth, and eleventh dorsal laminæ, and found a fusiform dilatation of the spinal cord, with no pulsation; and on slitting up the dura no cerebro-spinal fluid escaped. By touch a lemon-shaped, central cyst was discovered and aspirated by a hypodermatic syringe. The withdrawal of 3 jss. of fluid was followed by collapse of the cyst. The patient recovered from the operation and showed some improvement, but died seven months later from cystitis and other complications. I have myself done two operations on similar cases, which have not as yet been reported. In one of them, done January 31, 1891, at the Philadelphia Orthopædic Hospital and Infirmary for Nervous Diseases, I exposed the lower cervical and upper dorsal cord, and found what I and the experienced neurologists present all supposed to be a very thin,

grayish-white layer of lymph on the surface of the cord, under which was a dark, blackish-gray tumor, which I thought lay posterior to the cord. In a few minutes my suspicions were aroused that I was wrong, and I discovered that the excessively thin layer of supposed lymph was the thinned layer of the white matter of the cord, and that the mass which I took for a tumor back of the cord was really a glioma of the cord itself. I, of course, instantly desisted from operation and closed the wound. The patient lived five days, and the post-mortem revealed a very extensive syringomyelia.

The second case I have every reason to believe was a syringo-myelia, from appearances, but happily I have not yet had the opportunity of making a post-mortem. The operation was done on a patient of Drs. Putnam and Warren, of Boston, on December 28, 1891. In that case I removed the arches of the tenth, eleventh, and twelfth dorsal vertebræ. The cord was greatly thickened, of a dark-gray color, and was adherent to the dura. No cerebro-spinal fluid escaped on slitting up the membranes, which I did not suture, but left open for about two inches in order to relieve the pressure on the cord. No trouble has arisen from any adhesion between the cord and the adjacent soft parts. The patient has shown a little improvement. There was evidently no localized cyst, but probably an extensive syringo-myelia.

These, so far as I know, are the only three cases that have been operated on. These results show that where the diagnosis of syringo-myelia can be made beforehand —a difficult task in many cases—it would be best to abstain from operation.

XI. Technique of Laminectomy.—Before any operation on the spine, the usual cleansing and, if need be, shaving of the back should be done over a very large area. The preparation of the surgeon's hands, instruments, etc., differs in no way from that which prevails in an ordinary operation. He should be provided with about two dozen hæmostatic forceps and with various rongeur and bone forceps, raspatories, etc. The patient is placed on his abdomen, and thus the anæsthetic must be administered in a most unfavorable position, the face being at the edge of the table; and if the injury is high up, the muscles of the abdomen and chest being paralyzed, the conditions are still more unfavorable. Great care, therefore, should be used in administering the anæsthetic, and this responsible post should be filled only by one who has had large experience, and whose judgment can be relied upon. Strychnia, digitalis, and atropia should be ready to be administered if the necessities of the case call for them, and the patient should be well protected from chilling, both by blankets covering all the body except the field of operation, and by hot-water bottles.

An incision is made in the middle line, not less than four inches long, even for a single lamina, and as much longer as is necessary. Other incisions have been proposed, such as the "T" and "V" incisions, as well as the "H" by Bullard and Burrell, the last with a view of lifting the posterior arches with the muscles and replacing them later. Ample experience has proved, however, that the longitudinal incision is quite sufficient. If there be any difficulty in separating the edges widely enough, which I have never found to be the case, an incision may be made in the fascia at right angles to the first. Next the muscles are to be cut away from the arches, which must be laid bare so as to be clearly seen. It is much better to cut the muscles away from the arches so far as it can be done instead of doing any blunt dissection, in order that there shall be as few ragged fragments of muscular tissue as possible which may undergo necrosis, with probable later suppuration. When the muscles have been cut away a raspatory can then be used to remove entirely the fragments of muscle adhering to the arches, and so expose them clearly to sight. During this dissection the hæmorrhage will be very free, and the technique of Horsley is the best, viz., the moment that one side has been cleared, pack it thoroughly with sponges wrung out of hot water, and then proceed with the opposite side. By the time the other side has been cleared the sponges can be removed from the first, and a clean field is thus secured.

To remove the arches the interspinal ligaments should first be cut by a vertical incision, and some care should be taken that the knife does not enter the spinal canal and wound the membranes and the cord during this step. This is an especial danger only in the cervical or lumbar region, as in the dorsal the laminæ overlap so much that this danger is *nil*. Hey's saw, the trephine, and the variously-shaped cutting forceps have been used to open the canal. Abbe (New York *Medical Record*, July 26, 1890) has proposed not to remove the arches entirely, but after separating the muscles on one side to cut loose the spines at their bases, leaving them attached to the other lateral flap instead of to the upper and lower flap in the "H" incision proposed by Bullard and Burrell. I can scarcely see any especial advantage in either of these procedures, and a possible disadvantage of wounding the cord by spiculæ of the replaced bone. The fear that has been expressed by Pilcher and others, that the solidity of the spinal column would be impaired by removal of the arches has not been realized. The bodies of the vertebræ carry the superincumbent weight, and the arches are practically merely to complete the canal for protection of the cord.

During this removal of the arches in the cervical region care must be taken not to wound the vertebral artery.

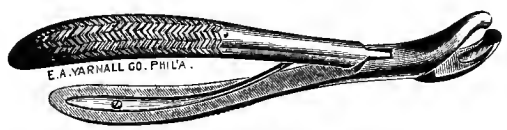


Fig. 590.—Double Rongeur Forceps.

This caution would seem almost superfluous were it not for the fact that Chipault (*Rev. de Chir.*, August, 1892, 685) states that in at least three cases speedy death has resulted from wounding this vessel. He gives, however, no references to the cases, and I have not found any such reported. The best and quickest method of opening the spinal cord I have found is to gnaw away the spinous processes, and then a part of one of the arches by the double rongeur forceps (Fig. 590), and then the arches can be bitten away to any extent by the rongeur forceps which I devised originally for linear craniotomy, but which answers this purpose admirably (Fig. 591). Occasionally there will be considerable hæmorrhage from the vessels, especially the veins within the spinal canal. This can usually be controlled very soon by pressure and hot water.

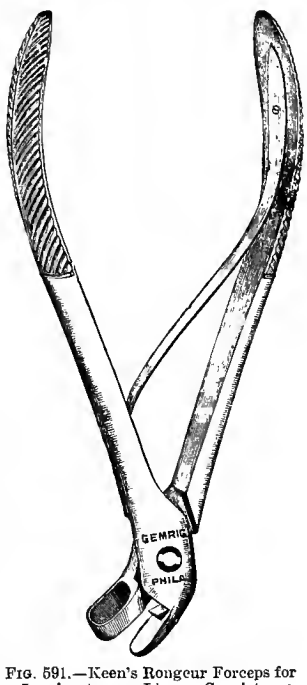


Fig. 591.—Keen's Rongeur Forceps for Laminectomy, Linear Craniotomy, etc.

Between the membrane and the bones is usually a moderately thick layer of fatty tissue which can be best treated by dividing it in the middle line, and pushing it to each side with small bits of gauze or sponge. As soon as it is pushed aside it gives no further trouble. The dura should next be observed as to whether it pulsates, for if not, there are probably either some adhesions or other

causes of interference in the continuity of the subdural space. The color may indicate whether there is blood or pus underneath the dura, and its tension will show whether there is more cerebro-spinal fluid within the membrane than there ought to be.

Touch will also verify this. But although there may be no excess of cerebro-spinal fluid, there may be thickening of the cord from a tumor, or syringo-myelia, etc., or thickening of the dura itself, all of which can be more or less well appreciated by touch. If it be necessary to examine the bodies of the vertebræ, the cord and its membranes can be carefully drawn to one side by means of an aneurism needle or other similar instrument, so as to expose the bodies of the vertebræ both for observation and, if need be, for operation. Mills has proposed to cut one or two nerve-roots if necessary, but this, as a rule, does not seem to be needful. To facilitate such observation Chipault places two cushions under the patient, so that the spine will be concave backward, which will facilitate the lifting of the cord. The nerves are sufficiently elastic to allow of moderate stretching. At this stage any extra-dural tumor, thickening of the dura on its external surface, or any further pressure by dislocation or fracture of the arches or bodies of the vertebræ can be suitably treated.

The question of opening the dura is a somewhat more serious one in the spine than in the brain. In the brain we can close the opening without drainage and prevent the continuous escape of the cerebro-spinal fluid. In the spine this is not so easily done, as the injury to the thick muscles sometimes prevents absolute primary union, and so favors the establishment of a fistula. Such a fistula is not only a source of irritation to the surrounding skin, and an annoyance by its constant dressing, but also, as has been observed by Verneuil and Chipault, subsequent infection may take place through such a sinus. The mere escape of the cerebro-spinal fluid itself is not a very serious matter. On p. 814 a case of withdrawal of very large quantities of cerebro-spinal fluid shows how innocuous this is, and in many cases of spinal operation the escape has been free and continuous for some time. As a rule, however, in the spine as in the brain, in spite of these objections, it is best to open the dura, and, when the operation is completed to suture it with a continuous catgut suture so as to favor speedy union. If it is not opened serious errors may occur, due to defective information about the cord. Once that it is opened, the condition of the subdural space can be ascertained by the dural separator of Horsley or by an ordinary bent probe, and it should certainly be explored both upward and downward. The same is true of the space between the dura and the laminæ. This should be explored to determine any irregularities, obstructions, etc. If there be a tumor of the cord, if it be on the surface of the cord, it can now be removed, usually with ease. If it involve the substance of the cord it is more difficult of treatment, and may require such serious injury of the cord as may make it inadvisable to remove it. If the cord has been injured or crushed by accident, little can be done beyond freeing it from pressure. It has been proposed to suture the cord by Morris (*Annals of Surgery*, 1886, iii., 490), Abbe (*Medical Record*, July 26, 1889, 85), Maydl, and others, but no successful case has been reported. Duncan (*Edinburgh Medical Journal*, March, 1889, 883) has stitched the sheath above and below, but this attempt also failed. Leckie (*British Medical Journal*, October 1, 1892) has even proposed to shorten the spine by removing the part or whole of a vertebra, or portions of two adjacent vertebræ if necessary, by means of gouges or drills; a proposal which will scarcely meet with any favor. In gunshot wound of the cord, Tuffier has sutured the nerves themselves.

Occasionally, after opening the theca and instituting suitable treatment of the cord, it will be better to leave the dura open. In one case of my own, probably a syringo-myelia, in order to relieve the pressure on the cord I left the dura open for a space of two inches; and Horsley has left it open for as much as four inches. Two dangers exist in connection with this. First, the continuous escape of cerebro-spinal fluid, already alluded to, and secondly, possible injurious effects from cicatricial adhesion of the soft parts to the posterior surface of the cord. As yet, however, in reported cases there does not seem to have been any pain or other unfavorable symptom as a result of such adhesions. As a rule, it is much better to suture the dura, and in such a manner that the two internal or serous surfaces shall be in approximation, in order to obtain the speediest union. This may be done either by continuous or by interrupted sutures of catgut or fine silk. I have found the best means of applying the suture to be with the finest semicircular Hagedorn needle and a needle-holder. In order that the dura may close and prevent the continuous escape of the fluid, no drain should be inserted under it. It is much better, however, to place a rubber drainage-tube for a day or two, deep under the muscles, on account of the free oozing which will always follow so extensive a wound. The muscles should be approximated by buried sutures of catgut, the skin being sutured in the ordinary way, and the usual antiseptic or aseptic dressings applied.

After-treatment. — The first redressing will usually have to be made within the first twenty-four hours, or possibly twice during the first day, on account of the free oozing and the escape of cerebro-spinal fluid. The most careful antiseptic precautions should be observed in the redressing, lest infection should take place. The drainage-tube may be removed usually in twenty-four to thirty-six hours. Especial care should be taken, that if there are bed-sores present no contamination occur through them, and also, if control of the bladder and bowels has been lost, that infection do not arise from these sources. Thorburn has proposed to drain the bladder by a suprapubic cystotomy after injury of the cord, passing by this means through parts which are not anæsthetic or apt to slough, and preventing the constant wetting of the wound as a result of the incontinence of urine; an operation which would seem to be reasonable, although I am not aware of its having been done. The bed-sores will often improve very much, and even get well, after such an operation. The ordinary care as to food, etc., will suggest itself to every operator. *W. W. Keen.*

STOMACH DIGESTION AND THE TESTS OF ITS EFFICIENCY EMPLOYED IN DIAGNOSIS. The careful study of the past few years into the physiology of gastric digestion, and the desire on the part of clinicians to apply the knowledge thus gained to the more accurate differentiation of the various disorders of the stomach, have developed methods of examination for diagnostic purposes requiring special description. Before considering these in detail, it will be well to briefly summarize our present knowledge of the digestive process within the stomach.

Gastric digestion may be divided into two periods of unequal duration, a first or amylolytic period, and a second or proteolytic period. The amylolytic period usually lasts for about three-quarters of an hour after the ingestion of an ordinary meal. During its continuance the reaction of the gastric contents is alkaline, the acidity of the gastric juice secreted at the beginning of gastric digestion being neutralized by the alkaline food and saliva, and the amylolytic action of the saliva continues. Starches are converted through the activity of the ptyalin into achroödextrin, erythrodextrin, and in part into glucose, and saccharose is in great part split up into glucose. These changes take place rapidly and soon cease, but they are usually soon followed by a fermentative change of a different nature, dependent upon the presence of ordinary germs of fermentation in the ingested food. These in their growth split up a certain amount of the glucose resulting from the amylolytic action of the saliva, with the resultant formation of lactic acid. As this fermentation can go on only in a feebly alkaline or neutral medium, it is quickly terminated by the appearance of free hydrochloric acid.

Although the secretion of gastric juice is at once stimulated by the entrance of food into the stomach, the

time at which free hydrochloric acid appears in the stomach contents varies greatly with the nature of the food taken. Thus, food rich in alkalies and proteids, by chemically combining with the acid of the gastric juice, materially delays the appearance of free acid in the stomach. With the appearance of free acid the amylolytic period comes to an end, the amylolytic action of ptyalin being thereby interfered with, and the proteolytic period begins.

This period is characterized chiefly by the conversion of the proteids of the food into albumoses and peptones through the agency of the pepsin of the gastric juice. This latter is secreted by the gastric mucous membrane in the form of propepsin, an inert substance which becomes changed into the active ferment in the presence of free hydrochloric acid. Though secreted during the amylolytic period, its proteolytic action is therefore delayed until the presence of free acid brings the first period to an end and inaugurates the second. Through the same agency the lactic acid and other mycotic fermentations which may have been active during the amylolytic period are arrested, an acid medium preventing the development of the necessary germs, and shortly after the commencement of the proteolytic period the organic acids formed as the result of these fermentations disappear.

Since the secretion of gastric juice continues so long as there is food remaining in the stomach, a continual increase in the acidity of the gastric contents would be expected after the first appearance of free hydrochloric acid. This is, however, not the case, as much of the free acid after a time becomes loosely combined with the products of the digestion of the proteids of the food, with the albumoses, peptones, leucin, tyrosin, etc. This fact is of great importance, as the hydrochloric acid so combined is powerless as a digestive agent; and it not infrequently happens that the proteolytic action of the gastric juice is in this way materially impaired. Furthermore, the low content of free hydrochloric acid in the stomach contents at this time may cause the physician to underestimate the secretory activity of the gastric mucous membrane, and may lead him into error of diagnosis in that way. It is accordingly only after the stomach has in a measure emptied itself of the products of proteid digestion, that the maximum content (0.2 per cent.) of free hydrochloric acid is reached. The time at which this occurs differs with the character of the food, the presence of a considerable quantity of albuminous material markedly delaying it, so that after a meal rich in proteids the maximum acidity of the gastric contents is not reached till four hours or more after the ingestion of the food, though reached in about two hours after a meal composed chiefly of carbohydrates.

Besides propepsin and hydrochloric acid, the gastric mucous membrane elaborates lab-zymogen, an inert substance converted by free hydrochloric acid into the active lab-ferment, causing the coagulation of the casein of milk. As the conditions modifying the secretion of this substance are at present little understood, and it is consequently of small diagnostic significance, it may be passed without further notice.

During the entire period of stomach digestion energetic peristalsis materially aids in the mixing of the digestive juices with the food, and as the latter becomes more and more liquid, is an active factor in its discharge into the duodenum. At the expiration of six hours after the ingestion of an ordinary meal the stomach should be empty. Until the next meal it should remain more or less quiescent and should contain only a small amount of thin liquid of neutral reaction, and containing neither pepsin nor hydrochloric acid.

It is probable that very little absorption is accomplished by the gastric mucous membrane. The more liquid portions of the food are quickly driven into the duodenum as the result of the peristaltic activity of the stomach, and the products of ordinary proteid digestion in the stomach, the albumoses and peptones, are now known to be less readily assimilable than was formerly supposed. It is fair, therefore, other things being equal, to judge of the muscular activity of the gastric wall from the time elapsing after the ingestion of a meal and until the stomach has completely emptied itself.

With these fundamental facts of normal gastric digestion in mind, the particular effect upon digestion of any given departure from the normal of either the secretory or motor function of the stomach may be readily inferred.

Diminished secretion of hydrochloric acid* permits undue prolongation of the amylolytic period and continuance of the mycotic fermentative processes, which normally occur during that period, and causes delay in proteid digestion. The fermentative processes lead to the formation of lactic and other organic acids as well as to the production of an excessive amount of gas. These lower the tone of the stomach and interfere materially with its normal peristalsis, thus augmenting the injurious effect of delayed proteid digestion with its resultant stagnation of food in the stomach. This condition of insufficient hydrochloric-acid secretion is made evident by the discovery of a low percentage or absence, so far as our tests indicate, of free hydrochloric acid in the stomach contents throughout the whole course of digestion; by the presence of fermentative products, especially lactic acid, in excess or at a time when they should have disappeared; by the delayed emptying of the stomach; by the presence of undigested proteids in the stomach contents seven hours or so after the ingestion of the meal; and by the fact that the digestive power of the gastric juice, tested experimentally, is below the normal.

Excessive hydrochloric-acid secretion shortens the amylolytic period, and so interferes with the digestion of the amyloids of the food. If associated with proportionate increase in the secretion of propepsin, it may hasten digestion unduly and out of proportion to the ability of the stomach to empty itself. Usually, however, excessive hydrochloric-acid secretion is not accompanied by proportionate secretion of propepsin, and the excessive acidity tends rather to delay than to accelerate digestion. In either case there is usually more or less stagnation of the gastric contents, which, being more irritative than usual, in time lead to inflammatory changes in the gastric mucous membrane, with resultant diminution of acid secretion. Hyperacidity is indicated by an increased percentage of free hydrochloric acid throughout gastric digestion and by its earlier appearance; by the finding in the gastric contents of remains of undigested starches, the amylolytic period having been shortened; by the shortening of the time of gastric digestion in many cases, though not in all; and experimental testing of the digestive power of the gastric juice may show it to be abnormally active.

We have seen that inefficient motor activity of the gastric wall may be a result of either diminished or excessive secretion, and that it then intensifies the primary abnormal condition. But it may also result from mechanical hindrance to the emptying of the stomach, notably from stenosis of the pyloric orifice. In any event it is a prime factor in the production of gastric dilatation, in which secretory disturbance, motor inactivity, and fermentation of retained materials combine to intensify the disorder already present. If, seven hours after the ingestion of an ordinary meal (better the test-meal to be presently described), the stomach is still found to contain any considerable quantity of food, we may infer diminished activity on the part of the gastric wall. The stomach contents in gastric dilatation present the following characters: decided diminution or absence of free hydrochloric acid; presence of the fatty acids of fermentation in large quantity, notably lactic, butyric, and acetic acids; low digestive power with presence in the stomach-washings of undigested fragments of all the foods ingested; and the presence of large numbers of fermentative bacteria of various kinds.

From what has been said it will be evident that the determination of the efficiency of gastric digestion in any

* The secretion of propepsin is apparently not subject to such variation as that of the hydrochloric acid, nor are slight variations in its amount of such moment. It is believed never to be absent when hydrochloric acid can be detected in the gastric contents.

given case must involve the solution of several distinct problems, each requiring its own special mode of examination. The degree of acidity of the gastric contents must be learned, as it throws important light upon the secretory activity of the stomach. The duration of ordinary stomach digestion must be determined, as it affords information not only as to the digestive power of the gastric juice, but as to the motor activity of the stomach itself. The content of lactic acid must be studied, as its presence in excess is positive indication of abnormal fermentation. And, finally, the character of the digestive products must be investigated to determine the completeness of digestion.

The examination is usually begun by the determination of the time required for the digestion of a definite standard test-meal. Several test-meals have been proposed for this purpose, but that suggested by Leube and known by his name, is the one most commonly employed.* This consists of a plate of barley soup, six to eight ounces of well-cooked beefsteak, a French roll, and a glass of water. It should be taken on an empty stomach. Seven hours after the ingestion of this meal the stomach should be empty. At the expiration of seven hours, then, the stomach-tube should be passed and the stomach should be completely emptied of any contents, first by Ewald's expression, then by lavage.† If the stomach is found to be empty, with the exception, perhaps, of a very few shreddy remnants of the ingesta, it is proper to infer that no very material impairment of the secretory activity of the stomach is present, and that its motor function is efficiently performed. Hyperacidity or hypersecretion may, of course, exist, and in all cases in which their existence is suggested by the symptoms the test above described should be repeated, shortening the interval between the ingestion of the test-meal and the washing of the stomach until the exact time required for digestion is determined.

If, on the other hand, after an interval of seven hours the stomach is found to contain any considerable quantity of food, digestion is impaired and subsequent examination is indicated to determine the precise character of the defect. Again, if the period of gastric digestion is markedly shortened, further examination will be necessary to learn whether this is the result of hypersecretion or of excessive motor activity, such as is occasionally met with in certain forms of nervous hyperexcitability.

The great value of this test as a preliminary, directing the course of subsequent examination, must be apparent.

The existence, then, of abnormality of gastric digestion having been shown by the test above described, we pass to subsequent tests directed to the determination of the following points :

1. Is the food properly disintegrated and mixed with the gastric juice, and does it contain extraneous substances, as blood, bile, pus, bacteria, etc., whose presence may throw light upon the existence of organic disease of the stomach ?

2. Is it acid, and, if so, is free hydrochloric acid present ?

3. Are lactic acid and other products of fermentation in excess of the normal ?

4. What is the total acidity, and what the quantity of free hydrochloric acid present ?

5. What is the digestive power of the gastric secretion as indicated by the amount of peptone present in the stomach contents, and by the artificial digestive power of the filtered gastric juice ?

6. What is the degree of motor activity of the gastric wall ?

These we shall consider in the order given. The material obtained from the stomach in the preliminary test may be employed for this subsequent examination, or the stomach may be emptied again four or five hours after the ingestion of another test-meal.

1. Careful inspection of the gastric contents frequently throws much light upon the disorder of digestion. The food may have been imperfectly masticated and may appear as large masses, difficult of penetration by the gastric juice and hence delaying digestion. Much mucus may be plainly visible, indicating a catarrhal condition of the mucous membrane, or blood, bile, or pus may in rare cases make their presence known to the naked eye, and may serve as valuable indications of disease of the gastric tissue.

Gross inspection should always be followed by a more minute examination with the aid of the microscope. The methods employed in this examination and the significance of the various substances occurring in stomach contents have been dwelt on in detail in treating of vomited matters in the article on Microscopy in the body of this work, and need no repetition here.

After the inspection above referred to the gastric contents obtained for examination should be thrown upon a moist filter. The filtrate is employed in the majority of the succeeding tests. The solids may be used for the microscopic examination.

2. The acidity of the filtrate is tested with litmus paper. The positive result of this test does not, however, prove the presence of hydrochloric acid, as all free acids give a similar reaction, as do also a large number of acid salts. It is necessary, therefore, to test more particularly for free hydrochloric acid.

Many tests have been proposed for this purpose, but it will be necessary to limit their description in this place to three of the most delicate, which are in most cases sufficient for all purposes of clinical examination.

(*a.*) Tropaeolin.* This is a finely crystalline brownish dye, readily soluble in alcohol, the solution having a deep amber color. This color deepens to a dark brown on addition of hydrochloric acid, and if the mixture be evaporated to dryness and gently heated, a beautiful lilac or blue color develops, the exact shade depending in part, at least, upon the quantity of acid present. This serves as an exceedingly delicate test for hydrochloric acid, yielding a positive result in solutions containing only 0.05 per cent. of hydrochloric acid alone, though less delicate in the presence of albumin, peptones, and phosphates. For the detection of free hydrochloric acid in gastric contents the test is conducted as follows :

A few drops of a saturated alcoholic solution of Tropaeolin OO are added to double the quantity of stomach filtrate in a flat porcelain dish.† If free hydrochloric

* Among other test-meals may be mentioned that of Ewald and Boas, consisting of a roll and a cup of tea, or a glass or two of water. The stomach contents should be examined one hour after ingestion of this meal. The Klemperer test-meal consists of a pint of milk and two small rolls ; and the stomach is emptied two hours after its ingestion. Both of these meals should be taken in the morning on an empty stomach. They are particularly well suited to the requirements of hospital out-practice, where the patient can be controlled for a comparatively short time only. For private practice and for ordinary hospital work, the Leube test-meal will usually be preferred.

† The passage of the stomach-tube, the various precautions, etc., to be observed in so doing, and the most approved method of washing out the stomach will be found fully described in the article, "Stomach Lavage" in this supplement. The technique of lavage there described needs no modification for diagnostic purposes. But a word is necessary regarding the method of expression recommended by Ewald. To accomplish this the tube is passed in the ordinary way, and when well in place, the patient is instructed to rather vigorously contract the muscles of the upper portion of the abdomen, as if he were vomiting. If there is anything in the stomach this is usually sufficient to force a portion of it into the tube and out at its distal end, where it should be caught in a clean dish for examination. If the muscular contractions of the patient are inefficient in forcing the stomach contents through the tube, the physician may endeavor to assist the expulsory action by pressure over the stomach during the efforts of the patient. If nothing appears at the distal extremity of the tube it must not be inferred that the stomach is necessarily empty, for a considerable amount of the stomach contents may have been forced into the lower end of the tube, or the tube may have been obstructed by large particles of undigested food. If in such a case it is particularly desired to obtain some of the gastric contents undiluted, the distal extremity of the tube should then be tightly compressed to prevent entrance of air, and to cause retention of its contents, and the tube should be removed and its contents allowed to run out into a clean dish. Whether anything has been obtained by expression or not, the stomach should be thoroughly washed out to make certain the diagnosis.

* Several dyes are manufactured in Germany under this name; that here intended is designated "Tropaeolin OO." It may be had of Merck & Co., of 71 and 73 William Street, New York.

† The writer has found the covers of the ordinary small porcelain crucibles so commonly used in chemical laboratories to be exceedingly well suited to the requirements of the color tests connected with the examination of the gastric contents. They are small, very flat, and furnish a clear white background for the color changes. They are, furthermore, so thin that the heat necessary to most of the tests may be got from a single match burning under them.

acid is present in any considerable quantity the color of the tropaeolin solution will deepen as the mixing of the two liquids takes place. But if present in only small amount no such change may be noticed, and in any case the mixture should be gently warmed, as the subsequent change in color is a much more delicate indication of the presence of free hydrochloric acid than the deepening in color above referred to. If free hydrochloric acid is present a clear beautiful lilac or blue color will develop as the mixture dries at the edges and becomes heated.

As has been said, this is an exceedingly delicate test of the presence of free hydrochloric acid. Lactic and other organic acids occurring in the gastric contents fail to give any similar reaction in any concentration in which they are found in the stomach, and their presence in no way interferes with the delicacy of the test. The presence of much albumin and of the products of proteid digestion and phosphates, somewhat impairs its delicacy, but even under these conditions the test is to be regarded as one of the most delicate at our disposal for the detection of free hydrochloric acid.

Filter-paper soaked in tropaeolin solution and afterward dried, may also be employed for this test. If hydrochloric acid is present the color should deepen on addition of a drop of the stomach filtrate, and the lilac color should develop as before on gently heating to dryness. The test is, however, considerably less delicate when conducted in this way, and, if negative, should never be accepted as final unless corroborated.

It should be remembered that the delicate and characteristic part of this test is the development of the lilac color, and that this may often appear on heating when there has been no perceptible deepening of the color on mixing the two solutions. The heating should, therefore, never be neglected.

(*b.*) Phloroglucin-Vanillin Test (Günzburg's Test). This is by far the most delicate and reliable test which has been proposed for the detection of free hydrochloric acid in the gastric contents. It depends on the development of a characteristic red color in an otherwise colorless solution.

The reagent proposed by Günzburg and known by his name, has the following composition:

Phloroglucin	2 grm.
Vanillin	1 grm.
Absolute alcohol	30 c.c.

It should be kept in a dark blue or brown bottle, as it is less stable in the light. The test is conducted precisely like the tropaeolin test. A few drops of the stomach filtrate are mixed with an equal amount of the reagent in a flat porcelain dish, and the mixture is *gently* heated. If free hydrochloric acid is present a brilliant carmine-red mirror develops as the mixture dries and becomes heated. This color should remain unchanged after treatment with ether. If free hydrochloric acid is not present a yellowish-brown residue is left after evaporation.

Organic acids yield no similar reaction in any concentration, and their presence in the solutions tested in no way interferes with the delicacy of the reaction. The test is further valuable in that it responds in the presence of *free* hydrochloric acid only, that which is loosely combined with the albuminoids of the food, etc., and is consequently useless for purposes of digestion, not giving the characteristic reaction. It, therefore, gives information as to the existence in the gastric contents of hydrochloric acid in the condition necessary for digestion.

The formula given above is that originally proposed by Günzburg. Boas has recently proposed a slight modification of it, claiming greater stability and somewhat greater delicacy for the modified reagent. His formula is as follows:

Phloroglucin	2 grm.
Vanillin	1 grm.
Alcohol (eighty per cent.)	100 c.c.

This is employed in the same way as the original Günzburg reagent, and the result is the same.

Phloroglucin-vanillin paper may be prepared by soaking washed filter-paper in the reagent and drying it. This, also, should be kept in a dark bottle. It is used precisely as the tropaeolin paper.

(*c.*) Resorcin Test (Boas). This test is said by its inventor to be as delicate as the phloroglucin-vanillin test. The reaction is similar.

The reagent employed has the following formula:

Resorcin resublimat.	5 grm.
Sacchar. alb.	3 grm.
Spiritus dil.	100 c.c.

Five or six drops of stomach filtrate are mixed with from three to five drops of the reagent in a white porcelain dish, and are gently evaporated to dryness, when a fine rose or cinnabar color is produced, which disappears on cooling.

Organic acids are said to give no similar reaction.

3. Having been informed by the above-described tests as to the presence or absence of free hydrochloric acid in the stomach contents under examination, we proceed to the third step in our analysis, the determination of the presence of organic acids. As lactic acid is by far the most constant of these under those conditions which lead to their formation, and as its determination is both simpler and more delicate, we shall limit our description to a consideration of its principal test, alluding only cursorily to the reaction of butyric and acetic acids.

The most delicate reaction for lactic acid is that proposed by Uffelmann. The reagent employed consists of

Carbolic acid (two per cent.)	100 c.c.
Liq. ferri chloridi	1 to 2 drops.

This reagent has a steel-blue color. Its ingredients should be kept in separate bottles and should be mixed immediately before applying the test, as it quickly changes and becomes useless for the detection of lactic acid. Under the action of lactic acid this solution is quickly decolorized and a greenish-yellow coloration develops. Hydrochloric acid simply decolorizes the reagent. Butyric and acetic acids cause an orange-yellow coloration; they rarely lead to much confusion, owing to their characteristic odors. But a reaction very similar to that caused by lactic acid is caused by alcohol, sugar, and various acid salts, though the green quality of the final color is less distinct.

In making use of this test for the detection of lactic acid in the stomach contents, a few cubic centimetres of the freshly prepared reagent are poured out into a flat porcelain evaporating-dish or a test-tube and the stomach filtrate is slowly added, when, if lactic acid is present in any significant amount the characteristic greenish-yellow color will appear. If the previous test for hydrochloric acid has shown the presence of a large quantity of it in the stomach filtrate, and on its addition the Uffelmann reagent simply becomes decolorized without the development of the characteristic color, we may infer the absence of lactic acid. If the final color produced is yellowish or orange, without the greenish tone, it should not be forgotten that the substances above named, butyric and acetic acids, alcohol, sugar, and acid salts, any of which may be present in the stomach, may cause such a reaction, and before finally admitting the presence of lactic acid a portion of the stomach filtrate should be thoroughly shaken with ether, which dissolves the organic acids, and the residue, after evaporation of the ether, should positively yield the typical lactic acid reaction.

4. The presence of free hydrochloric acid having been determined, and a rough idea of the content of organic acids having been gained by the tests already described, it becomes important to learn approximately in what quantity the hydrochloric acid may be present.

The tests which have been proposed for the exact quantitative estimation of free hydrochloric acid in the gastric contents, are all either inaccurate and therefore unsatisfactory, or necessitate complicated and tedious chemical manipulation, rendering them unsuited to the needs

of the physician. However, the estimation of the total acidity is easy, and in cases in which the result of Uffelmann's reaction has been negative, and we may fairly exclude the presence of organic acids in any material amount, the result of the determination of the total acidity affords sufficiently accurate data for most diagnostic purposes. It alone will be described here, the reader being referred to more special works for descriptions of the more complex methods of analysis. (*Von Jaksch, Boas, Leo.*)

The estimation of the total acidity is accomplished by titration of a measured quantity of the stomach filtrate with a standard solution of alkali. The standard alkaline solution is made by dissolving four grammes of sodium hydrate (5.6 grammes of potassium hydrate) in a litre of distilled water. One cubic centimetre of this solution should exactly neutralize 0.00365 grammes of hydrochloric acid. It is slowly dropped from a graduated burette into a carefully measured quantity of the stomach filtrate to which a small quantity of an aqueous solution of Congo red has been added. In the presence of acid Congo red changes to a deep blue, and the titration is therefore continued until the reappearance of the characteristic brilliant red color of the Congo red in neutral and alkaline solutions. The instant at which this occurs marks the complete saturation of all the acid combinable with the alkali employed. By reading off on the burette the number of cubic centimetres of the alkaline solution required to accomplish this neutralization, by multiplying this number by 0.00365, the amount of hydrochloric acid equivalent to one cubic centimetre of the alkaline solution, and by then dividing by the number of cubic centimetres of stomach filtrate taken for the test, the content of acid in one cubic centimetre of the stomach filtrate is determined, and from this the percentage may readily be calculated by multiplying by one hundred. Thus, if 6 c.c. of the standard alkaline solution are required to neutralize 10 c.c. of the stomach filtrate, the following formula represents the necessary calculation in determining the total acidity:

$$\frac{6 \times .00365 \times 100}{10} = .219 \text{ per cent.}$$

It will have been observed that in this estimation the acidity is calculated in terms of hydrochloric acid, and this at once suggests an error in the method, for we have seen that other acids may be present. Still the error is slight, as a rule, when the reaction for lactic acid has been negative. Of far greater importance, however, is the fact that by this method we neutralize not only the free acids, but also that hydrochloric acid which has entered into loose chemical combination with the albuminoids of the food, the alkali used in the titration having the power to separate this combination. As this combined acid is useless for digestion, very erroneous inference as to the digestive power of the gastric juice may be drawn from the amount of total acid determined. Yet this, too, which would at first sight appear a serious error in the method, is less so when we consider that the examination is made after the ingestion of a standard test-meal, the amount of whose proteids is the same in all cases, and that accordingly the amount of hydrochloric acid entering into such combination must be always approximately the same. While, therefore, the result arrived at in the determination of the total acids fails to give information as to the amount of free acid present with that accuracy which could be desired, it still affords data for the comparison of healthy and disordered digestion sufficiently accurate for most purposes of clinical examination. It is much to be regretted that up to the present time no simple, practical, and sufficiently accurate method for the separate determination of the free and combined acid has been devised.

When the test for organic acids (Uffelmann's) has demonstrated their presence in any considerable quantity, they should be removed before the titration, by shaking with ether.

5. The digestive power of the gastric juice may be inferred from the result of two very simple tests: the first, for peptone in the stomach filtrate; the second, to determine the actual power of the stomach filtrate to digest albumin under proper conditions.

(*a*) Peptone is tested for by the ordinary "biuret reaction." A small amount of the stomach filtrate is rendered strongly alkaline by addition of sodium or potassium hydrate, and a few drops of an aqueous solution of cupric sulphate are added. If peptone is present in any considerable quantity a characteristic purple color is produced on addition of the copper salt.

In connection with this test is should be remembered that albumin, which is almost always present in some form in the gastric contents in cases of disordered digestion, gives a similar reaction, a blue-violet color, and that the distinction between these two colors may be quite difficult, leaving the physician in doubt as to whether peptone is present in large amount, indicating good digestive power on the part of the stomach, or as to a large content of albumin, indicating impaired digestive power, since at the time of the examination it should have been in great part converted into peptone.

(*b*) The most reliable test, therefore, of the digestive power of a given sample of stomach filtrate is the time which it requires for the digestion, under proper conditions, of a given quantity of albumin. Normal gastric juice should digest a piece of hard-boiled egg albumin, one centimetre square and a millimetre thick, at the body temperature, in one hour. In the test, then, such a piece of egg albumin is dropped into a test-tube, is liberally covered with stomach filtrate, and the tube is placed in a warm-air chamber or a water-bath kept at the body temperature, 37° C. If at the expiration of an hour the albumin is not digested, we may infer that the digestive power of the gastric juice is impaired.

We have seen that impairment of the digestive power of the gastric juice is almost always due to deficiency of hydrochloric acid. But occasionally, when an atrophic condition of the gastric mucous membrane exists, there may also be diminution or even abolition of the pepsin-forming function. When there is reason to suspect such a condition a second test of the digestive power of the stomach filtrate should be made, adding a few drops of dilute hydrochloric acid. If the albumin remains still undissolved after the required interval, we are justified in assuming deficiency or absence of pepsine as well as hydrochloric acid.

6. The most reliable information relative to the motor activity of the gastric wall is gained from the result of the preliminary test of the time required for the digestion of the standard test-meal, and usually the information so gained is amply sufficient for all ordinary diagnostic requirements. If, seven hours after the ingestion of the test-meal, food is still contained in the stomach, we may infer diminished motor activity on the part of the stomach.

A special test of the motor activity of the stomach has been devised by Sievers and Ewald. This test depends upon the fact that salol, which is insoluble in the stomach, is converted by the alkaline intestinal juices into phenol and salicylic acid, both of which are readily absorbed and speedily appear in the urine. In carrying out the test the patient is made to swallow with the meal a capsule containing about fifteen grains of salol. Under normal conditions salicylic acid can be detected in the urine in about an hour by the following test:

To a few drops of urine in a flat porcelain dish a drop or two of a rather dilute solution of ferric chloride is added. If salicylic acid is present a reddish-violet color is at once developed, which is permanent on standing.

If, after the ingestion of the salol capsule, this reaction does not develop in the course of an hour and a quarter, it may be inferred that the activity of the stomach is diminished, but careful tests have shown that this is not necessarily always the case. It is believed, however, that absolute absence of the reaction at any time, and after repeated testing, may be considered quite positive proof of obstruction of the pylorus.

It has been the purpose of the present article to present the principal tests of the efficiency of gastric digestion which have been developed during the past few years, and to suggest the conclusions which may be deduced from their use. Any detailed discussion of the subject is beyond the scope of this HANDBOOK, and the reader must be referred therefor to the more exhaustive works mentioned in the appended bibliography.

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In most of these books will be found references to the leading magazine articles upon the various phases of the subject.

John Slade Ely.

STOMACH LAVAGE. Lavage of the stomach, as at present practised, consists of the introduction of a tube into the stomach, the removal of the stomach contents, and the cleansing of the gastric mucous membrane by the repeated introduction and removal of tepid water.

Though it is within a few years only that the stomach-tube has attained to anything like a widespread use in medicine, we nevertheless find that John Hunter, about the middle of the last century, made use of hollow tubes inserted into the stomach as a means of applying irritating substances to its mucous membrane. As the remedial effects of this treatment were slight the method seems to have attracted little attention. In 1822 F. Bush, an English surgeon, employed the first stomach-pump to remove the gastric contents in a case of opium poisoning. Seven years later, in 1829, the stomach-syphon was introduced by Arnott, but, though recommended by Sommerville, Blatin, and Canstatt, it was soon lost sight of, and the attention of the profession was not at all generally drawn to its use until the publications of Kussmaul in 1867 and 1869. The more recent development of the method and its general acceptance as one of the most valuable of our therapeutic resources, are due principally to the investigations of Oser, Leube, Ewald, and Boas.

The tube at first made use of was of thin rubber, and received support during its passage from a flexible stylette. This was quickly superseded by a stiff tube of cloth and gum-elastic material which could be passed without the aid of the stylette. These tubes are hard and very stiff when cold, but become moderately flexible after immersion in warm water for a few moments. They are still to be found in the shops, though their use is now almost entirely restricted to cases of profound coma, and to those in which the resistance of the patient prevents the passage of the ordinary softer tube, now commonly in use. This tube is of soft red rubber, is about twenty-eight inches long, has a calibre of about one-fourth inch, is closed at the extremity, and has two good-sized openings near its tip. This tube was originally introduced by Nélaton, and is frequently designated by his name. It is kept in stock in several sizes by all the leading instrument makers, but the size above mentioned will be found to be most generally useful.

In the selection of a stomach-tube the following points should be borne in mind. While being perfectly flexible, the tube should still have a certain amount of firmness, so that it may withstand a moderate amount of pressure without collapsing; it should be perfectly smooth everywhere, and without cracks in its surface; and the openings near its tip should have rounded edges ("velvet-edged"), so that no irritation may be caused by their sharpness. Some difference of opinion exists as to the preferable form and arrangement of these openings. Schütz and some other German observers advocate the use of a tube with an open "velvet-edged" extremity, a large elliptical opening on one side near the tip, and several small "pin-head" openings opposite this larger one. This tube is said to possess the advantages of several openings without consequent impairment of the stiffness of the tube. It has the disadvantage common to all tubes open at the end, of delivering a rather forcible direct stream of water through that opening, a thing to be avoided in delicate states of the gastric mucous membrane.

Recently flexible tubes of silk have been introduced, but they possess no advantage over the rubber tubes, and are considerably more expensive.

Various forms of suction apparatus have been proposed at different times for emptying the stomach, but these have all been superseded by the syphon. This consists of the stomach-tube above described, to which a funnel is attached by means of a second rubber tube somewhat longer than the stomach-tube proper. The two rubber tubes are usually united by a piece of glass tubing of equal calibre, so that the lumen of the whole syphon may be the same throughout. Such a stomach-syphon is shown in the accompanying cut.

The principle upon which the proper working of this tube depends is that of the ordinary syphon. When the stomach-tube is passed, and the tube is filled with water by means of the funnel, lowering the funnel to a position below the level of the stomach converts the tube into a syphon, and causes an amount of suction measured by the difference in level of the inlet and outlet of the tube. It will be evident that by this apparatus a most simple and accurate adjustment of the pressure employed in emptying the stomach is possible—an important consideration in some of its more serious disorders—and for this reason the stomach-syphon is to be recommended above every other form of apparatus for routine use in stomach lavage. It has the additional advantages of simplicity and portability.

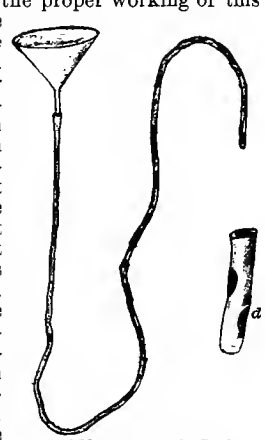

FIG. 592. — Stomach Sypbon. *d*, Tip of Tube, showing the Lateral Openings.

As a rule no great difficulty attends the passage of the stomach-tube. The patient should sit erect with the face in the median line and the head *not* thrown back. The clothes should be protected by towels. The tube, which has been previously warmed in water, is grasped in the right hand, the left being free to steady the head of the patient if necessary. No lubricant is required. The patient then opens the mouth and protrudes the tongue slightly. The tube is passed quickly backward over the centre of the tongue to the posterior wall of the pharynx. On coming into contact with this, its extremity bends downward, sliding over the pharyngeal mucous membrane to the introitus œsophagi. The contact of the tube with the pharyngeal mucous membrane usually sets up reflex spasmodic contraction of the faucial and other pharyngeal muscles, and may even give rise to rather troublesome expulsive efforts. These should not alarm the operator, however, nor cause him to desist, but should be met by him with the command to swallow. A determined effort of the patient to obey usually quickly controls the expulsory efforts, and after passage of the extremity of the tube into the œsophagus its further progress is unattended by any hindrance, being aided by gentle onward pushing of the tube by the operator and by re-

peated efforts at swallowing. As the tip passes the cardiac orifice a slight increase of resistance may at times be appreciated, and is then of assistance to the physician in giving definite information as to the location of the cardiac orifice, a factor of some importance in determining the exact size of the stomach. After passing the cardiac orifice, the tube should be pushed on until eight or ten inches of it have passed into the stomach. Its extremity should then lie along the greater curvature of the stomach, pointing toward the pylorus.

During the passage of the tube, and so long as it remains in position, the patient should be made to breathe deeply, and while this is possible the operator has assurance that everything is going well. The quite universal dread that the tube may pass into the larynx is, in the opinion of the writer, quite unfounded, that accident never having occurred to him. It is, furthermore, unattended with serious results, as the stoppage of the larynx is at once indicated by violent cough, by the inability of the patient to breathe, and by commencing cyanosis, whereupon the tube should be immediately withdrawn. Usually no difficulty of respiration is experienced by the patient after the first insertion of the tube.

There is an instinctive tendency on the part of the patient to throw the head back as the tube is being passed. This should be forbidden, and, if necessary, prevented by steadying the head with the left hand. Extension of the head causes material narrowing of the upper portion of the œsophagus, thus imposing increased resistance to the passage of the tube.

Excessive sensitiveness of the pharyngeal mucous membrane in neurotic individuals may rarely necessitate painting of the posterior pharyngeal wall and fauces with an anæsthetic. For this purpose a ten per cent. solution of cocaine is to be recommended. It should be applied with a camel's-hair brush about ten minutes before the tube is passed. The writer has found the mucous membrane of the fauces, in nearly all cases, much more sensitive than that of the posterior pharyngeal wall, and it is his habit to avoid irritation of the fauces as much as possible by carefully passing the tube in the median line, allowing it to come into contact with the upper surface of the tongue only before reaching the posterior pharyngeal wall. Of course this is not always possible, as some patients raise the tongue as soon as anything is felt to touch it, thereby usually pushing the tube to one side; but by a little attention to the above suggestion, much of the reflex spasm often produced by less careful efforts to pass the tube may be avoided.

The insertion of the finger of the operator into the mouth of the patient is entirely unnecessary.

In the hands of an experienced manipulator there may be said to be no valid contra-indication to the passage of the stomach-tube. Nevertheless, its employment is by no means always to be advocated in disorders of the stomach, and there will be many occasions when the judicious physician will refrain from its use. He will, for example, spare his patient the slight discomfort attendant upon its passage in cases where neither diagnostic nor therapeutic advantage can result from its use; he will not advocate its employment in cases of extreme exhaustion from general diseases, even though attended with stomach symptoms; and he will be very cautious in its employment in cases of advanced heart disease, when aneurism of any of the larger arteries is present, and immediately after hæmorrhage from any of the internal organs, especially from the stomach, whether the result of ulcer or carcinoma of that organ.

As has been already said, for all ordinary purposes of stomach lavage the syphon is to be recommended above every other form of apparatus. The tube having been passed the funnel is held in the left hand at about the level of the patient's head, and is slowly filled with water of about the temperature of the body or only slightly cooler. As it flows out of the funnel into the stomach the funnel should again be filled, and this should be repeated until the desired quantity of water has been introduced or the patient experiences a sense of uncomfortable fulness in the epigastrium. While still partially filled the funnel should then be lowered to a point below the level of the lower border of the stomach, when the water introduced into the stomach, together with the previously contained remnants of undigested food and mucus, will flow out through the syphon thus formed into the pail or other receptacle which has been provided for its reception. This procedure should be repeated until the wash-water comes away perfectly clear. If this result is finally accomplished the amount of wash-water which may have been required is a matter of little importance. Nevertheless, the amount introduced at each washing, as well as the amount returned, should be measured in order to make sure that all the water introduced has been removed from the stomach before the removal of the tube.

Not infrequently the return of the wash-water will be quite suddenly interrupted before the complete emptying of the stomach. This may result from stoppage of the openings in the tube by solid particles of food too large to pass through them, or from the entrance of gas contained in the stomach into the tube, thereby interfering with its action as a syphon. When through the glass tubing uniting the rubber tubes of the syphon it is seen that the tube is still full of water, it is fair to infer that particles of food are blocking the openings of the stomach-tube. Under these circumstances the simple deeper insertion of the tube may serve to dislodge the obstructing particles, or the effort may be made to draw them through the eyes of the stomach-tube by increasing the suction upon them either by lowering the funnel, thus lengthening the long arm of the syphon, or by means of a rubber bulb or other suction apparatus. The writer has found the following manipulation to accomplish as much under these circumstances as more elaborate suction apparatus. It is much simpler and is believed to be devoid of all danger. The rubber tube constituting the long arm of the syphon is tightly grasped near the glass connecting tube by the left hand of the operator, and is drawn between the thumb and index-finger of the right hand, which should compress and force all air out of the portion of the tube drawn between them. On relaxing the pressure exerted by the left hand the contents of the stomach end of the tube rush in to fill the portion of the tube from which the air has been expressed and thereby exert suction at the openings of the stomach-tube, which in most cases is sufficient to dislodge the obstructing particles. If after repeating this manipulation the syphon action is not re-established a little water may be poured into the funnel and allowed to run into the stomach, in doing which it will often dislodge the obstruction. If this, in turn, is unsuccessful, there is nothing to do but to remove the tube, clean it, and reinsert it.

When it is evident that the presence of air in the syphon is the cause of its non-action, deeper insertion of the tube and filling the funnel again with water, will in the majority of cases serve to re-establish the syphon without further trouble. It should, however, be remembered that, if inserted too far, the tube may bend upon itself and its extremity may in consequence come above the surface of the liquid, thus permitting the entrance of air. If, therefore, the syphon still fail to work after its deeper insertion and filling, the tube should be slightly withdrawn and the effort to syphon repeated.

It is of much importance that the stomach should be thoroughly emptied at the end of the lavage, and every effort should be made to accomplish this result. The irritation caused by even a small amount of residual wash-water may often be sufficient to materially interfere with the beneficial effect of the lavage.

When prolonged use of lavage is necessary the patient frequently becomes so accustomed to the passage of the tube, etc., as to be able to carry out the treatment himself without the aid of the physician.

In the great majority of cases plain water meets all the requirements of lavage, but occasionally advantage is gained by the use of weak saline solutions or mild antiseptics. The most frequently employed salts are sodium chloride (one per cent. solution), sodium bicarbonate or carbonate (two to five per cent. solution), and Carlsbad salt or water. As mild antiseptics the following

may be used: Boracic acid (three per cent. solution) or borax, sodium salicylate (one-half to one per cent.), sodium benzoate (one to three per cent. solution), creolin (fifteen drops to a quart of water), and chloroform water.* It is almost superfluous to say that the more powerful and poisonous antiseptics, as carbolic acid and bichloride of mercury, should not be made use of for lavage.

The sovereign indication for lavage is the presence in the stomach of deleterious material, whether this be poisou, imperfectly digested and fermenting food, or other retained and irritating substance, and whether its presence be due to hindrance of its onward progress into the duodenuum or is the result of inefficient gastric digestion.

In the majority of cases of acute poisoning it is the imperative duty of the physician to empty the stomach of his patient as speedily as possible, and where there is any possibility of his deriving benefit from that procedure there can be no contra-indication to the use of the stomach-tube. Often it is greatly to be preferred to an emetic, both on account of the slow action of the latter in many cases, notably in opium poisoning, and because the evacuation of the stomach by the tube may be made much more thorough. In the case of opium poisoning the lavage should be frequently repeated for at least two hours, as recent investigation has demonstrated that morphine, even when administered hypodermatically, is eliminated in considerable proportion through the mucous membrane of the alimentary tract, particularly of the stomach, and may afterward be reabsorbed.

In arsenic poisoning the intense inflammation of the gastric mucous membrane induced by the irritant action of the poison, has been regarded by many as a valid contra-indication to the emptying of the organ by lavage. If carefully performed, however, it can do no harm at all commensurate to that which is being caused by the presence of the arsenic, which latter should be removed as speedily as possible at all hazard.

In cases of poisoning by concentrated mineral acids and by some of the more corrosive organic acids, as, for example, oxalic acid, the irritant and corrosive action of the acid is so immediate and complete as to reduce the benefit derivable from lavage to a minimum, and the physician will preferably resort to the administration of large draughts of alkaline waters, with the object of diluting and neutralizing any residual acid.

In poisoning by strychnine the passage of the soft tube may be very difficult, owing to the general convulsions stimulated by efforts to pass the tube and the intensity of the trismus oftentimes present. In such case the jaws should be held apart by a strong metal gag, and it may also frequently be necessary to substitute the stiffer "gum-elastic" tube for the more flexible rubber one.

In profound alcoholic stupor and in delirium tremens, great benefit usually results from removal of the sour, irritating liquid usually filling the stomach, unless vigorous emesis has previously occurred. As in all cases of profound narcosis, great care should be taken to prevent any entrance of the contents of the stomach into the larynx by tightly compressing the tube during its removal, thus rendering escape of its contents impossible.

In intestinal obstruction from whatever cause, lavage has recently been warmly advocated by Mahnert, who supports his recommendation by the report of eight cases in which it was employed by him with marked benefit. In all the cases stercoraceous vomiting was controlled, the feculent material in the stomach and upper portion of the intestine was removed, and the condition of the patient was much improved. In three cases, after repeated washings the obstruction disappeared, and recovery quickly followed. When obstruction is the result of constriction of the lumen of the intestine by a neoplasm, lavage can of course be only palliative, but in those cases in which the obstruction is due to a twist in the gut with accumulation of a feculent mass above the point of constriction, thus intensifying the mischief already done, it appears in many cases to exert a decidedly curative influence. This is attributed by Mahnert in part to the relief of pressure above the constriction resulting from emptying the stomach and upper intestine, and in part to the stimulation of a healthy peristalsis which tends both to force the fecal accumulation upward into the less choked intestine and also to remove the primary cause of the obstruction. Whatever may be the correct explanation of the relief obtained, certain is it that lavage is often followed by marked amelioration of the symptoms in many of these cases, and its trial is unquestionably indicated, though in many cases it will be found necessary to couple it with other treatment.

In gastro-intestinal disorders of children lavage of the stomach has been attended with most signal success. The investigations of Escherich and others into the etiology of the summer diarrhœa of infants, and careful study of cholera infantum, have shown both to be due in great part, if not solely, to intestinal fermentation caused by bacteria of various kinds. The profound general symptoms met with in these diseases are attributed to the absorption of deleterious and poisonous substances generated in the course of these fermentations, and the vomiting and purging have come to be regarded as conservative measures directed to ridding the alimentary tract of its harmful contents. With the object of aiding this effort at elimination, lavage of the stomach has been extensively used by Escherich, Baginsky, Ebstein, Seibert, Ehring, Faucher, and many others, and has been followed by such decided and often almost immediate benefit, as to have received their warmest recommendation. In the simple gastro-intestinal catarrh of infants, so common in our large cities during the summer months, a single thorough lavage of the stomach with slight regulation of the diet for a few days, is often sufficient to bring about most gratifying improvement or complete cessation of the alarming symptoms. The same may be said of the benefit derived from the treatment in cholera infantum, but here repeated lavage is usually necessary: in severe cases it may even be ineffectual unless combined with thorough lavage of the colon.

The passage of the tube in the case of young infants is not difficult, provided the head is properly held by an assistant. In very young children it is usually wise to insert the index-finger of the left hand, to insure the easy passage of the tip of the tube over the epiglottis. When this has been accomplished the finger should be withdrawn, as the tube may very easily be pushed onward into the stomach. The œsophagus of the child is, of course, too small to accommodate a stomach-tube of the usual size, and an ordinary rather thick-walled, soft red rubber catheter, will be found to answer every purpose. If desirable a second eye may be cut in the side of the catheter, care being taken to smooth its edges. As with the adult, the lavage should be continued until the returned wash-water is quite clean.

We come now to the consideration of lavage as a therapeutic measure in disorders of the stomach itself. The principal conditions in which its employment in these cases is indicated, may be classed under two heads: 1. Mechanical hindrance to complete emptying of the stomach. 2. The accumulation of substances in the stomach which impede or stop the natural process of digestion.

It should be remembered that while either one of these conditions may exist alone, they are very frequently associated.

By far the most important condition giving rise to incomplete emptying of the stomach is dilatation of that organ, gastrectasia, whether the result of inefficient motor activity of the gastric wall dependent upon chronic gastritis and atrophy of the gastric mucous membrane, or the result of obstruction at or near the pyloric extremity by tumor or cicatrix of any kind. All of these conditions bring about retention and stagnation of the ingesta, and the resulting fermentation both intensifies the gastric disorder and furnishes toxic material, the ab-

* Prepared by shaking a little chloroform with a quart of water, allowing separation of the two liquids, and pouring off the supernatant chloroform water. This should be used at once.

sorption of which induces more or less derangement of the whole process of nutrition. For this condition nature herself suggests the needed remedy, in the copious and frequent vomiting which inevitably becomes a prominent symptom in those cases of dilatation of the stomach which are left untreated. Formerly attempts to rid the stomach of its noxious contents by means of cathartics constituted the accepted treatment, but we are now possessed of a far superior and almost indispensable agent in the stomach-syphon. It is not to be inferred, however, that lavage is to be employed in every case of atony of the stomach with consequent impairment of its motor activity. Diet and drugs may often overcome this difficulty, and should always be first given a fair trial. But in advanced dilatation lavage may be said to be indispensable, and the relief experienced by the patient is usually most gratifying. Flatulence, eructations, and other dyspeptic symptoms cease. Vomiting, if it have existed, is controlled. Constipation, often very obstinate, is relieved. And the cerebral symptoms dependent upon poisoning of the system by products of fermentation, and which are often such a source of alarm to the patient, usually quickly disappear. Unfortunately, however, the treatment is palliative only in the majority of cases, and its interruption is almost certainly followed sooner or later by return of the symptoms. It should, therefore, be patiently persisted in. As has been hinted before, the patient may learn the necessary manipulation and so be able to carry on the treatment himself, advising with his physician, however, at stated intervals. Daily lavage, undertaken six or seven hours after the principal meal of the day, is usually accredited with the best results, and should always be urged in every case of pronounced dilatation. In milder cases and after amelioration of the symptoms of severer cases, it may be sufficient to thoroughly cleanse the stomach every alternate day. Great care should be taken to completely remove all residue of the wash-water, as even a small quantity left in the stomach may be sufficient to wholly prevent or greatly diminish the beneficial result. In cases in which fermentation is an important factor the last wash-water may often, with much advantage, consist of a weak solution of borax (two to four per cent.), salicylic acid (three to five per cent.), chloroform water, or other anti-fermentative.

The accumulation in the stomach of substances which impede the normal process of digestion constitutes an important indication for their removal, and usually lavage is the most prompt and efficient means of so doing. Thus the acid dyspepsia dependent upon excessive secretion and accumulation of gastric juice in the stomach, is usually immediately relieved by lavage with a weak solution of soda. The interference with digestion resulting from accumulation of mucus in the stomach in chronic gastric catarrh, or in cases where much mucus is swallowed, may oftentimes be entirely removed by an occasional washing of the stomach. For this purpose weak acid solution and lime-water usually give the best results. The advantage gained by the removal of fermenting material from the stomach has already been alluded to in discussing the use of lavage in gastrectasia. Other more or less toxic substances may accumulate in the stomach in carcinoma of that organ, in uræmia, and in pernicious anæmia, and their removal is often attended by considerable relief to the patient.

From what has been said it will appear that stomach lavage is neither an universal panacea, nor is it even indicated in all diseases of the stomach itself. In ulcer, which is often unassociated with decided catarrh of the gastric mucous membrane, no benefit is usually to be expected, and the danger of inducing hæmorrhage should be remembered. Again, in some acute conditions of the stomach, as, for example, in acute gastritis, it may do positive harm by irritating the inflamed mucous membrane and so intensifying the disease. But, judiciously employed in cases in which benefit may rationally be expected from its use, it must be regarded as one of our most valuable and most reliable therapeutic measures. In Germany it is already very extensively used, and in this country the circle of those who have become convinced of its efficacy is rapidly widening. It is no longer a new, untried, or dangerous procedure, having passed from the realm of the theoretical into that of the eminently practical. *John Slade Ely.*

STOOLS, DIAGNOSTIC VALUE OF, IN THE DIARRHŒAS OF EARLY LIFE.* A careful study of infant stools usually affords a simple working classification that will prove valuable in the treatment, if not always unerring in the prognosis, of diarrhœa. The vast majority of cases of infantile diarrhœa may be included under one of three heads, viz., the diarrhœa of acute indigestion, the diarrhœa of inflammation, and the diarrhœa of chronic indigestion or atrophy.

Acute Indigestion.—In the diarrhœa associated with this affection the stools are more or less profuse, consisting at first of fecal matter, but later becoming serous as a result of the hypersecretion of the intestinal glands and of the greatly increased peristalsis. Scattered here and there are seen small masses of undigested casein and fat, and soon, if this condition continues, thin mucus may be found. Occasionally the stools acquire a greenish tint. If starchy food have been taken it will often appear unchanged in the discharges. In the summer, owing to the depressing effect of the heat upon the splanchnic nerve, there may be copious yellow watery stools when the intestinal indigestion is actually quite moderate in degree. In very acute cases there may at first be a moderate elevation of temperature, but this soon subsides, unless the indigestion passes into actual inflammation. When the latter condition supervenes, the fever persists.

Acute Inflammation.—It is a difficult matter to determine just when the irritation of the intestinal tract has passed into true inflammation, as one condition merges so gradually into the other, but when once the catarrh is fully established the diagnosis is usually clear enough. As before stated, the temperature remains elevated, and the discharges ordinarily become more frequent, the character of the latter depending in the beginning largely upon the nature of the food. When the diet consists of milk the stools will be found to contain particles of fat and coagulated casein, mixed possibly with altered epithelial cells, forming masses of putty-like appearance. When meat broths, with or without milk in very dilute form, are given, the stools are apt to become very dark-colored, watery, and exceedingly offensive. The presence of mucus is a sign of considerable value, and it is almost always present if the diarrhœa continue for any length of time. According to Nothnagel, it is difficult or impossible to detect mucus on ordinary inspection when the catarrh involves the jejunum and ileum only. Under the microscope, however, it can be seen as little islets floating in the substance of the discharges. When these little masses of mucus are stained with bile-pigment, they become, of course, much more distinctly visible, and this is an indication that the inflammation involves the small intestine as well as the large. When the upper part of the colon is affected together with the ileum, this bile-stained mucus will be mixed with particles of undigested food and fæces, and the degree of admixture will afford a tolerably correct idea of the portion of the colon most affected. The more intimate the admixture, the nearer the lesion is to the ileum, but when the mucus is passed in glairy masses, or in shreddy particles looking almost like false membrane, the disease will be found located in the lower part of the colon. The condition of the blood passed with the stools also furnishes an indication of the seat of the lesion. Thus, when it is present in dark sticky masses it has come from the upper part of the bowel; when mixed in streaks with mucus and fecal matter, it is from the upper colon or the ileum; but when red in color and not intimately mixed with the other intestinal contents, it points to a lesion of the lower colon or rectum.

It is important to note the color of the stools. When

* The present article is based largely upon one which I published on the same subject in the New York Med. Journal (Oct. 29, '92). H. D. C.

they are white and of putty-like consistence they will be found to consist principally of fermenting fat; when brown, of albuminous matter from broth; or this color may be caused by bleeding in the upper bowel or by drugs, such as iron or bismuth. Red discharges are an indication of hæmorrhage from the lower bowel, and watery yellowish stools are composed of ordinary fecal matter diluted with the secretions of the intestinal glands. The significance of green stools has been variously stated by different writers, but, however caused, I have found them clinically in connection with signs of great irritation of the intestine and of fermentation of its contents.

While the character of the stools furnishes us with a fairly reliable indication of the seat of the lesion, it does not tell us much of its nature. We are often unable, for example, to satisfy ourselves of the presence or absence of ulceration of the bowel from a simple inspection of the discharges. Eustace Smith says that a shreddy deposit mixed with small black clots of blood in the stools is a symptom of ulceration, but I have found it by no means a reliable sign of this condition, and have often been surprised to find ulcers on autopsy that were unsuspected during life. For example, a large flabby child, seven months old, was admitted to the babies' ward of the Post-graduate Hospital, with a history of vomiting and frequent stools. She had been fed for five months on cow's milk. A moderate diarrhœa continued for ten days without any unusual features, the temperature not rising above 100° F. She exhibited a continuous failure of vitality, however, in spite of taking and apparently digesting her food fairly well. She died suddenly, and the autopsy revealed numerous ulcers in the lower two feet of the ileum, while the colon was dotted with ulcers throughout its whole length, some even extending through the muscular coat; but there were no perforations. No other lesion was found except a passive congestion of both lungs. In cases in which there is a rapid loss of vitality not to be accounted for by the character and frequency of the intestinal discharges, I have come to suspect more or less extensive ulceration. When there is other evidence of tubercular infection, the presence of diarrhœa with much prostration should lead one to look for tubercular ulceration of the intestine.

Cholera Infantum.—This condition presents a striking contrast, when we consider the violence of the symptoms and the paucity of lesions found after death, to the diarrhœa depending upon ulceration. The great difference between this and all other forms of diarrhœa in children, leads us to the belief that its cause is to be found in the presence of a specific germ. The disease begins often as a simple diarrhœa accompanying intestinal indigestion. After these symptoms have existed for several days the stools suddenly become very copious and watery, barely staining the diaper, but imparting to it a peculiar musty odor. Vomiting soon sets in, everything, even water, that is taken into the stomach is rejected at once. The tissues are quickly drained of their fluids and become so shrunken that the child is hardly recognizable. The sphincter is relaxed and the discharges ooze away almost uninterruptedly. The skin is cold and clammy, and convulsions or coma often precede death. This disease is fortunately not of common occurrence, only a small proportion of the diarrhœas of children seen in the summer months being of this form.

Chronic Indigestion and Atrophy.—The diarrhœa depending upon this cause is one of the most obstinate and difficult to treat of any occurring in childhood. It affects chiefly cachectic infants whose hereditary history is bad or who have been unwisely fed, and who live amid unhygienic surroundings. They may be the subjects of syphilis, rachitis, or tuberculosis. In other cases, however, none of these diseases is present, but the infant simply falls away despite the most careful attention to its diet. The discharges are usually offensive and consist largely of fermenting food, but they may not be numerous. Their appearance changes from time to time, putty-like stools alternating with green or brown discharges which are mixed with mucus and of an offensive odor. The sudden appearance of one or two copious serous discharges is of evil prognostic import. The child may take food readily, as the stomach is often but little affected, and occasionally a decided change for the better may be noted; but this is only temporary, for the digestion and assimilation of the food taken seem to be impossible, and the infant soon relapses into a worse condition than before. As death approaches the stools become thinner and more frequent, and emaciation progresses steadily. The temperature is usually subnormal during nearly the entire course of the disease. At autopsy the intestinal mucous membrane is seen to be rather pale and flabby, but evidences of active inflammation are absent. The epithelium is seen under the microscope to be in a state of fine granular or colloid degeneration, and the lymphoid bodies are somewhat swollen. The underlying condition, which may be either hereditary or acquired, is an essentially defective vitality. When the vital powers are low the organs of digestion and assimilation are the first to suffer in function, from feeble innervation. Hence the uselessness of astringent, antiseptic, or any other kind of drugs in these cases.

Henry Dwight Chapin.

STRONTIUM. In 1890, Dr. Labord recommended strontium in the place of potassium as a base in the formation of various salts, its advantage being an absence of all unfavorable effects upon the system when administered for a prolonged period. It is well known, from experimental research, that potassium salts will produce paralysis of sensibility and motion, collapse, and asphyxia; and upon the heart it acts by slowing the circulation, and finally paralyzing the cardiac muscle. The salts of strontium were found to be perfectly innocuous. Labord performed his experiments upon animals, and in a few instances upon man, using the various salts of strontium and comparing the effects with the similar salts of potassium. The salts were used by intra-venous, endermic, and intra-muscular injections, and also by introducing them into the stomach by means of an œsophageal tube. Very large quantities were administered without producing any local irritation or causing any derangement of the system. Upon the heart it exerted a stimulant action, increasing the strength and force of the beat, upon the digestive organs it also acted as a stimulant, and under its influence the appetite and general condition of the patient improved. All the salts, but especially the lactate and tartrate, were found to exert a diuretic action, although not in a very marked degree.

After the appearance of Dr. Labord's communication, the salts of strontium were extensively used in the French hospitals, and numerous clinical reports were made by Dujardin-Beaumetz, Sée, Paul, and others, all very favorable to them as therapeutic agents, and confirming the statements as to their harmlessness. Their stimulating effect upon the digestive organs led to their employment in various dyspeptic troubles, in which they proved of decided value. In cases reported they caused a rapid improvement in the gastric disturbances accompanying cardiac and renal disease, and also in the various forms of dyspepsia in which hyperacidity, flatulence, and pain were prominent symptoms. They have also acquired a reputation as a valuable anti-emetic remedy. They have proved useful in nearly all forms of vomiting, and some remarkable results are reported of their use in the vomiting of pregnancy. They have also been of benefit in the vomiting of acute and chronic gastritis, the vomiting occurring in the puerperal period, and in hysteria. To relieve this troublesome symptom, thirty grains should be given immediately before or immediately after meals.

For all stomachic disorders the bromide of strontium is the salt usually selected, as it is most soluble, and has been found to be more active than the other combinations. It is given in doses of fifteen to thirty grains, repeated three or four times a day, and has been given to the extent of five or six drachms in the twenty-four hours without causing any ill effect. As the salt is very hygroscopic it requires to be given in solution. It possesses a rather

unpleasant taste, which may be disguised by syrup of orange.

The bromide has also been used as a substitute for potassium bromide in the treatment of epilepsy. The dose in these cases is thirty grains every three hours. Although it contains less bromine than the potassium salt, it is said to prove equally efficacious in controlling the attacks. Its main advantage is its freedom from the local irritating action and depressing effects of potassium. Whenever there is any gastric irritability, or when bromides have to be administered for a prolonged period, it is very superior to the other salts.

As a diuretic it was found to be serviceable, but its effect upon albumin, when present in the urine, proved much more important. Its employment in this condition was found to cause a rapid diminution in the amount excreted and to cause improvement in the patient's condition. Beaumetz reports five cases, in one of which the albuminuria was due to nephritis, and in the others to heart disease. In all the cases there was within four days a diminution in the amount of albumin of one-half, and an amelioration of all the symptoms. Many other cases have been reported in which it was equally beneficial. It appears to be particularly useful in the albuminuria of chronic heart disease and in that occurring during gestation. It has not been as successful in cases of acute nephritis, and should not be used where there is much destruction of renal tissue. In chronic parenchymatous disease it appears to be more beneficial than in the interstitial form. Its beneficial effects are explained by its general tonic and alterative action. By its action on the excretions it relieves the system of much morbid material, and the improvement in the digestive organs reduces the formation of toxines to a minimum.

Quite recently the iodide of strontium has been suggested as a better means of administering iodine than the iodide of potassium. It has proved useful in many forms of heart disease, relieving the anasarca, dyspnœa, angina, and other distressing symptoms. It is much better tolerated than the potassium salt, and its beneficial effects are rapidly manifested. It does not appear to have been used in syphilitic diseases. The dose is the same as that of the other strontium salts.

Beaumont Small.

STYRACOL. CINNAMYL-GUAIACOL. A German patented compound of guaiacol and cinnamic acid. It is described as the cinnamic-acid extract of guaiacol, and is obtained by mixing molecular proportions of cinnamyl chloride and guaiacol, and heating the mixture in a water-bath. The resultant mass is treated with boiling alcohol and filtered; as it cools, the styracol is deposited in long silky needles. Styracol possesses the antiseptic properties of its constituents, and was introduced as a substitute for guaiacol (q.v.). It has been used for the treatment of tubercular disease, and for catarrhal affections of the gastro-intestinal tract, vesical catarrh, and gonorrhœa. It has not been employed to any extent, and its therapeutic value cannot yet be estimated.

Beaumont Small.

SULPHAMINOL. A new antiseptic said to be formed by the action of sulphur upon certain salts of the aromatic series. In the body it is supposed to decompose into carbolic acid and sulphur compounds. It was introduced for the purpose of replacing iodoform, on account of its active antiseptic action and freedom from odor. It is a pale yellow powder, without taste or odor, insoluble in water but dissolved by the addition of alkalies; it is soluble in alcohol. When subjected to heat it turns brown and melts at about 155° C. The dose for internal administration is four grains three times a day, but it does not appear to have been used to any extent. To test its therapeutic value a series of experiments were made by Wojtaszek, a Polish physician. Rabbits were selected and the drug was either injected under the skin or given internally, in doses equal to three or four grammes per kilogramme of the animal's weight. He found that, 1, when injected hypodermically, the substance formed a foreign body which became encapsuled in a few days; 2, when given by the mouth, it was eliminated with the fæces without undergoing any decomposition; 3, in neither case did the drug give rise to any physiological effect, except a trifling congestion of the gastric mucous membrane when given internally.

Externally, it has been used in all cases in which iodoform is employed. It has proved of service in the treatment of ulcers, wounds, etc., and appears to possess a desiccating action upon suppurating surfaces which greatly hastens their healing. It has been used with very marked success in affections of the nose and throat, and in abscess of the antrum. In the form of a powder, it is blown into the cavity, or on the diseased surface, and rapidly checks any offensive discharge and hastens repair.

Beaumont Small.

SULPHONAL. This hypnotic has attained a position second only to chloral hydrate, and in the opinion of many is superior even to that well-known drug. It has proved itself to be purely a soporific, and is rarely employed for any other purpose than to procure sleep. The usual properties which are so common to the newer drugs are wanting in this. It does not influence the body temperature, it has no antiseptic qualities, and as an analgesic is of no practical value. Unlike other narcotics, it has no period of excitement, does not check or alter the secretions or derange the digestive organs, and is almost without any influence upon the heart or circulation. Devoid of these many disadvantages, its success as an hypnotic is readily understood.

Sulphonal has proved of greatest service where the insomnia is of purely nervous origin, as in neurasthenia, mental depression, over-work, and worry, and has found a field of great usefulness in the various forms of mental disease. It is in the latter class of cases that it is most used, and asylums throughout the world employ it very extensively. When pain is the cause of the sleeplessness, its good effects are greatly modified, but in many forms of neuralgia and pain of a reflex character it may be used with success. Experiments upon animals have demonstrated that it exerts, in a moderate degree, a sedative effect on the spinal cord, lessening the reflex function, and also modifies the action of the motor and sensory nerves. Where pain is due to organic disease it has no influence whatever. In the insomnia of acute and chronic disease, and during convalescence from disease, it is of much benefit, but requires to be given with some caution, particularly when there is much debility or prostration. In the sleeplessness of cardiac disease and other forms of organic or mechanical derangement, it is not of much use. In delirium tremens it has been much used, in many instances with benefit, but in these cases the effect is uncertain, and the dose required is excessive and approaching the limit of its physiological action.

As an hypnotic, the dose is from fifteen to thirty grains. It is usual to commence with fifteen grains and increase the quantity until the proper effect is produced. Ten grains will often be sufficient in the aged and debilitated, or where the insomnia is of a mild degree. Under ordinary conditions thirty grains is a perfectly safe dose, and this quantity is usually required to produce its full hypnotic action. When the drug requires to be given for a prolonged period the dose can generally be lowered, as the drug is cumulative. On account of its insolubility the action is slow, and the dose should be administered at least one hour before bedtime. Its action is rendered more rapid if the drug is finely powdered and administered in hot solution. Six or eight ounces of boiling water are recommended as sufficient to dissolve thirty grains; after it is dissolved, cold water may be added to render it sufficiently cool to be taken. Hot milk and broth may also be made use of; tea and coffee are frequently used, but they undoubtedly, to a certain extent, counteract its effect. It may also be administered in alcohol or any spirituous liquor.

The sedative action of sulphonal on the spinal cord and nerve-centres has led to its use in some nervous troubles. In chorea it has been given to children in

doses of from two to five grains, and has been followed by a fair percentage of successes. In old-standing cases it has little or no influence.

It is now fully recognized that sulphonal is not without its toxic action, and numerous fatal cases have followed its employment. The simplest symptoms that may arise generally follow the passing off of its soporific effect. They include drowsiness and stupor, giddiness, vertigo, ataxia of the tongue and muscles of the throat and face, and of the extremities. These symptoms gradually disappear after an interval of ten or twelve hours, without leaving any ill effects. The symptoms of toxic action generally appear after large doses, or more frequently after repeating an ordinary dose of thirty grains two or three times. In some instances, when the patient is debilitated and the subject of some wasting disease, very small doses may be followed by these symptoms. They appear to be due solely to the action of the drug on the nervous system, the heart and respiration are not depressed or altered, and very rarely is there any alteration in the appearance or quantity of the urine.

The fatal cases that are reported are due to overdoses or to the prolonged use of the drug.

In one case (*British Med. Journal*, October 25, 1890) the patient was supposed to have taken about an ounce of sulphonal. The stupor which followed deepened into insensibility and anæsthesia, the pupils remaining normal and acting to light, while the conjunctiva was insensitive. Breathing was natural, pulse very slightly disturbed, but the temperature ranged between 100° and 103° F. A profuse perspiration bathed the body, and there was total suppression of urine after the first day. On the third day the breathing suddenly became short and jerky and ceased altogether. Another case is reported (*Medical News*, August 10, 1890) in which two doses of fifteen grains, given within an hour and a quarter of each other, caused death. The patient was a young insane woman who had formerly been given large quantities of chloral, and other hypnotics. No medicine had been given on the day she took the sulphonal. She slept quietly all night, and on the following day was drowsy, but could be roused and made to talk rationally; sleep at once came on when she was left alone. The pulse and respiration were slightly accelerated and the pupils normal. Eighteen hours after taking the medicine the pupils began to contract and her temperature rose to 102° F.; in forty hours cyanosis began, and she died from failure of respiration.

The occurrence of fatal cases following the prolonged use of sulphonal, is evidently much more common. Lépine (*La Semaine Médicale*, January 20, 1893) has collected a series of thirteen cases terminating in death. These patients had taken the drug for periods varying from sixty to over a hundred days in ordinary doses. Severe symptoms suddenly supervened and death followed within a few days, although the medicine was stopped at once. The prominent symptoms were gastro-intestinal disturbances, symptoms referable to the nervous system, such as failure of co-ordination, difficulty in speech, and diminution of the reflexes; diminished secretion of urine, which became of a peculiar red color and contained biliary pigment, mucin, and albumin, with leucocytes, numerous red cells, and epithelial casts. In these cases the drug was well borne until the toxic symptoms set in. The disturbances of the digestive organs generally masked the nervous symptoms, and the fatal termination was due to heart failure with œdema of the lungs.

How these poisonous effects are produced is as yet uncertain. What decomposition the sulphonal undergoes after administration, or what products are formed, has yet to be discovered. At present we must hold to the hypothesis that it is the action of sulphonal on the nervous system that is to account for the symptoms of poisoning. No unfavorable changes are produced in the blood, and it cannot be classed as a blood poison. The effects upon the kidneys and urine are important, and are now receiving a great deal of attention, although they appear late in the train of toxic symptoms. One point alone has been definitely established, and that is the dangerous state the patient is in when hæmatoporphyrin (hæmatin without iron) appears in the urine. How this is produced is not known, but as soon as it is detected the administration of sulphonal should be stopped.

Beaumont Small.

SYMPATHETIC NERVOUS SYSTEM. The opinion expressed in the HANDBOOK, Vol. VIII., p. 506, that the sympathetic nervous system is an outgrowth from the cerebro-spinal, has been called in question by the researches of Paterson upon embryos of small mammals, particularly of rodents. He finds that the main sympathetic cord develops independently as a cellular rod or column without any sign of ganglia, and that the connection of the spinal nerves with it occurs secondarily. The formation of the ganglia is subsequent to this. He therefore holds that the sympathetic cord is primarily unsegmented.

The most striking of the conclusions of Paterson is, however, that the sympathetic is not formed from the ectoderm as are the structures of the nervous system, but unmistakably (as he supposes) from the mesoderm. This is distinctly opposed to the views advanced by Balfour and Onodi.

Paterson suggests that it is quite possible that the sympathetic nervous system may comprise two independent apparatuses, one the sympathetic system proper, derived from the mesoblast, and another an offshoot from the cerebro-spinal system. In support of this he adduces the histological character of the nerve-cells, those of the spinal ganglia being rounded, while those of the ganglia of the sympathetic chain are angular. He calls attention also to the fact that these latter cells appear to have a regulating or trophic function, rather than one that is automatic or reflex. Part of the sympathetic system appears also to be employed in the construction of the supra-renal bodies, a matter that is certainly very foreign to anything now known concerning the behavior of the cerebro-spinal system.

It is not likely that Paterson's views will be accepted without challenge. In the meantime, however, the histologists who, by the Golgi method of impregnation, have already done so much toward advancing the knowledge of the anatomy of the central nervous system, have turned their attention to the spinal and sympathetic ganglia.

Some of the features of the spinal ganglia have been referred to in the article on cranial and spinal nerves in this volume. These ganglia are, in the main, composed of certain large, rounded cells, termed gangliоblasts, which are primitively bipolar, sending one process to the periphery of the body and another toward the central nervous system, where it gives off collaterals at different levels.

The ganglia of the sympathetic have hitherto been described as consisting of multipolar cells which differed from those of the cerebro-spinal system in that each was connected with a nerve-fibre. Ramón y Cajal and Retzius have shown that this is not the case. There is always a long axis-cylinder process and several short or protoplasmic processes, and thus is here confirmed the general law of structure for the nervous elements.

There is a striking similarity between the cells of the ganglia of the sympathetic chain and those of the anterior horn of the spinal cord. There are the same short processes distributed in the vicinity of the cell, and the long process which passes out to make up the interganglionic cord, and sends its ramifications probably as far as the viscera, giving off collaterals which may be used to correlate other cells.

From the spinal cord there come by way of the anterior roots, centrifugal fibres that terminate in each sympathetic ganglion by free ramifications.

Ramón y Cajal found that most of the short fibres of the sympathetic cells are disposed around the bodies of other cells in a peculiar manner, making what he terms a pericellular nest (Fig. 593).

This however is considered by Van Gehuchten to be merely an accidental phenomenon.

The cells of the visceral ganglia of the sympathetic have also been examined by means of the new methods. There are found, in the plexuses of the intestine, in the walls of arteries, and in the stroma of glandular organs, small nerve-cells scattered here and there and giving off processes that ramify again and again, and end by free ex-

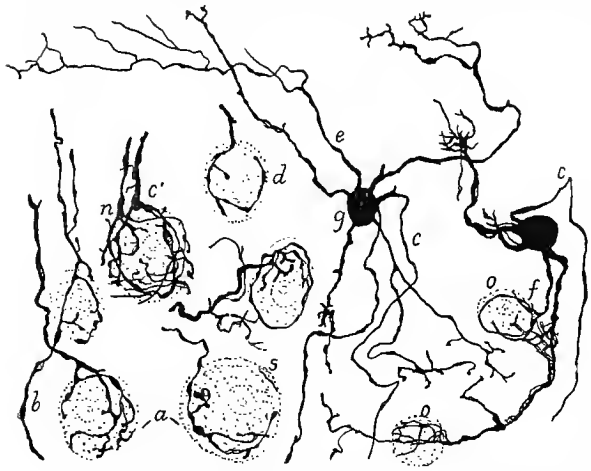

FIG. 593.—Sympathetic Cells from the Inferior Cervical Ganglion of a Full-grown Dog (Ramón y Cajal). *a, b, c', d*, pericellular arborizations of short or protoplasmic processes of sympathetic cells; *c, c*, axis cylinder processes passing into fibres of Remak; *g*, a cell with short, fine processes; *f*, another with thick processes that form pericellular nests; *s*, capsule of a cell; *n*, nucleus of an arborization.

tremities among the muscular or epithelial elements. These appear to be similar in character to those that collect impressions from the retinal rods and cones, and from the mucous membrane of the auditory passages. Such cells I have elsewhere called æsthesioblasts. If further investigations show that this structure is general throughout the distribution of the sympathetic nervous system, it may then be concluded that there are here certain elements that perform for these mesodermic and entodermic surfaces the same functions that the æsthesio-

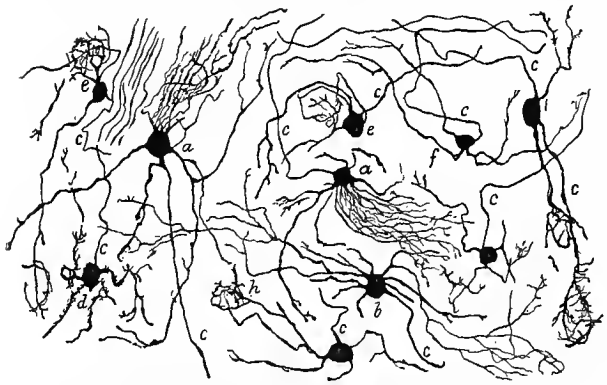

FIG. 594.—Diverse Types of Sympathetic Cells taken from the Superior and Inferior Cervical Ganglia of a Full-grown Dog (Ramón y Cajal). *c, c*, axis cylinders; *a*, cell with a panicle of short protoplasmic processes; *b*, another with short, fine processes widely ramified; *d*, a cell with a few short, villous processes; *e*, cells with short protoplasmic processes forming a pericellular arborization; *f*, cell with a few fine, short processes; *h*, pericellular nest formed by processes from several cells.

blasts do for the ectodermic, and to such elements the name splanchnoblasts might be applied.

Much yet remains to be done with regard to the details of distribution. Berkley has shown that the mucous membrane of the small intestine is supplied wholly from the plexus of Meissner, the nerve-bundles giving off collaterals to the muscularis mucosæ, and ending in small expansions that he considers as homologous with motor plates. The small rounded knobs found immediately beneath the epithelial covering of the villi, which were considered by Ramón y Cajal to be nerve-cells, are thought by Berkley to be homologous with tactile corpuscles.

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Frank Baker.

SYMPHYSEOTOMY.—Section of the symphysis pubis during parturition, where there is not sufficient pelvic space to admit of the passage of the fœtus without seriously endangering its life, has quite recently, after subjection to a long and persevering trial, become, under antiseptic management and a rigid technique, one of the established and approved operations of surgical obstetrics. For more than a century it held a position of very bad repute, and in France, where it originated, it was only performed twice during a period of seventy years, down to February, 1892. In Germany it was abandoned after a few trials, and was not resumed, except once in 1852, for fifty years, or until April of this present year. For one hundred and fifteen years it was rejected and condemned by the obstetrical teachers of the United States, and was never performed until September 30, 1892; since which date five successes in order, in less than ten weeks, have made it the talk of the profession. We wish no better evidence in its favor than the fact that forty-eight women have been operated upon in order since January 1, 1886, in Italy, with only two deaths.

To Dr. Sigault, of Paris, is due the credit of having inaugurated the operation in the year 1777. We can now say *credit*, as to his scheme of opening the pelvis, although obstetricians the world over were, for a century, inclined to attach to his memory epithets that were far from complimentary. We now give him credit for his scheme of enlarging the pelvic calibre, and for this only, for the reason that the operation of to-day has discarded every step in his original technique, and has superaddcd antiseptic precautions, to the great reduction of maternal deaths, as evinced by the fact that fourteen women were lost out of the first forty operated upon, covering a period of twenty-six years, or thirty-five per cent., against a loss of twelve per cent., which is the present general mortality.

The first change in the method of operating was the substitution of the subosseous division of the symphysis, cutting from within outward and below upward, for the direct section through the mons veneris and symphysis, which caused a greater hæmorrhage and endangered the integrity of the bladder or urethra. This was tested in Spain at a very early period (August 9, 1780), by Amonio Delando, of Utrera, who operated under the direction of Professor Francisco Canivel, of the University of Cadiz, upon what appears to have been the twenty-second subject in order. This was a primapara of forty-two who had been in labor for three days; her child was saved and she recovered in thirty-eight days. This improvement appears to have been either overlooked or disregarded until the time of Professor Genaro Galbiati, of Naples, whose sixteen operations cover the years 1815 to 1840, and who originated the use of the curved probe-pointed bistoury that bears his name, is still in general use, and will be until its defect of curve is appreciated under the test of experience, when a form obtained by adaptation rather than conjecture may be expected to take its place. Such a knife is already in existence, and theoretically promises to be a decided improvement over

the old form. To cut to advantage, the curve of the blade should be made to conform to that of the posterior wall of the symphysis in deformed pelves, and with the line of direction under the pubic arch, reaching a short distance beyond it in front. The curve of Galbiati's knife makes it impossible to use it upon the back of the symphysis at the first step of the operation, and the long end of the blade is apt to produce hæmorrhage by incising the veins under the mons veneris.

Professor Galbiati commenced to operate as stated in 1815, and continued his work until 1840, delivering in this period sixteen women, one of them of twins, and saving eight women, and only four out of seventeen children. During these twenty-five years, Naples had three other operations under three operators, who saved two women and two children. The last hold of symphyseotomy in its first period was Naples, where after six operations had been performed, in thirteen years, by three operators, saving five women and four children, the scheme of Sigault died out in July, 1858.

The Revival of Symphyseotomy in 1866.—In the first period of the operation there were over one hundred women delivered under it, in the eighty years during which it was performed; and it died a natural death because of its discouraging results. Too much was attempted to be accomplished under it, and hence its death-rate was high. Had the *conjugata vera* been limited in measure as it is now, and the women been delivered early in their labors, there would no doubt have been much more favorable results; as it was, there were too many deaths of mothers and children, and notably of the latter, to make the method of delivery justifiable. We have not been able to find any evidence of a symphyseotomy having been performed in any part of the world, from July 25, 1858, to February 14, 1865, at which latter date the late Professor Cesare Belluzzi, of Bologna, thought proper to make trial of it, but lost the mother by tuberculous pneumonia in twelve days. He operated a second time, on October 17th, in a case of rachitic deformity, as was also the first, and the woman died of peritonitis in six days, believed to have been purely puerperal, as was verified on autopsy. Before these operations by Belluzzi, steps had been already taken (in 1863) by Professor Ottavio Morisani, of Naples, which ultimately led to the revival of the operation, and to its performance with very little mortality. Professor Morisani, by operating upon dead parturient women, became convinced that the method of delivery was not only feasible but quite philosophical, and was prepared to look for favorable results in the living subject, in which his initial section of January 5, 1866, did not disappoint him.

The establishment of symphyseotomy as a commendable method of delivery has been the result of a long, patient, and persevering effort to reduce its rate of mortality by various steps of improvement in its performance, and the after-management of the patients. Although the introduction of antisepsis has accomplished wonders for the operation, it has only been one of the steps of improvement since the days of Sigault. This is shown conclusively by the fact that the marked reduction in the rate of fœtal death can have no dependence upon an aseptic condition in the mother. In the days of Sigault, the first thirty operations lost *eleven* women and *nineteen* children; but the same number, after the revival under Morisani, saved twenty-four women * and twenty-three children; an increase of maternal recovery from nineteen to twenty-four, and of children born alive from twelve to twenty-three. And this only represents a part of the improvement, for in the first period a woman that escaped death was often seriously disabled by lameness, or incontinence of urine, which in the second period she escaped from by a better management. When Professors Morisani and Novi began their symphyseotomies, they saved two women out of three, or ten out of the first fifteen; just as was done under Sigault and his followers; but they were encouraged by the marked improvement in the delivery of living children, eleven against three. Under the second fifteen, when all of the women were saved but one, and twelve of their children, came the encouragement to persevere and to perfect the technique. This last was not satisfactorily effected until seven years ago, when more than seventy operations had been performed (1866 to 1886) in Naples.

With January 1, 1886, commenced an era of remarkable success for symphyseotomy, so much so, that it is difficult to realize the extent of the change that has been effected. The operation had such a bad reputation among obstetrical writers, many of them still living, that it has taken an almost incredible array of facts to convince them that it has become their duty to revolutionize their opinion, and recommend what they had formerly condemned in no questionable terms. Seven and a half years of active work, covering over two hundred operations in ten countries, have shown that the method has a low grade of risk. Having seen the operation four times performed, saving all of the women and three children, I cannot but recommend it to be resorted to where deformity of the mother demands it. Its low rate of mortality makes it not only a substitute for craniotomy, but for the cases in which it becomes very doubtful whether the fœtus can be saved either under a delivery by the forceps, or after version. There are obstetricians who abhor a craniotomy, and yet are ready to take the risk of the forceps and version, where they feel that either may prove a failure. Are such men ready to prepare themselves to do a symphyseotomy in this emergency? I have just seen a quintipara a week after this operation, where the fœtus weighed over eight pounds, and the symphysis had been separated two and one-quarter inches in its delivery, whose convalescence was quite equal to that after a normal labor, and whose expression was "I do not think I could be doing any better." This woman has had two children saved respectively by the Cæsarean section, and by labor induced at eight months; the latter fœtus weighing exactly three pounds less than that delivered under pubic section.

It was thought by Morisani, in 1881, that one essential of success in forty cases out of fifty reported by him, was in the fact that three-fourths of the women were allowed to deliver themselves after the section was made; but this has been discovered to have been an error of judgment, and now, under a rigid antisepsis, the forceps is resorted to in a large majority of cases, and with a greater saving of fœtal, as well as maternal life.

It might seem strange that Professors Morisani and Novi, of the Maternity of the Hospital for Incurables, should so soon be able to reduce the mortality of the women to twenty per cent. and of the children to eighteen; but for the fact that the history of symphyseotomy shows that its early advocates were deficient in skill in pelvimetry, in obstetrics, and in the surgical management of their cases. They could not make a reliable pelvic measurement; performed the operation where the sacro-pubic diameter was entirely too short; did not suture the wound over the symphysis; and appeared to know nothing of the importance of fixing the pelvis. A great deal of the bad reputation of the operation was earned for it by a worse management of the cases. Without any antiseptic precautions, the obstetrics and surgery of the present day should be competent to save many more lives under the operation than was done in the time of Baudelocque, when eighteen women and thirty-six children were lost as the result of the first fifty operations.

Mode of Performing the Operation.—This should not be undertaken where disease has produced an ossification of a sacro-iliac synchondrosis, or where the true conjugate diameter is less than sixty-seven mm. (two and five-eighths inches); there must also be no obstructing tumor in the cervix or pelvis. The instruments required are two scalpels, a symphyseotomy knife, some hæmostatic forceps, a needle-holder and needles, a silver catheter, ligature silk, gauze, cotton, canvas bandage for pelvis, and cotton bandages.

After these have been sterilized, place the parturient woman on her back, upon an operating-table, with her

* There were six deaths out of the first thirty-six cases.

knees drawn up and separated, shave the pudendum, and disinfect the supra-pubic region, the vulva, the perineum, and vulvo-vaginal canal. Examine the depth, thickness, and direction of the symphysis, and search out the fossa in its superior edge, which marks the point of union of the ossa pubis; then examine the inferior margin, and the anterior and posterior faces of the symphysis.

Introduce the catheter and give it into the hand of an assistant who is to depress the urethra from the pubic arch, and carry it to the right side to save it from injury. The operator may stand on the right of the patient or sit between her lower extremities, as he prefers, the former being the usual position.

Make a vertical incision through the skin and fat above the symphysis, of an inch and a half to two inches in length, ending three-quarters of an inch above the pubis. Cut down to the pubis subcutaneously, and back to the attachment of the recti muscles. Separate these from the bone on either side, so that the index-finger may be admitted. Insert the left index-finger, hold it vertically,

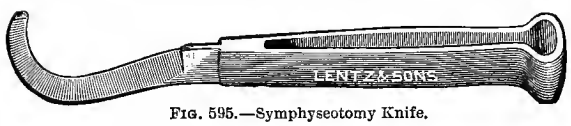


FIG. 595.—Symphyseotomy Knife.

and by rotating it to and fro, bore with it under the retro-pubic tissue down to the pubic arch, and force it under the arch above the catheter. Apply the palm face of the finger over the part to be cut through; introduce the symphyseotomy bistoury, and pass it under the finger until it protrudes beneath the arch. Incise the interosseous ligaments and cartilage from within outward and below upward until a creaking sensation indicates that the separation is effected: the bones will then be sensibly disconnected. In some operations it is quite difficult to pass the finger behind the symphysis, and occasionally it will require much force to separate the pubic bones by the knife.

When the symphysis has been divided, cover the wound with the gauze dipped in a bichloride solution of 1 to 4,000, and attend to the delivery of the fœtus, having at the same time the separation of the innominata antagonized by pressure with the hands of assistants. During the passage of the head, ascertain the width of pubic separation; spray the vagina, and when the placenta has been delivered, attend to the incised wound. Close this with six or eight interrupted silk sutures, and dress with sublimated cotton, 1 to 2,000. Bandage the pelvis with the canvas bandage, and fasten the knees together to prevent any pelvic strain.

The symphysis will sometimes reunite in a week; but it is safe to keep the woman from walking until the end of the fourth week, or until the union is solid. The time for consolidation appears to depend upon the subject, and does not seem to be influenced by the amount of separation that may have been produced in the delivery.

Some women will bear a separation of three inches as well as others will one of two. In one American case, where the gap measured $2\frac{7}{8}$ inches, restoration was remarkably rapid. In another, a separation of $2\frac{1}{4}$ inches produced no trace of gluteal pain during convalescence. The widest separation recorded in Europe (June, 1891), was $3\frac{3}{10}$ inches, and the woman was out of bed on the twentieth day. There was no injury to her powers of locomotion.

Much has been written about the mechanism of labor, after the pelvis has been opened by symphyseotomy; and diagrams with calculations prepared to show how little is gained in the antero-posterior diameter of the pelvis. This little gain has been used repeatedly as an argument against the propriety and practicability of the operation, and as an explanation of its large fœtal mortality. A flat pelvis gains in its transverse and oblique diameters, and the separation of the pubic bones gives space for the accommodation of part of the fœtal head, generally a parietal protuberance. The moulding of the head, and the pressure of the forceps, have a share also in the passage of the cranium. The fact of the low fœtal mortality during the past seven years, sufficiently attests the practicability of symphyseotomy as an obstetric measure.

The fact that a woman has previously borne living children, is no proof against the propriety and requirement of a delivery under symphyseotomy. Multipara occasionally produce children so large that they cannot be delivered through a pelvis that is under size, except with very great risk to fœtal life; or it may be, without a fatal cranial pressure under the forceps. There cannot be a maximum limit to the true conjugate, in a pelvis that is under the average size, because even with a measure of $3\frac{3}{4}$ inches, Professor Freund, of Strasburg, felt warranted in operating, after a labor of six days, where the bi-parietal diameter proved to be $4\frac{9}{16}$ inches. The operation saved both child and mother. A fœtus of eleven pounds has been delivered under symphyseotomy, through a $2\frac{5}{8}$ inches C.V. with a B.P. of $3\frac{5}{16}$, and lived. The mother was up in twenty days, and left the Maternity a few days later. The case was under the care of Professor Raffaele Novi, of Naples, in April, 1890.

Robert P. Harris.

SYNTHETIC REMEDIES. Medical science has long been indebted to chemistry for many of its best weapons with which it combats disease. Within a few years it has received an unusually large number of new ones, and nearly all from a quarter where half a century ago it would not have added to one's popularity to have predicted such a result as possible. It would have seemed like a direct blow at the doctrine of vital force. The laboratory of the chemist is fast taking the place of that of nature, as manifested in the vegetable world, so that the materia medica of the future seems likely to be one, almost or wholly, composed of synthetic products. So rapidly do these new remedies crowd upon us that it is almost impossible for the busy practitioner to even take note of their names, to say nothing of giving them anything like an extended study or trial. While each may possess some merit, the fate of all not possessing exceptionally valuable qualities must necessarily be oblivion, owing to the intense competitive struggle they are forcing upon one another. Experience is bound to eliminate the inferior and select the superior.

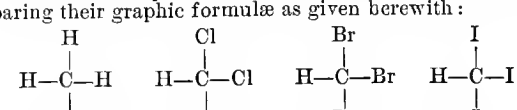
Should anyone infer from the title "Synthetic Remedies" that these remedies are wholly synthetized, they would commit a grave error. Many of these new substances could be built all the way up from their elements, but the cost of such a procedure would be so great that they would be practically excluded from general use. As found in the market they are all derived from substances chemically quite complex, by substituting desired radicals for some less desirable held within the compound. Substances once deemed valueless, or of relatively small value, have their molecules reconstructed in minor details, but in such a way that their value is very materially enhanced. This is on the principle that it costs less to remodel and finish a house already partly built, than to construct the same house *de novo*.

A number of well-known remedies, at one time derived exclusively from the vegetable world, are now built by the chemist out of what once were waste products of gas-works. This is accomplished at a cost much below that required in extracting them from plants. Salicylic acid, oil of wintergreen, and resorcin are good examples. Gaultheria procumbens and Betula lenta for years supplied the first two, and Ferula galbaniflua the last. Then salicylic acid was made from oil of wintergreen. Now oil of wintergreen is made from salicylic acid, and the acid is produced synthetically. The number of plant products for which synthetic processes are known is now quite large and is constantly increasing, but in many of them the cost is too great to make the transmutation financially profitable. This, however, is a most promising field for the future.

The vegetable alkaloids have received a large amount

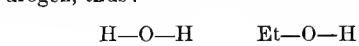
of attention from chemists, but so far not with as brilliant success as might be desired. The promise, in spite of innumerable failures, is exceedingly good, and what has been done is of very great interest. Cocaine has been synthetized from ecgonine, benzoic aldehyde, and methyl iodide. When these three substances are heated together at 100° C. for ten hours it is produced. If we could but synthetize the ecgonine from some common material our triumph would be complete. As it is, our only source of ecgonine is cocaine itself. There is, therefore, no other known source of cocaine than Erythroxylon coca. A study of its decomposition products shows it to be beta-oxy-methyl-beta-pyridyl-propionic acid. Conine, the poisonous alkaloid of Conium maculatum, has been produced from allyl-pyridine by the action of metallic sodium on a boiling alcoholic solution. The allyl-pyridine is synthetically constructed from alpha-picoline and paraldehyde. The methyl, ethyl, and propyl ethers of cupreine have been produced and are said to possess the antiperiodic and antipyretic properties of quinine. Besides these, two alkaloids isomerous with quinine are likewise known. In the cupreine ethers the significant fact has been observed that their therapeutic activity is directly as their molecular weights, that of methyl being least active, of ethyl intermediate, and propyl most active. When Dr. Knorr synthetized antipyrine he thought he was on the way to quinine. On producing a substance known as phenyl-methyl-pyrazolone, from which the antipyrine was subsequently made, he thought he had secured a body that enters into the structure of quinine, and known as methyl-oxy-quinizine. Luckily for him, he had found a prize more valuable than that he sought. His experience was much like that of Columbus, who went forth in search of a new route to an already known world, but finished up by discovering a new world. He has the honor of producing a substance in every respect similar to the vegetable alkaloids, but which no plant has, so far as known, ever contained. Furfurine and thalline are two more just such remarkable bases that attest the skill of modern synthetic chemists in their imitation of the methods of organic creation.

At the very threshold of organic chemistry lie three synthetic remedies, two of which are well known to every medical man. They are chloroform, iodoform, and bromoform. It is more economical to produce these from alcohol or some alcohol derivative than to directly synthetize them from the basic nucleus of organic bodies. Their positions make them of supreme theoretical importance in connection with this subject. Marsh gas or methane (CH_4) bears the same relationship to complex organic molecules that a cell does to our bodies. From it every other organic substance is supposed to be built. It is the fire-damp of mines and one of the main constituents of illuminating gas. When a long pole is pushed to the bottom of a marsh or swamp where much organic matter is decomposing, it bubbles up and may be collected in inverted bottles of water by displacement. If this gas is mixed with chlorine and carbon dioxide, and exposed to direct sunlight, one of the products is chloroform. This substance is therefore one of the easiest to synthetize. The hydrogen of the marsh gas unites with part of the chlorine to form hydrochloric acid, while the rest of the chlorine takes its place around the carbon atoms. Where but three of the hydrogens are thus displaced the product is chloroform. The usual method of preparing this substance is by distilling dilute alcohol and chloride of lime together. It can be prepared much more economically in this way. When the hydrogen of marsh gas is replaced by iodine and bromine to the same extent, iodoform and bromoform result. In practice, however, marsh gas is not used in producing any of these substances. Their relationship to one another is very obvious on comparing their graphic formulæ as given herewith:



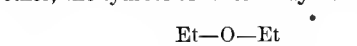
Marsh Gas. Chloroform. Bromoform. Iodoform.

There is an extensive series of bodies having for their molecular skeletons chains of carbon atoms, and that are known as the fatty series. Methane and its derivatives are at the beginning. A large number of the synthetic remedies, when considered chemically, belong therein. Most of them are derivable directly or indirectly from alcohol. Among them may here be mentioned ether, paraldehyde, chloral hydrate, acetic acid, acetic ether, and ethyl nitrite. Alcohol is procured commercially from the fermentation and distillation of amylaceous or saccharine substances. Its synthesis from olefiant gas by dissolving it in concentrated sulphuric acid, diluting, and distilling is easy of accomplishment, but never done to any extent. Chemically considered, it is a molecule of water in which the radical ethyl has displaced an atom of hydrogen, thus:



Water. Alcohol.

Here the symbol Et stands for C_2H_5, a group that behaves very much as an atom would. The olefiant gas used in making alcohol can itself be synthetized from sulphuretted hydrogen, bisulphide of carbon and carbon, monoxide, by passing a mixture of them over red-hot iron. As any elementary work on chemistry tells how these last gases can be prepared from their elements, it is unnecessary to follow them farther. If the second hydrogen of the water molecule is replaced by a second ethyl, we procure ether, the symbol of which may be written thus:



Sulphuric Ether.

This substitution is very easily accomplished by distilling alcohol with sulphuric acid. The acid itself takes no part in the new molecule, so that to call it sulphuric ether is wrong. It would be an easy task to trace out the synthesis of a large number of these remedies, but it would occupy more space than is alloted to this article. Those already given will answer for the fatty series, since they show the general methods pursued.

Seven new substances have lately come forward, claiming to be good anæsthetics. Some of them are intended for the production of general, and others of local, anæsthesia. The three in the second column of the list given below are used as sprays to destroy the sensitiveness of parts intended to be operated upon. Bromoform and carbon tetrachloride are being put forward as almost specifics for the abortion of whooping-cough. They are administered by inhalation, or the bromoform may be given one or two drops at a dose internally.

ANÆSTHETICS.

Bromoform, $CHBr_3$	Ethyl chloride, C_2H_5Cl
Carbon tetrachloride, CCl_4	Methyl chloride, CH_3Cl
Ethyl bromide, C_2H_5Br	Methylene chloride, CH_2Cl
Pental $(CH_3)_2$	$C.CH.CH_3$

The great majority of our new hypnotics and all of the old ones belong, chemically, within the series we are now considering. When we come to the aromatic series, we shall find thymacetin, hypnone, and hypnol, as bodies containing aromatic radicals in their structures. As hypnol contains antipyrine in its composition, it possesses many of the properties of that substance. Amylene hydrate possesses anodyne and antispasmodic qualities combined with its hypnotic. Chloralamide and chloralimide are sedative. Paraldehyde is said to aid the appetite in those who use it for producing sleep. Its great drawback is the strong odor it imparts to the breath. Sulphonal is usually slow to operate, requiring to be taken at least an hour before the time it is wanted to act. Some authorities have seriously condemned its use, while others pronounce it perfectly harmless. An anomalous feature connected with its manufacture is the fact that in Germany, whence our whole supply is derived, the government will not patent it. Owing to competition, it there

sells at the rate of forty cents per ounce. Here, where it is not made, it is patented and the price is $1.35 per ounce. "The sick of the United States are taxed ninety-five cents per ounce to pay a German a bounty his own country refuses him." This is one of the bad features of protection.

NEW HYPNOTICS.

Name.	Formula.	Dose.	Condition.	Water solubility.
Amylene hydrate	$(CH_3)_2C_2H_5COH$.	45 to 60 m.	Liquid.	Slightly.
Chloralamide	$CCl_3CH.OH.CONH_2$.	30 to 45 grs.	Crystals.	Slightly.
Chloralimide	$CCl_3CH.NH$.	6 to 10 grs.	Crystals.	Insoluble.
Methylal	$CH_2(OCH_3)_2$.	15 to 30 m.	Liquid.	Slightly.
Paraldehyde	$(OCHCH_3)_3$.	30 to 60 m.	Liquid.	Slightly.
Sulphonal	$(CH_3)_2C(SO_2C_2H_5)_2$.	20 to 40 grs.	Crystals.	Insoluble.
Tetronal	$(C_2H_5)_2C(SO_2C_2H_5)_2$.	15 to 30 grs.	Crystals.	Insoluble.
Trional	$C_2H_5.CH_3C(SO_2C_2H_5)_2$.	20 to 40 grs.	Crystals.	Insoluble.
Urethane	$CO.NH_2.OC_2H_5$.	15 to 45 grs.	Crystals.	Very soluble.
Uralium	$CCl_3CH.OH.NHCO_2.C_2H_5$.	15 to 30 grs.	Amorphous.	Insoluble.

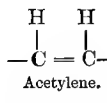
The next list embraces a number of substances having diverse therapeutic qualities, some of them being only applied externally in skin diseases. Opposite each is given its most important use. None of them contain the closed carbon rings of the aromatic series. They do not all belong, however, to the fatty series.

MISCELLANEOUS NEW REMEDIES.

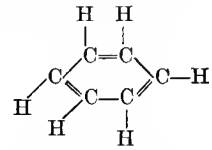
Name.	Formula.	Use.	Dose.	Condition.	Water solubility.
Allyl tribromide	$C_3H_5Br_3$.	Antiasthmatic.	2 to 5 m.	Liquid.	Insoluble.
Ethylene bromide	$C_2H_4Br_2$.	Sedative.	6 to 12 m.	Liquid.	Insoluble.
Ethyl iodide	C_2H_5I.	Antispasmodic.	3 to 5 m.	Liquid.	Insoluble.
Hydroxylamine hydrochloride	$NH_2.OH.HCl$.	Dermic.	External use.	Crystals.	Very soluble.
Iodol	C_4I_4NH.	Dermic. Alterative.	8 to 15 grs.	Powder	Insoluble.
Mercury succinimide	$(C_4H_4O_2N)_2Hg$.	Antiseptic. Alterative.	$^1/_{60}$ to $^1/_{30}$ gr.	Crystals.	Very soluble.
Piperazine	$C_4H_{10}N_2$.	Uric solvent.	10 to 15 grs.	Solid.	Very soluble.
Potassium di-thiocarbonate	K_2COS_2.	Dermic.	External use.	Powder.	Very soluble.
Sodium thiophene sulphonate	$C_4H_3S.NaSO_3$.	Dermic.	External use.	Powder.	Insoluble.

The rest of the synthetic remedies now about to be considered, all contain within their structures groups of carbon atoms in closed rings. This peculiarity of their structure was first proven by Kekule, and has since been confirmed by many new discoveries and independent facts. The knowledge of this fact has been of direct service to the student of organic chemistry, and has aided discovery to a marked degree. The source of the raw material from which they are built up is usually coal tar. The famous English metaphysician of whom Lord Byron wrote, "When Bishop Berkeley said there was no matter, he proved it was no matter what he said," had at least one kind of matter that he seemed to believe in. He spared no pains in extolling tar as a sovereign remedy in almost every ailment. Many an invalid he supplied with tar water, assuring them of its wonderful curative power. As a vestige of his propaganda we find it still endorsed in some quarters as a popular remedy in colds. Previous to this time superstitious people found its greatest use in decorating doors, walls, and fences with the sign of the cross. They believed that this sign, so made, kept devils away, stayed plagues, and checked epidemics of disease. Its black color and adhesive quality made it an admirable pigment for this purpose. Could the good bishop of Cloyne now see the wonderful array of new synthetic remedies that have lately been produced from it, he would most likely be heard to say, "I told you so!" Not only do we use its products to sooth pain, check fever, subdue inflammations, and heal wounds, but we have drawn from it a wonderful array of brilliant colors with which to decorate our homes and persons.

The study of the chemical relations of the synthetic remedies derived from coal tar is one of the most fascinating chapters in modern science. To trace the successive steps by which substances almost wholly unlike in properties are transmuted into each other, seems almost like a fairy tale. Some slight appreciation of the subject can be acquired by following the route leading toward some of the simplest. As methane (*i.e.*, marsh gas) is the commencing nucleus of the fatty series, so benzene (*i.e.*, benzol) is the point of initiation of the aromatic series. Either can be transmuted into the other. When methane is exposed to a strong heat, part of its hydrogen is driven off and acetylene formed. Part of the acetylene instantly coalesces into triple-sized molecules that form the benzene ring. A glance at the graphic formula of acetylene and then at benzene, will show that the latter is merely three of the former united together.

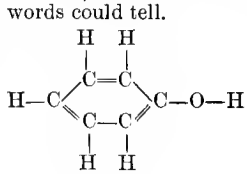


Acetylene.

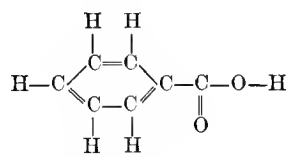


Benzene.

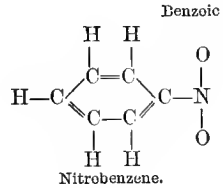
By a single act of synthesis for each there are three substances of interest to medical men producible from benzene. They are carbolic acid, benzoic acid, and nitrobenzene. The latter has been extensively used as an adulterant of oil of bitter almonds, which it resembles. The true oil is mainly composed of benzoic aldehyde and is produced synthetically on a large scale. Carbolic acid results when oxygen is passed into boiling benzene in the presence of aluminium chloride. When benzene is oxidized with plumbic oxide and sulphuric acid, benzoic acid results. When fuming nitric acid acts on benzene, nitrobenzene is the product. The following graphic formulæ of these three bodies, when compared with that of benzene, will show how close of kin they are, better than words could tell.



Carbolic acid.

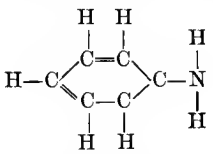


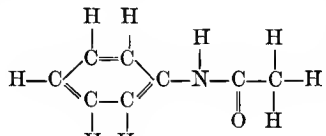
Benzoic acid.



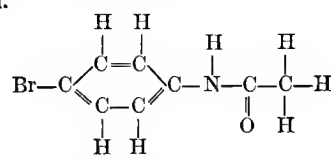
Nitrobenzene.

It is a well-known fact that hydrogen immediately on its release from combination, and before it has had time to recombine even into its own gaseous molecules, is much more active than at any other time. It is then said to be nascent. If such hydrogen is allowed to act on nitrobenzene, it produces aniline oil. The oxygen is removed to form water and the nitrogen takes two atoms of hydrogen into their places. The nascent hydrogen is procured by acting on zinc or iron with a dilute mineral acid. If the aniline oil so procured is boiled for about forty-eight hours with strong acetic acid, one of the products is acetanilid, chemically known as phenylacetimid. This last body is the first important antipyretic ever produced synthetically, and so few are the steps necessary to reach it that it is the cheapest, and by many deemed the best, yet given to the world. As "antifebrine" a fictitious price has been placed upon it, but "a rose by any other name will smell as sweet." A comparison of the graphic formulæ of these two with that of nitrobenzene will show clearly the steps of change.

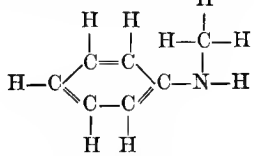

Aniline oil.

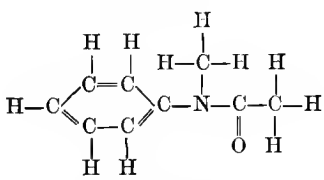

Acetanilid.

If bromine is passed into a solution of acetanilid, parabromacetanilid results. This body has been put upon the market as a good antipyritic, antiseptic, and nervine, under the names of antisepsine and asepsine. It has not met with a great deal of success, and is now seldom heard from.


Antisepsine.

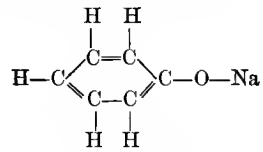
Exalgine, or methylacetanilid, was first described by Hoffman, the German chemist, in 1874. It only differs from acetanilid in that the hydrogen atom united with the nitrogen is removed to give place to a methyl group. The route taken in its construction is somewhat different from that followed in the case of acetanilid. The aniline oil, instead of being acted upon by acetic acid, is caused to react with methyl chloride, thus forming methyl aniline. The methyl aniline thus formed when heated with acetyl-chloride gives exalgine.

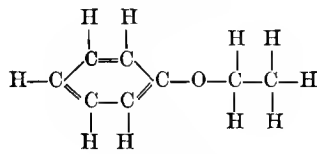

Methyl aniline.


Exalgine.

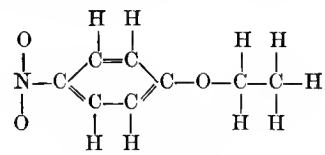
Exalgine is very largely used as an analgesic. Some authors have pronounced it superior to all others for removing pain, while others have condemned it as dangerous. It has been successfully used for chorea, and locally, on burns, to allay pain.

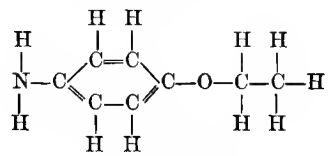
At present one of the most extensively used new synthetic remedies is phenacetine. To reach its structure more steps must be taken than for any yet given. It rejoices in the long chemical name of para-acet-phenethidine. It is well for those not familiar with the nomenclature of organic chemistry to remember that every syllable in such titles tells something about the structure. In this one the "para" tells that the two added groups are opposite to each other, or at the farthest distance from each other in the phenyl radical which the "phen" stands for. The "acet" represents the acetic group and the "eth" the ethylic. The "id" stands for the ammonia radical that has had part of its hydrogen replaced. The synthesis of this body begins with carbolic acid. When this pseudo-acid is acted upon by strong soda lye the product is sodium phenate. When equal volumes of sulphuric acid and alcohol are mixed and cooled, the mixture neutralized with caustic soda and evaporated till crystals appear, and the liquid poured from the crystals into a strong solution of sodium phenate heated under heavy pressure to 150° C., phenctole results. The changes that occur in these reactions can be seen by comparing sodium phenate and phenetole's graphic formulæ with that of carbolic acid before given.


Sodium phenate.


Phenetole.

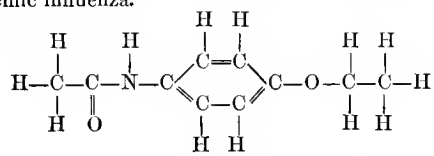
When phenetole and fuming nitric acid are brought together union occurs, and the product is para-nitrophenetole. This reaction is the same as that which gives nitrobenzene from benzene. The next step on the way to phenacetine is the same as that from nitrobenzene to aniline oil. The oxygen of the "nitro" radical is removed by nascent hydrogen, procured, as already described, by the action of a mineral acid on zinc or iron. This gives para-phenethidine. A comparison of the graphic formulæ of these two bodies will show that they bear exactly the same relationship to each other as nitrobenzene bears to aniline.


Para-nitro-phenetole.


Para-phenethidine.

When para-phenethidine is purified by successive recrystallizations, heated with glacial acetic acid for some hours, and the products of this reaction recrystallized from water, phenacetine is one of the substances produced. This is one of the best remedies we have in aborting attacks of whooping-cough and in incontinence.

of urine. Mixed with salol it is admirable in headaches of a neuralgic type. It has proven of great service in epidemic influenza.



Phenacetine.

Most of the ring grouped medical compounds possess antiseptic qualities. Some are decidedly bacteriacidal and have been put upon the market for use by the surgeon and dermatologist. The cresols are particularly interesting because of their freedom from toxic qualities and their great antiseptic power. They are many times more active than carbolic acid, and yet eight or ten times less poisonous. Preparations containing them have been marketed under the names creolin, lysol, and solveol. Chemically there are three isomeric bodies bearing the name cresol, and all are highly antiseptic. Of bodies containing iodine, and therefore believed to possess some of the qualities of iodoform, while free from its objectionable odor, we have aristol, europhen, losophane, picrol, and sozoiodol. Two aniline dyes have proven of great value in this field, some excellent authorities going so far as to claim for them the power of curing carcinoma. One is a blue and the other a yellow. They are known as pyoctanins.

Synthetic External Antiseptics.

Anthrarobin, $C_6H_4.C.OH.C_6H_2(OH)_2CH.$
Aristol, $C_6H_2(C_3H_7.CH_3)_2C.OI.$
Cresols (3), $C_6H_4.CH_3.OH.$
Diaphtherin, $C_6H_4(HO.C_6H_9.NH.O)_2SO_2.$
Europhen, $(C_6H_3O.C_4H_9.CH_3)_2HI.$
Gallacetophenone, $C_6H_2(OH)_3.COCH_3.$
Losophane, $C_6H.I_3.OH.CH_3.$
Naphthols (2), $C_{10}H_7.OH.$
Oxynaphthoic Acid (a), $C_{11}H_8O_3.$
Picrol, $C_6HI.(OH)_2.SO_3K.$
Pyoctanin (blue), $C_{19}H_{12}(CH_3)_5N_3.$
Pyoctanin (yellow), $(C_6H_4.N(CH_3)_2)_2C.NH.$
Sozal, $(C_6H_4.OH.SO_2)_6Al_2.$
Sozoiodol, $C_6H_2I_2.OH.SO_3H.$
Sulphaminol, $C_{10}H_3.OH.S.NH.$
Xylene, $C_6H_4(CH_3)_2.$

The following four are said to be good antiseptics, whether administered internally or applied externally. The first and fourth have been extolled as cures for consumption. The third has anodyne, tonic, and antipyretic properties :

Synthetic Internal Disinfectants.

Name.	Formula.	Dose.	Condition.	Water Solubility.
Benzosol	$C_6H_4.OCH_3.OC.O.C_6H_5$	4 to 12 grs.	Powder.	Insoluble.
Bromol	$C_6H_2Br_3.OH$	$^1/_{10}$ to $^1/_3$ gr.	Crystal.	Insoluble.
Ichthyol	$C_{28}H_{36}S_3O_6(NH_4)_2$	5 to 20 m.	Liquid.	Very soluble.
Styracol	$C_6H_5.(CH.)_2CO_2.C_6H_4OCH_3$	1 to 2 grs.	Crystal.	Insoluble.

The most important and most numerous of the new synthetic remedies are the antipyretics. They all possess some antiseptic power and the majority of them can be used as analgesics. The power that a few of the best known have in subduing pain is quite remarkable. The greatness of the boon they have thus conferred upon us cannot be over-estimated. Thousands are thereby saved from contracting the morphine habit and becoming moral wrecks. The great solubility of antipyrine in water gives it a decided advantage over its rivals, and the fact that it has in a remarkable degree the power of checking hemorrhage is likewise in its favor. Cases of epistaxis that nothing seemed able to arrest will instantly cease on injecting a twenty per cent. solution into the nares, and that, too, without forming an annoying clot or giving the patient any discomfort. The following list comprises such antipyretics as have gained notoriety up to the present time :

Synthetic Antipyretics.

Name.	Formula.	Dose.	Condition.	Water Solubility.
Acetanilid	$C_6H_5.NH.CH_3CO$	3 to 8 grs.	Powder.	Slightly.
Acetyl-amidophenol	$C_{18}H_9NO_4$	3 to 8 grs.	Powder.	Slightly.
Agathin	$C_6H_4.OH.CH.NH.CH_3C_6H_5$	3 to 8 grs.	Solid.	Insoluble.
Antipyrine	$C_6H_5N.CO.CH.NCH_3.CCH_3$	15 to 30 grs.	Powder.	Very soluble.
Antisepsin	$C_6H_4Br.NH.C_2H_3O$	3 to 10 grs.	Crystal.	Insoluble.
Asaprol	$(C_{10}H_8SO_3.HO)_2Ca+3H_2O$	15 to 60 grs.	Powder.	Very soluble.
Benzanilide	$C_6H_5NH.CO.C_6H_5$	15 to 45 grs.	Crystal.	Insoluble.
Benzo-naphthol	$C_6H_5.CO_2C_{10}H_7$	4 to 10 grs.	Powder.	Insoluble.
Betol	$C_6H_4.OH.CO.O.C_{10}H_7$	5 to 6 grs.	Powder.	Insoluble.
Chinoline	C_9H_7N	5 to 20 m.	Liquid.	Insoluble.
Cresalols (3)	$C_6H_4OH.CO.C_6H_4.CH_3$	10 to 20 grs.	Powder.	Insoluble.
Diuretin	$C_6H_4.OH.COONa.C_7H_7Na.N_4O_2$	15 to 20 grs.	Powder.	Very soluble.
Eugenol	$C_{10}H_{12}O_2$	4 to 15 m.	Liquid.	Insoluble
Euphorin	$C_6H_5.NH.COO.C_2H_5$	3 to 8 grs.	Powder.	Insoluble.
Exalgine	$C_6H_5N.CH_3.CH_3.CO$	1 to 5 grs.	Powder.	Slightly.
Guaiacol-salol	$C_{19}H_{12}O_4$	3 to 4 grs.	Powder.	Insoluble.
Hydracetine	$C_6H_5.HN.NH.CH_3.CO$	$^1/_6$ to 1 gr.	Crystal.	Slightly.
Hydroquinone	$C_6H_4(OH)_2$	10 to 50 grs.	Crystal.	Soluble.
Iodopyrine	$C_6H_4IN.CO.CH.NCH_3.CCH_3$	8 to 24 grs.	Crystal.	Slightly.
Methacetine	$C_6H_4OCH_3.NH.CH_3CO$	1 to 3 grs.	Crystal.	Insoluble.
Methylene blue	$(C_6H_3N[CH_3]_2Cl)_2NS.$	1 to 8 grs.	Crystal.	Slightly.
Ortho-amid salicylic acid	$C_6H_3.HO.COOH.NH_2$	6 to 10 grs.	Powder.	Insoluble.
Phenacetine	$C_6H_4.OC_2H_5.NH.CH_3CO$	4 to 12 grs.	Powder.	Insoluble.
Phenocoll hydrochloride	$C_6H_4.OC_2H_5.NH.CO.CH_2NH_2HCl$	7 to 15 grs.	Powder.	Soluble.
Resorcin	$C_6H_4(OH)_2$	1 to 15 grs.	Crystals.	Very soluble.
Salicylamide	$C_6H_4.OH.CO.NH_2$	3 to 5 grs.	Crystals.	Slightly.
Salipyrine	$C_{11}H_{12}N_2O.C_7H_8O_2$	10 to 15 grs.	Powder.	Insoluble.
Salol	$C_6H_4.OH.COO.C_6H_5$	5 to 20 grs.	Powder.	Insoluble.
Salophen	$C_6H_4.OH.COO.C_6H_4.NH.COCH_3$	60 to 90 grs.	Powder.	Insoluble.
Sodium di-thiosalicylate	$(C_6H_3S.NaO_2C.OH)_2$	1 to 3 grs.	Powder.	Very soluble.
Sodium paracresotate	$C_6H_3.CH_3.OH.COONa$	15 to 30 grs.	Crystal.	Slightly.
Sodium salicyl-sulphonate	$C_6H_3HO.COOH.SO_3Na$	6 to 10 grs.	Crystal.	Very soluble.
Thalline tartrate	$C_{10}H_{12}NO.C_4H_6O_6$	2 to 8 grs.	Crystal.	Soluble.
Toluene	$(C_6H_5)_2CH_2$	3 to 7 grs.	Crystal.	Insoluble.

The following three bodies have distinct hypnotic qualities that entitle them to a separate classification, although they possess, in a marked degree, the antipyretic and analgesic powers of the members of the last group. Acetanilid and phenacetine have so quieting an effect on most persons who take them that they might almost have been placed in this group. Many a sick and restless child has been put to sleep by a dose of acetanilid as effectually as it could have been by paregoric.

SYNTHETIC HYPNOTIC ANALGESICS.

Name.	Formula.	Dose.	Condition.	Water solubility.
Hypnal	$C_6H_5(CH_3)_2C_3HN_2O.CCl_3CHO$	10 to 15 grs.	Crystal.	Slightly.
Hypnone	$C_6H_5.COCH_3$	1 to 3 m.	Liquid.	Insoluble.
Thymacetine	$C_6H_2.CH_3.C_3H_7.OC_2H_5.NH.C_2H_3O$	5 to 15 grs.	Crystal.	Slightly.

The next list contains the new sweetening substances that have been such a boon to diabetic patients who are not permitted to use sugar. The sodium salts of the last two are quite soluble in water and sweeter than themselves.

SYNTHETIC SUGAR SUBSTITUTES.

Name.	Formula.	Dose.	Condition.	Water solubility.
Dulcin	$C_6H_4.OC_2H_5.NH_2.NH.CO$	3 to 10 grs.	Powder.	Soluble.
Saccharin	$C_6H_4.CO.SO_2.NH$	½ to 8 grs.	Powder.	Slightly.
Saccharin amide	$C_6H_4.CO.SO_2.NH_2$	½ to 8 grs.	Powder.	Slightly.

The final list contains substances, each of which has properties unlike any of our groups and unlike each other.

Fluorescine is a product of the union of resorcin and phthalein, having the remarkable power of selecting and staining diseased corneal tissue, thus being a valuable means of diagnosis in the hands of the ophthalmologist. Orexine hydrochloride has been used for the purpose of promoting the appetite, especially of tuberculous patients. It acts much as capsicum would. Pyridine is a cardiac stimulant and antiasthmatic remedy that can be used by the mouth or by inhalation. Terpin hydrate is an expectorant and diuretic. It is a product of the interaction of turpentine, alcohol, and nitric acid.

MISCELLANEOUS SYNTHETIC SUBSTANCES.

Name.	Formula.	Dose.	Condition.	Water solubility.
Fluorescin	$(C_6H_3[OH]_2)_2(CO)_2$	0.	Crystals.	Soluble.
Orexine hydrochloride	$C_6H_4.NCH.CH_2N.C_6H_5HCl$	4 to 8 grs.	Crystals.	Very soluble.
Pyridine	C_5H_5N	3 to 4 m.	Liquid.	Very soluble.
Terpin hydrate	$C_{10}H_{16}(OH_2)_2$	3 to 15 grs.	Crystals.	Insoluble.

When the United States Pharmacopœial Convention met in Washington in May, 1890, one of the most serious questions that body had to consider was the admission of synthetic remedies into the revised edition of our national standard text-book of materia medica. The Committee of Revision was instructed to exclude all patented substances, on the ground that, however definite they may be as chemical bodies when pure, no one could be certain of their composition while but one firm had the right of production. In proof of this fact was cited the case of saccharin, that different chemical observers had found ranging in sweetening power all the way from 130 to 330 times that of sugar. The testimony of Professor Remsen, that it was often adulterated to half its proper strength, was also referred to. Now its manufacturers have come out with what they claim to be an article of double the strength of that formerly made by them. For the revisors to fix a standard of say 200 times the sweetness of sugar, would be to lay pharmacists liable to prosecution for deviating from that standard, when in fact the manufacturer might alone be responsible. The maker of any patented substance can, upon a mere whim, change it as much or as often as he chooses, and no one can interfere. It is theirs, and they can do as they see fit with it. In fact they are not even compelled to supply that article at all. Medical men and pharmacists are totally at their mercy. They can add or subtract what they choose and when they choose. The one thing, of all others, that makes it possible for a science of medicine to exist, viz., uniformity, is in no such case assured, and is in fact frequently lacking. When antipyrine, phenacetine, exalgine, iodol, hypnal, sulphonal, aristol, and a host more of these remedies are used, we are compelled to trust to the honor of the manufacturer as to their purity. Many of them have been found adulterated and the blame cast upon the pharmacist who supplied the same. But why blame the pharmacist? What evidence can anyone get that the work of adulteration was not that of the manufacturer? In all other kinds of goods the law can compel purity. The man who sells adulterated goods can be punished. When there is no competition the only standard we can have is that the manufacturer may see fit to make. It might be said that he would naturally desire to keep up the standard of his goods, and would therefore not resort to such methods. In answer to this stands the fact that one manufacturer has practically confessed that he did resort to adulteration to the extent of fifty per cent.

Since acetanilid is not patented it will be admitted to the Pharmacopœia. One enterprising firm finding itself unable to secure a patent on so well-known a substance, resorted to the device of rechristening it "antifebrin," and thus gaining a perpetual patent on the name. This enables them to demand a fabulous price from all sick people whose physicians know no better than to prescribe it under their name. Various combinations of this substance with others are being extensively sold under copyrighted names, the most popular of which begin with the prefix "anti." Samples are freely distributed among medical men. Advertisements appear in nearly every medical journal. Even journals supported by medical societies and that ought to be free to reject such advertisements, cater to such trade. Such mixtures have been recommended in apparently grave scientific papers before medical societies. Their manufacturers describe them as coal-tar products of certain chemical series. Indefinite formulæ of these series are given, but never a definite one of any kind. They are neither more nor less than secret remedies, such as the sarsaparillas and safe cures of the drug stores. Since tens of thousands of dollars are spent annually in advertising them among medical men, it is certain that, in defiance of ethics and in

defiance of the necessities of science, they are being, not slightly, but to an enormous extent, prescribed. Every physician who uses such preparations is robbing his patients, himself, and his profession of money, dignity, and progress. The iodide of potassium in a patent sarsaparilla helps many cases of disease where that remedy is indicated. Mixtures of acetanilid with bicarbonate of soda and caffeine, are, no doubt, excellent succedaneæ for morphine, but when administered under copyrighted names and in ignorance of their true natures, wherein do they differ from the worst patent-medicine frauds? They do differ in one thing. These pretended coal-tar synthetic remedies are sent out enveloped in a false claim as to their very natures, while the well-known cure-alls are honest in their secrecy. Why, then, do medical men patronize the worst and indignantly reject the best? Let no medical man prescribe a remedy that claims to be synthetic, and yet will effervesce on the addition of a dilute acid. It can safely be set aside as something other than it is represented to be.

Power is power. Of course this is a truism well known to all. In its application, however, it is very frequently overlooked. In using synthetic or any other remedies, it is wise to remember that all forms of power can be either injurious or beneficial according to when, where, and how they are used. If anyone is waiting for a perfectly harmless remedy that is therapeutically potent, he is likely to wait in vain. Enterprising manufacturers, when introducing their new products, invariably tell us that they are free from ill effects. Such statements should always be taken *cum grano salis*. Rivals soon discover their ill effects and exaggerate them, thus playing upon the fears of the prescriber. Great allowances should likewise be made on what these say. Always anticipate some ill effects, and there will not be incessant disappointment. From irrational laudation to disgust and rejection are but a step. No surgeon refuses to use a keen-edged bistoury because it has done harm in unskilled hands. He should not lay aside a useful drug for a similar reason.

It is a singular fact, that although chemists have synthetically produced scores of antipyretics, analgesics, hypnotics, and antiseptics, no new cathartics like that which gives croton-oil or elaterin their qualities have been produced this way. Nor have we heard of any powerful anthelmintics like santonine, mydriatics like atropine, oxytocics like ergotin, or emetics like emetine. The synthesis of a local anæsthetic, like cocaine, would be of great value. It would not be surprising if cocaine itself should prove to be the first. One important step has already been successfully taken. To find one body having valuable new therapeutic qualities, is usually to be on the way toward the discovery of more with the same quality. An ortho preparation among the derivatives of benzene suggests a meta and a para of the same kind with similar qualities. A methyl derivative suggests an ethyl or propyl as good ones to try. In quinoline derivatives an alpha suggests a beta. When a prospector, in the mountains, strikes a vein of gold, he usually knows how to follow, even though it appears to run out. Experience teaches him not to give up immediately because the "color" disappears. He is more likely to be successful in following a lead that begun well than he would be should he try to discover a totally new one in a different region. It is the same in synthetically producing new remedies. No one can predict what will come next after exhausting a certain type, but once begin on a new, and we may expect a number of additions from the same quarter. *Robert G. Eccles.*

SYPHILIS. Syphilis and the Columbian Discoveries.—Interest has been revived in the questions relating to the supposed American origin of syphilis by fresh studies of original documents, and by recent discoveries in different portions of the continent of bones supposed to exhibit changes due to the disease. Papers touching on the theme originally so well elucidated by Joseph Jones, of New Orleans, have appeared from the pen of Bruehl and others, throwing further light upon both sides of the problem. The writings of Sahagun, Torquemada, Roman, Mendieta, Pane, and others have been found to show, as to New Spain, that the bodies of those affected with syphilis were interred, as distinguished from those dead of other disorders, which were cremated; that the infected were not deemed fit for religious sacrifices; that they were not represented at the festivals; and that the disease was counted a punishment sent from the gods for the non-performance of religious rites and other offences. The Mexicans not only recognized the connection between the earliest and later manifestations of the disorder, but distinguished between several types of the former, understanding also its remedial treatment far better than the Spaniards, even seeking thermal resorts for the purpose of securing relief. In seventeen Indian dialects, each of which has a primitive and native term for designating the disease, none of the terms thus employed suggest confrontation with a new malady, although soon after contact with the whites the natives were compelled to apply new names to many novel objects with which they were to become familiar. These new names either bear witness to the impression on their ears made by the speech of the Castilians, or describe some prominent feature of the object to be newly named, a rule distinctly observed by them in the case of diseases known to have been imported from Europe to America, as for example, measles and small-pox. The singular confusion existing in the Mexican language of the sixteenth century, of the terms employed to indicate ideas of power, divinity, and the special disease here under discussion, possesses an interest in view of the fact that this is recognized in the dialects of Quechua and Aymeras, three hundred years before Pizarro conquered the capital of the Incas.

With a view to determining the nature of the osseous changes in bones of the class commonly cited as proofs of the existence of a prehistoric syphilis, the author selected from parts of a skeleton exhumed from a pre-historic burial site on the Animas River, Col., two tibiæ, one especially and characteristically deformed, which were submitted for examination to Dr. T. M. Prudden, of the laboratory of the College of Physicians and Surgeons of New York. The shaft of the left tibia, he reported, is bowed considerably forward at its middle and lower portions. The shaft, which is nearly cylindrical, is everywhere greatly increased in thickness, measuring from 4 to 4.5 centimetres in diameter in all parts except at the lower end, where it is slightly smaller. The whole bone is very light in weight.

"About the articular end, at the knee-joint, the bone presents erosions, irregular losses of substance, and numerous larger and smaller bony outgrowths — the latter being most marked about the front of the joint, and especially about the seat of attachment of the ligamentum patellæ. The fibular articular surface is completely destroyed. The entire surface of the shaft is roughened and porous, and beset here and there, especially along the lines of tendinous attachment, with larger and smaller rows and masses of the delicate bony outgrowths called osteophytes. These osteophytes are especially prominent along the lateral and posterior aspects of the shaft. Branching grooves in the surface of the bone, and delicate projecting bony plates and spiculæ and ridges, contribute to the roughness of the shaft.

"Transverse sections of the shaft of this bone at its middle third show that the bone, which from the outside appears to be largely hypertrophied, is a mere fragile cylindrical shell, the peripheral compact bone being almost everywhere thin and uneven, the bulk of the shaft consisting almost wholly of irregular cancellous or spongy tissue.

"The more delicate central trabeculæ of the cancellous tissue, which apparently nearly or completely filled the narrow cavity, have, except in a few places, largely disintegrated and fallen out with the lapse of time.

"Along many parts of the bone the cancellous tissue pierces the shell of compact bone—which, though very thin in general, encloses the shaft—and becomes contiuuous with the osteophytic outgrowths on the surface.

"The microscopical examination of the trabeculæ of the cancellous tissue in both bones, shows the usual appearance of such tissue, but the irregularity and apparent aimlessness of their grouping and arrangement indicate their formation under the influence of a chronic inflammatory process. Microscopical examination of the osteophytes exhibits irregular grouping and relative posi-

Fig. 596.—Tibia Exhibiting Osseous Changes; from a pre-historic burial site in Colorado.

tions of the bone cells and bone lamellæ, which is usually associated with inflammatory structures.

"The more compact bone-tissue from various places in the shafts of both bones shows the utmost irregularity in the arrangement, size, and direction of the Haversian canals and their surrounding lamellæ."

He reported that it was evident that these were the bones of an adult who for a long time had been the victim of an extensive chronic bone disease in both legs, with a probable involvement of the left knee. This disease was so extensive and prolonged that it had led to the nearly complete making over of the shafts of both tibiæ.

Under the influence of the inflammatory process the old bone was bit by bit absorbed, new bone being in greater or less degree formed near by to take its place. The new-formed bone has been only here and there developed in the proper amounts, situations, and relationships.

Morphologically, the character and extent of the lesions in these bones were perfectly clear. There was no evidence whatsoever that there had been either caries or necrosis. There had been, so far as the bones show, simply such a general rarefying and formative osteitis with formative periostitis, as to produce the condition often described as spongy hyperostosis. There was no evidence whatsoever of the presence, at any time, of the more common and typical circumscribed nodular or gummatous lesions, which are alone characteristic of syphilis of the bones. There were none of those circumscribed local losses of substance, associated with more or less localized sclerosis, which speak for the former presence of gummata. On the other hand, there was a more diffuse and general inflammation of the bone and periosteum, which, as is well known, not infrequently occurs in the tibia, and which is believed to be due to syphilitic infection. But even in this form of syphilitic bone lesion, the sclerotic rather than the rarefying character in the inflammation, as is the case here, is apt to prevail. In brief, there is no morphological evidence to justify a belief in their syphilitic character.

Admitting that among the bones exhumed in the northern part of the American continent, and found in the various collections of this country, there may be some which actually exhibit unmistakable lesions of syphilis, the last problem prescribed for solution is: Are any of these bones not merely syphilitic but unquestionably pre-historic? Are they parts of the skeletons of North American Indians or of the whites mingled with the latter in the confusion resulting from race admixture in war, captivity, and many common enterprises? Are they, in point of fact, the bones of individuals dead before the first of the Spaniards set foot on the soil of San Salvador in 1496? The conjecture that a people once dwelt on this soil of some pretension to civilization, building temples and cities comparable to those found in what we call the older world, has been dissipated. The artificial mounds and stone dwellings, numbering thousands, some of very small and some of imposing size, and scattered throughout the country, were once thought to be the work of an ancient race of people commonly called the "Mound-builders" and the "Cliff-dwellers," who were cited as a people showing evidence of an ancient civilization of no mean order and no common condition of culture. The bones which have been found in many of these mounds and other places of sepulture, with the so-called works of art which these tombs contain, have been regarded as the remains of these primitive peoples.

These views have, within a decade, been shown to have a broader basis in the imagination than in tangible fact. From about the middle part of the Pleistocene period to the epoch of the first advent of the whites to the American coast, the history of man in America is seen to be the history of his slow and feeble evolution from a lower to a higher advancement in the Stone age. The best product of this process of evolution was reached by the North American Indian when he first looked seaward upon the sails of the Spanish fleet. There had been nothing superior to him before; and it is a question whether anything better has been since produced by this process of evolution from his race. He built no cities; he carved no vases; his work in metals was of the crudest sort. He and his fathers, his inferiors in culture, builded these mounds for sepulture and other purposes, sometimes as the foundation for commmunal dwellings. In some por-

tions of the southwestern parts of the country, where there is little vegetation and the plains are arid, he and his fathers excavated lodgings in the cliffs that hemmed in the cañons, or constructed them of the loose rocks that were easily separated from the walls of stone on either hand. But all the mounds are not pre-historic, and the same may be said of the excavated cliff dwellings. Even of the pre-historic mounds, some have been occupied in our own day, and some have been used for the interment of bones of individuals dead long after the admixture of the white and red races upon our soil. Of the glass beads, the tools and ornaments of copper, and other articles found in them suggestive of contemporaneous interment with the human bodies, many were manufactured by the whites and furnished to the Indians in the way of barter for peltries. It is also of importance to note that, even within the mounds which are unquestionably of pre-historic structure and which undoubtedly at the first contained only the bones of a pre-historic race, there have been repeated intrusions, and these intrusive interments have resulted in depositing in such mounds, not merely bones of later generations surviving the Columbiau advent, but, indeed, large bundles of such bones, some of them apparently collected from the most miscellaneous sources.

The wide door to confusion opened by the complete recognition of facts of this character cannot be ignored. It furnishes a possibility for errors which it would be difficult to number and impossible to overestimate.

In order to demonstrate, in the case of bones obtained from any mound or burial-place of the cave-dwellers in North America, some of which exhibit evidences of syphilitic lesions of a suggestive or even unmistakable character, that the latter are proofs of a pre-Columbian prevalence of the disease, it is absolutely necessary to prove beyond question: first, that such mound or burial-place was pre-historic in construction; second, that such contained bones were interred at a pre-historic period; third, and lastly, that after such burial there had been neither intrusive interment of bones nor other disturbance of mortuary relics after their first deposit.

Chancres upon the Person of Individuals Previously Infected with Syphilis.—The occurrence of second attacks of syphilis is a possibility denied by some authors, but illustrated by cases carefully collated by Hutchinson, Diday, Koebner, Gascoyne, Taylor, Malherbe, and others. The most of these cases, when carefully examined, are to be recognized as the odd results of a re-awakening of morbid activity in the tissue of an individual previously infected. Persons thus immune against reinfection de novo, actually exhibit the evidences of exposure to syphilitic sores with results that may be classed as follows:

1. Genital lesions appear of the type of the so-called soft chancre (*chancrelle, chancre mou*, Einfacher Schanker, etc.). It cannot be demonstrated to-day in all cases that these lesions are absolutely identical with the soft chancre, but only that they strongly resemble the latter. These pseudo-chancres have no induration at the base; they secrete a puriform mucoid secretion; they are circular, sharply defined, clean-cut as to edge; they are unaccompanied by any characteristic sclerosis. It can be demonstrated by confrontation that these special lesions result from contamination of an undoubtedly syphilitic individual with the secretion furnished by mucous patches, condylomata, or indurated scleroses of persons no less certainly syphilitic. It is noticeable, however, that for the most part these sores are unaccompanied by the suppurating bubo, which so often complicates the soft chancre; and after healing, they do not appear to exert a constitutional effect upon the subject of the malady.

2. Typical initial scleroses appear with and without (usually the latter) the characteristic enlargement of the glands in the vicinity of the sore. Here the previously infected person is commonly a veteran of syphilis, having suffered a decade of years or more before the second exposure to the same virus. Even the large dense sclerosis may result which presents the most formidable picture in some cases of primary syphilis, with so slight an effect upon the adjacent lymphatics that the most expert are surprised at the absence of such symptoms. When this complication exists there may be a slight lymphangitis leading from the site of infection to glands that are very little influenced by the process. These scleroses rarely break down to ulcerations or gangrene. They are readily effaceable by the administration of mercury internally, and are followed by no consequences as respects the constitutional condition.

3. Typical initial scleroses occur, small or large, single or multiple, usually in persons not many years separated from the infection date of syphilis, sometimes but a few months, at other times one or two years so removed. These slowly or rapidly ulcerate, occasionally breaking down into really formidable losses of tissue, behind the corona glandis in men, about the hood of the clitoris or the meatus urinarius in women, the picture presented rapidly taking on the characteristic appearance of tertiary gummatous ulceration, with dense inflammatory base. These, at first of purely local significance, are shifted speedily to the point of production of the syphiloma in the subject still apt for the manifestations of constitutional syphilis.

The Destruction of the Initial Sclerosis by Cauterization or Excision is Powerless to Prevent the Occurrence of General Syphilis.—A careful survey of the later attempts to prevent the occurrence of general syphilis by the most radical measures (erasion; excision; destruction by caustics or cautery; and amputation of the entire tissue on which the chancre is seated, *e.g.*, prepuce, digit, etc.), demonstrates the futility of all. Even with the complete simultaneous removal of all enlarged glands in the vicinity of the chancre, the result is the same. The most modern of methods, and the most exhaustive of studies, have not as yet succeeded in shaking the old dictum, that every true chancre means a syphilis that follows: and every case of acquired syphilis acknowledges a chancre as its initial lesion. There are in fact few infective diseases that can be jugulated. The lymphatics are not the sole avenues by which the syphilitic virus is conveyed from its portal to any given peripheral point of the body. The failure of the tumid and indurated glands to entrap the bacilli or their toxine, is demonstrated in almost every classically developed case. Inasmuch, therefore, as cauterization of the chancre may be followed by a graver sclerosis, it is wisest to treat these local lesions by the methods proven satisfactory in all local infections, whether coccogenic or bacillogenic in origin. Absolute cleanliness, antisepsis, and unirritating dressings are indicated in all cases.

The Evolution of Syphilis Studied without Regard to the Artificial "Periods" of the French School. — Between the moment of infection and the earliest appearance of a chancre to the unaided eye, there is usually a delay of from fifteen to thirty-five or forty days, a period of twenty-one days for the average of cases. This is usually called the first incubation. Terms of this sort embody, however, the confession of an ignorance that is in part dissipated on any careful examination of the results of a successful culture in an artificial medium of micro-organisms, reproducing themselves in colonies, for example, in gelatine, or agar-agar. There is then apparent neither an incubation, a "hatching," a delay, nor an arrest. If our methods were without flaw, we should be able to detect the movement toward general infection from its very first to its completed step.

In an attempt, therefore, to study the evolution of syphilis as it is actually wrought, questions of time, the crude hypothesis of an incubation, and all really artificial distinctions, should be, for the purposes of critical investigation, assigned a true and not a fictitious value.

In the article on Syphilis, in this work, attention has already been drawn to the historical and interesting fact, that by the late eminent Philip Ricord, the evolution of syphilis was divided into three stages, the primary, the secondary, and the tertiary. The primary included the

symptoms concerning the chancre and its accompanying multiganglionic adenopathy. The secondary period included the symptoms displayed during the succeeding term, in which systemic infection occurred, with usually symmetrical and superficial cutaneous and other manifestations. This was loosely estimated at about one year in duration. Lastly, following this stage of efflorescence, came the tertiary period, that in which the deeper structures of the body are involved; that in which the disease commonly ceases to be transmissible, in which it may produce its most destructive effects, or pass into a complete innocuousness and decline. The influence of this doctrine of periods has been incalculably great and valuable. It once marked a revolution in the history, in the study, and in the treatment of the disease. It has dominated the minds of the medical men of all lands since it was first completely grasped by the intellect of its master.

But it has served its day. To thoroughly grasp the problems of syphilis, it is now needful, for the time being, to emancipate the mind wholly from the ingenious suggestiveness of this doctrine. It must be clearly seen to be nothing but an artificial device for classifying in a clumsy way the clinical phenomena of the disease.

As a matter of fact, there is no line of demarcation between the successive phenomena of syphilis as they appear in the evolution of the disease in any given case. From the moment when infection has been wrought, to that of the gravest injuries, or of the mildest efflorescence, there is, when no arrest occurs, a gradual but continuous progression of the disease. This advance is commonly marked by interludes as striking as they are salutary. They may be due to the intervention of treatment, or to changes in the general health of the infected due to other causes. Apparently capricious cessation of the advance of the disease may occur, since even the cutaneous symptoms of marked cases may wholly disappear without treatment. If we were in position to view with keenest scrutiny the unmodified progress of syphilis in cell and vessel, no one can doubt that the so-called period of incubation would disappear and the microscopic eye of the observer would be as busily occupied during that as throughout any other period of the disease. Similarly, there would be no sharp distinction possible between primary and secondary syphilis. One could scarcely note the hour when, from the first to the last, there was not in progress a slow and gradual progression from point to point of the toxæmic product originating in the changes wrought at the site and at the time of infection.

These suggestions are needed for a clear comprehension of the phenomena following the stage of so-called "primary syphilis." The "primary" hypothesis made it absolutely necessary to also assume that after the primary came a secondary; and after a secondary, an inevitable tertiary stage. More, the mind thus habituated to a study of the evolution of the disease in periods, looked to an evolution of symptoms in these periods in due order and line of procession. One was thus educated to expect in a typical and uninterrupted attack of syphilis (could such be observed) each and everyone of the several manifestations of the disease. After macules, papules should appear and, in course, pustules, gummata, ulcers, and successive involvement of organ after organ of the body. Some such definiteness of order is, in point of fact, to be recognized in the evolution of variola, with which, unfortunately, syphilis has been too often and too closely compared.

But no such syphilitic history has ever been observed. It is the artificial manikin of the schools, the figment required by the domination of the medical mind by the time-rules of the French school. It was this once useful and ingenious time-schedule which made it equally imperative for the French to coin for some of the manifestations of syphilis, the striking terms, "precocious" and "tardy," words which embody a confession of the weakness of the schedule to explain all the exact clinical pictures of the disease.

Dismissing, then, the conclusions based on this wholly artificial scheme, it can be clearly recognized that, almost immediately after lymphatic adenopathy has declared to the eye and the finger of the observer that the toxic product of the chancre-site is finding its way into the vascular channels of the body, the phenomena of the disease are evolved, not in the order of a time-card but, to employ a different figure, in radii from a pathological centre. Early indeed, in many cases, can it be seen that the future of the malady is to be sought along one or another line toward exceedingly variant results. The complexus of these results may be conveniently classified in four divisions, which are named later.

Toward these the advance is either slow or rapid. The gravest may be imminent when the chancre is yet unhealed, the adenopathy unrelieved, the lymphangitis discernible. The mildest may be attained when months have passed, the early accidents well-nigh imperceptible or forgotten, and the general health of the infected individual meanwhile not manifestly impaired.

Whether this apparent interval (the so-called "secondary period of incubation") be brief or protracted, none can doubt that when an ultimate evolution of the disease occurs there is a continuous progress toward complete or partial systemic intoxication. When well marked, this apparent interval occupies from forty to fifty days, but it has been noted as brief as twenty days and as prolonged as a twelvemonth. Its limits are usually defined between the date of the chancre's appearance on the one hand, and the date of the first cutaneous exanthem on the other. That this is a purely artificial distinction becomes at once apparent when one of these dates of limitation is questioned. There is nothing in a cutaneous exanthem which entitles it to pre-eminence above other symptoms of syphilitic invasion perfectly evident during the so-called second incubative stage. From the date first assigned to the last arbitrarily selected there is no real pause, no conspicuous absence of invasion-signs. On the contrary, the symptoms of this period are often more suggestive and significant than when, for example, the skin of the patient's belly is merely sprinkled with a macular syphiloderm.

The merest enumeration of symptoms possibly occurring in this period of apparent pause, is sufficient to indicate that no real incubation can be observed. Yet here again it is important to note that not all of the enumerated symptoms are to be observed in one individual, and further, that they observe no definite order when two or more chance to be parts of one syphilitic history. Rather are they different surface indications of the several lines along one or another of which the disease may advance toward its ultimate results.

After the chancre appears, and before the first exanthem of general syphilis follows, the condition of the average patient is far from an apparently sound health. The blood-globules commonly decrease, while the leucocytes by actual enumeration increase in number. The glands of the body elsewhere than those in the region of adenopathy near the chancre-site, slowly or suddenly enlarge, become tumid, painless, much less indurated than those first noted in the disease, and are often symmetrically, rather than, as in the other instance, asymmetrically involved. The spleen, so intimately is it concerned with the fluids traversing the vascular channels, becomes tumid and at times tender. The liver function is often disturbed, as shown by an icteroid skin with muddy conjunctivæ and the appearance of bile-products in the urine. The functions of the stomach, of the bladder, of the supra-renal capsules, and of other viscera, may be even seriously impaired. Continuous or interrupted febrile temperatures may be reached, the thermometer rising at times even to 105° F., the patient being not rarely treated by a physician ignorant of the nature of the effective poison for an intermittent or relapsing fever. The nervous system may seriously suffer. Atrocious neuralgias, substernal and periosteal pains, pains in the bones and joints, osteoscopic sensations, and even synovial effusions, may be the protest of the system against the advent of the recently introduced poison. Often there are signs of mischief even of a severer type. The lassitude and

depression are profound; a condition of mental hebetude gives place to partial syncope; a headache results in a temporary strabismus, a pain in the upper or lower limbs is followed by muscular contracture. None can doubt that in a carefully studied case where the evolution of syphilis is actually in progress, however mild its future is to be, a skilled diagnostician could recognize, at one point or another of the body presumed to be in the stage of this so-called secondary incubation, unmistakable evidences of an insidious advance of the malady.

The term "explosion" has been repeatedly employed, with many other metaphorical phrases, to describe the moment when the first cutaneous exanthem appears. Its use is an index of the absurd and most extravagant importance attributed to the onset of skin symptoms in early syphilis. As a matter of fact, the latter are surface indications of more serious and deeper processes (probably involving the nervous centres) and are all-important to the eye only of the vulgar. As a matter of fact, too, they never occur by explosion. The first efflorescence of the disease may be as gradual as the dawn of a day and as impossible to define. Before the human eye traces its first expression, the camera of the photograph can produce with fidelity the faint mottlings of a skin that is to be later visibly the seat of a syphilitic efflorescence. No one who has with minute care watched the oncoming of the cutaneous manifestations of the disease, can have failed to note how insidiously the approach is made to the eye. An accident may change all. The excessive heating of the body in a bath or by dancing, may simply precipitate the blushing of the first rash.

This once apparent, and let it be noted even without this, syphilis exposes its advance in numberless directions, probably in no two cases exactly the same. These advances may be, however, for practical purposes, classified in four principal directions, as previously suggested in these pages. They may be named and briefly sketched as follows:

1. Benignant syphilis with mild and transitory symptoms.

Every vaccinicultnrist has recognized the fact that a few heifers fail to respond to all efforts to inoculate the udder with vaccinia. The reason is not explained; the system of a few individuals in every thousand simply refuses to react against the introduction of the poison. No expert of wide experience can fail to have been impressed with the fact of the existence of this exceptional class of human subjects with respect to syphilis.

There are persons who exhibit typical chancres with characteristic adenopathy of the vicinage, who never after exhibit the slightest signs of systemic disease. The objection to this statement is suggested at once to the mind of the profane. It is, that an error was made in the diagnosis of the initial sclerosis. That which seemed to be a syphilitic chancre was really not such, but spurious, an imitation of the genuine lesion. But, it is responded, such chancres have been not carelessly, but with exquisite skill, studied by experts, and found not different from others followed by grave syphilis. Further, the persons enjoying this immunity have failed later to contract the disease when exposed to it; and, more important than all else, individuals of this class correspond to others of the same class who, having actually exhibited such chancres, do later have systemic symptoms of such mild type as to astonish those unfamiliar with these singular exceptions to the rule.

These interesting exceptions are either the triumphant proofs of the skill of the physician, or (what is far more probable) proofs that some of the phenomena of natural law defy ultimate analysis by the human mind. Persons of this class have typical, severe or mild, premonitory chancres. In due time, they have also slight ganglionic engorgement, post-occipital, along the nucha, or in the line of the sterno-cleido-mastoid muscle. An exanthem occurs, of macular type, upon the belly, over the chest, slightly upon the face, or perhaps limited to the trunk. When this fades, with or even without medical treatment, the disease is absolutely at an end. The ignorant declare that ten, fifteen, or twenty years after, this individual will suffer from a gumma of brain or liver, and be the worse for the mildness of his early syphilitic history. But some of these patients have been watched during the longer of the intervals named, without signs of resulting disease. Only the obstinacy of fixed prejudice can refuse to accept the necessary conclusions. These cases are not the figments of the imagination, but are annually observed in every extensive syphilitic practice. They are not rarely seen in women who have been infected without their knowledge by a husband, or by the innocent contacts of daily life.

2. Benignant syphilis with relapsing or persistent superficial symptoms.

Cases assignable to this category are those in which typical chancres are followed by typical early manifestations of general syphilis, the patient continuing, for months or even years after, to be annoyed by intractably persistent or relapsing, but wholly superficial syphilitic symptoms. If described according to the former phraseology, these would be classed with the subjects of prolonged secondary syphilis, never proceeding to tertiary stages. Two, three, and four years after infection, such subjects are found with an infiltrated patch of scaling papules on buttock or back; with mucous patches of lips, tongue, or fauces; with a squamous palmar or plantar syphiloderm; or with a cluster of superficial and crusted papulo-pustules over the occiput or temple in the pilary region. After alternately trying and tiring of all methods of treatment, the disease at last yields. Throughout all, from first to last, there is no sign of a formidable malady. When recovery has at last occurred, no trace is left on the body, of the infective process. There has been no deep ulcer; no cicatrix; no permanent impairment of any organ or tissue. The disease, viewed in retrospect, has been perhaps a long, but always rather an annoying than a dangerous affection. It may never have for a day prevented attention to the routine work of the sufferer. Had it not been for the incidental apprehension of the future, it would not have attracted serious attention nor demanded assiduous care.

Such, without any question whatever, is the course of the majority of all cases of syphilis. They are watched with intensest anxiety by many physicians, lest the serious phases of syphilis ensue, and with feverish alternations of hope and despair by the nervous and instructed of those who endure the ordeal. It is these which furnish the text for the prophets who claim that, however mild be these histories, each is liable to result in the graver forms of the disease, and that which determines the difference is treatment, always of highest importance. Against this palpable error, an error fostered by the pitiless time-schedule of the French school, it is proper to protest. The most superficial study of syphilitic statistics demonstrates without flaw, that the majority of all patients, with the best, with the poorest, and without treatment, escape what has long been termed tertiary syphilis; in other words, do not exhibit the destructive types of the disease. The percentage of the latter to the former, in both hospital and private practice, has been estimated at the lowest at about seven per cent., at the highest at nearly thirty per cent. The corollary, therefore, is wholly trustworthy that at the least two-thirds of all patients in all countries, and subjected to all methods of treatment or none (homœopathy, ignored cases, expectant treatment, "mind-cure," etc.) escape the destructive ravages of the disease. It is upon this issue in the immense majority, and not upon the dreaded results in the minority, that the evolution of syphilis in the average of cases is to be predicated. Nothing that is here set down is to be interpreted in denial of the equally palpable fact, that the mildest case of syphilis at the outset may become the severest in the end; that the patient fairly launched in the direction of benignancy may be mischievously turned in a different and more dangerous course; that scientific treatment of the disease furnishes one of the greatest triumphs of human ingenuity and skill. It is here intended merely to look at the results of the evolution of the disease, among all classes of men and in

all countries, from the broadest point of view. The lesson taught, not for the one case but for the many in such a study, is that in this second category of mild relapsing or persistent superficial symptoms, are wholly included the immense number of all cases and of all phenomena of the disease.

3. Malignant syphilis with relapsing or persistent profound symptoms.

A recent French writer has well distinguished between the syphiloma that resolves and that which degenerates. In this third category are included all patients exhibiting gummatous lesions that are either resolved and do not return, but leave serious consequences behind; or that are resolved and return later with serious consequences after either or all outbreaks; or that persist with no less harmful results. Here, too, are variations from the less to the more dangerous grades.

Anyone of these conditions may develop after the patient has exhibited only such lesions as would justify his being classed in the category just considered. But it is highly important to note that all the symptoms here described and catalogued may succeed the chancre stage without intervention of milder symptoms, and also without an important interval of time. Early, indeed, after the chancre has healed, often before this last is completed, there are indications of the evolution of the disease toward a malignant type.

The "malignancy" of this class of cases is seen in the deterioration of the general system and the production of a syphilitic cachexia, without absolute destruction of the tissues of the body. Gummata that never ulcerate or degenerate may form in the skin, subcutaneous tissue, bones, periosteum, periarticular and articular tissues, mammary gland, testis, or other organ. By the production of pain; by displacement or mechanical effects; by a subtle influence that is difficult of analysis on chylopoësis, sanguification, or nutrition, and by interference with other functions, a disastrous influence is exerted that justifies the term malignancy in describing the course of the disease. Its effect is most striking when the structural lesions are few and not in themselves grave. A patient with merely a submaxillary lymphoma or periosteal gumma, or with an obstinate pachymeningitis producing injury by pressure-effects rather than by destructive action, may be in a graver physical state than another with a profound ulcer of the leg or of the throat.

In this category are to be found the smaller number of all cases of syphilis. It is pre-eminently the category of the transitory. They who have suffered from a syphilis trending along these lines, either by force of good management, or as a result of the self-limiting energy of the disease or the reverse of these, are readily transferred to the class just described or that which is considered below.

4. Malignant syphilis with relapsing or persistent and profound lesions that are ultimately destructive.

In this category are classed all those patients who exhibit the worst phases of what is called by the French "tertiarisme," the symptoms which have made the disease to be dreaded as much as any of the pestilences that have visited destruction upon the human family, the histories which have engendered the popular and quasi-professional belief in the non-curability of the disease, those which have led philosophers to wish that the disease were one that kills, rather than one that can so frightfully mutilate without killing.

Here the resolving or disintegrating gumma opens an avenue to ulceration that pierces through connective tissue, cartilage, periosteum, and bone; to resorptive results which, when the gumma has disappeared, leave in its site shrivelled secreting cells, nervous, hepatic, renal, osteoid; that leave the testicle a shrunken miniature of its former self; that leave a sclerotic tissue in the place of brain-cells or spinal cells, whereby one-half of the body loses its motor function, or a portion of the brain its ability to preside over the function of speech. Here, too, remote as are these formidable consequences on the time-schedule of the French school, all are obliged to admit that but a few weeks may intervene between the chancre evolution and the worst ruin. In a few days, while yet the induration of the chancre persists, the hard palate may be perforated as readily as the finger may be pushed through a sheet of wet paper; or a liver may be stuffed with ominous nodules; or the surface of the body ploughed here and there with deep and even gangrenous excavations where a gummatous infiltration has rapidly melted to destruction. It is true that for the most part these grave results occur between the third and fourth years after infection; but the facts of earliest appearance of so called late symptoms in syphilis are by none better attested than by the French themselves. It is they indeed who have coined for science the phrases "malignant precocious syphilides" and those of similar import. It is they who freely admit that the malignancy and precocity are in these cases intimately associated. It may even be asserted as a fact that the majority of all truly malignant manifestations of syphilis are precocious to the extent of violating the old rule of tertiary syphilis as a sequel of an orderly and classically developed secondary stage. It is the characteristic of these dreaded devastations of the malady, that they are early declared and rapidly evolved as extremely formidable types rather than as dangerous complications or perilous sequels of lues. Even with the chancre unhealed, the surface of the body may be in these cases riddled with sloughing cavities. It is also the French, who, confessing that these are the cases inexplicable by their formula, have coined for them the significant and comprehensive appellation, "galloping syphilis."

Between the four main lines of evolution briefly delineated above, there are to be recognized clinically innumerable variations in the direction of both mild and severe symptoms. That these types mutually merge and are to a degree interchangeable by the accidents of environment, constitutional influences, and treatment, cannot be questioned. It is, therefore, important to inquire, what are the determining causes which make the syphilitic attack of one individual so different from that of another that the physician, who is quite qualified to make a diagnosis at sight of the one, so utterly fails in the case of the other that the disease may actually progress for years under his observation without being recognized.

Our ignorance at present of the limitations of existence and of development of the germs whose toxine produces the disease, wraps many of these causes in mystery. But upon some of them one may pronounce with reasonable certainty.

For a certain school of writers the chief difference between these variations in the expression of the disease, is the absence of all treatment, or the several extremes of ignorant, indifferent, or scientific treatment of the disease.

A Study of the Causes Effective in the Production of what is Termed by the French "Tertiarisme;" or the Symptoms Grouped together in the Fourth of the Classes Described above.—One thousand cases of syphilis in private practice were selected for study in the consecutive order of their application for relief. The cases were selected from private rather than from public practice, because it is the patients of this class rather than those who fill our hospitals, who are most anxious when infected to make inquiry as to what the future has in store for them; because theirs are not selected cases, as are those in the hospital wards, where as a rule, on account of lack of accommodation, only the severer forms of the disease are admitted for treatment; and chiefly because private patients, as distinguished from public, furnish us with the fruits of a patient study of the disease after its skilful management, demonstrating its amenability to hygienic measures, the medicinal here often playing a minor part.

Of the one thousand syphilitic patients thus registered, there were 79 affected with tertiary syphilitic manifestations, a percentage of 7.9. Rollet estimates that the proportion in the south of France is five per cent. as a minimum. Diday once thought it to be six per cent., but now considers that that proportion should be doubled. Mauriac believes that the figures should be between five

and fifteen per cent., and more precisely either eight, ten, or twelve.

Of the number applying, sixty-five were males and fourteen females, a disproportion once believed to be due to the decided and remarkable preponderance of nervous symptoms in the male sex. This difference is noted also by others as in large part due to the fact that men are, more often than women, aware of the essential cause of their late symptoms, and apply for relief of the same to physicians supposed to be competent in such matters; as well as to a fact not to be ignored, that the accidents to which men are exposed in the occupations and trades often co-operate effectively with the disease itself in evoking tertiary manifestations. Of the patients whose cases are here tabulated, eleven were treated for both early and late symptoms, but this does not represent exactly the proportion of tertiarisme in the practice of a single individual, seeing that in our large cities so many patients change both their residence and their physician for diverse reasons which do not concern us here.

Of the entire number, six only were profoundly cachectic; and among the latter are found the few patients in the list changing their social conditions, as only Americans manage to do, shifting from the class of hospital and public patients to that of a somewhat higher grade. The average weight of these six cachectic patients was but one hundred and twenty-four pounds; of thirty-four, in fair health otherwise, whose weight was ascertained, the average was one hundred and sixty pounds, a weight, it will be seen, above that of the average hospital patient, and pointing to a fact well recognized by those familiar with the curious features of this disease, that not rarely its grave tertiary manifestations occur in persons of good nutrition and fair vigor. The danger, indeed, of tertiarisme lies in extremes of weight. If it be a portent of mischief to find the infected individual much below the normal weight, it is scarcely less unpromising to find the patient enormously above the weight that belongs to his or her height and age. The fat and the fleshy pay a high price per pound when immunity from tertiarisme is to be purchased.

In 75 cases where was ascertained the length of time after infection before there were evidences of "late" syphilis, the average was five years, two months, and a few days; but if we exclude from the list 9 cases where the disease had been unusually prolonged, lasting, respectively, for ten, ten, twelve, twelve, fourteen, fifteen, sixteen, twenty, and twenty-five years, the average of the remaining 66 cases is but a trifle over three years, falling thus within the average quoted above. In further corroboration of the data of precocity previously suggested, it is interesting to note that no fewer than thirteen patients exhibited their so-called late symptoms within one year after infection, the symptoms being, as usual in all such precocious phenomena, formidable. The average age of the patients in this list was some few months over thirty-four; but if we exclude from the category the ages of eight patients (three women and five men), who were fifty years of age and over, the average of seventy persons, the duration of whose life was ascertained, was but a little over thirty-two; emphasizing thus the fact that we must look for the greater number of all the manifestations of this disease between the second and fourth decades of life. Of 290 cases collated by Haslund, of Copenhagen, nearly one hundred and seventy were those of patients between the twenty-fifth and the thirty-fifth year of life.

An examination of the symptomatology in 96 cases reveals several points of interest. The organs affected were, in 47 cases, the derma, subcutaneous, and adjacent tissues; in 11, the bones and periosteum; in 11, the brain and cord; in 7, the soft and hard palate; in 6, the tongue; in 7, the testes; and in one each, the vulva, the eye, the kidney, the rectum, the muscles, the lungs, and the joints. Fournier, of Paris, reported before the International Congress of Syphilography and Dermatology in Paris, in the year 1889, the fruits of twenty-nine years of private practice in the French capital. In these twenty-nine years he had been able to study 2,600 cases of tertiary syphilis occurring in private patients. Some of his results were in the highest degree confirmatory of the important data of tertiarisme given above. But he also demonstrated that among 3,429 instances of tertiary manifestation, he had tabulated 1,085, or nearly thirty-two per cent. of cases, in which there was some involvement of the brain and cord. Haslund, of Copenhagen, has studied patients treated in the Communal Hospital of his city. Of 514 cases of tertiary syphilis observed by him there, there were 133 of involvement of the nervous and other systems, or a percentage of the latter to the entire number of cases of twenty-five; while the derma was implicated in 290 cases, a percentage to the whole of nearly sixty. Among Americans the statistics of private practice indicate that the nervous system is involved in but a trifle more than thirteen per cent. of all forms of tertiary syphilitic manifestations under observation; while the derma and its connections were implicated in about sixty per cent. of all cases.

The order of importance of the recognized causes of grave syphilis requires careful investigation. Among the accepted and recognized causes of late syphilis, that should be chief upon the list which Neumann names as second, Haslund as the seventh, and other writers on the subject as in places of varying importance. This is the constitutional condition of the patient. For him who aims to be exact and who has the fewest vagaries in diagnosis to answer for, this does not mean in private practice that the patient suffers from that catalogue of glittering generalities commonly summed up as "scrofula, tuberculosis, scorbutus, and rickets." As respects tertiarisme these latter are names and scarcely more. The more tangible conditions of the constitution, chiefly effective in furnishing the field for the display of these lesions, are malnutrition from whatever cause producing a marked decrease in the weight of the subject (note average weight of the cachectic subjects registered above); and also the excessive weight of patients who are more fleshy than the average, a class in private practice decidedly outnumbering the others.

Second only in importance, and often indeed co-operating with the cause already named, may be placed Neumann's third and likewise Haslund's third class of causes, viz., the agencies producing debilitating effects upon the system, including among men alcoholism and excessive tobacco usage. The alcoholism of private practice does not mean that of the habitual drunkard of the pauper class, nor of the day laborer who, once a week or even more often, becomes intoxicated. It means the drinking of men in clubs, of men who go on 'Change, of men who have supplies of this character in their own homes. It means the pallid-faced lad inhaling the fume of his medicated cigarette at the rate of a package daily. All other debilitating agencies (anxiety, affliction, overwork in business or profession), all that engender anæmia, loss of vigor, neurasthenia, are here properly included.

At the foot of the list should be placed that which Neumann sets at the head, and Haslund in both first and second places, viz., complete absence of treatment, insufficient or injudicious treatment, and even intolerance by the patient of mercury. These are effective causes of tertiarisme; when effective at all, we find the results formidable, and even frightful. But they are not necessarily effective. Many patients with no treatment at all, thousands of patients with the very poorest and most ignorantly directed treatment, escape tertiarisme. It is idle to deny it. Hundreds of patients, after the best directed treatment efficiently and thoroughly pursued by the most skilful of experts, have marched down to tertiarisme with steps that admitted of no pause nor arrest. In private practice, as contrasted with public practice, absence of, or defective, treatment possesses a minor significance. There are more men than women suffering from the "late" symptoms of syphilis; yet women are conspicuously those whose syphilis is most often unrecognized, and therefore longest untreated. A cause of this sort, in order to account for the occurrence of a large number of cases, should operate generally; it is impossible to assert this of the different grades of treatment employed over

the world for the relief of the disease. Looking at the immense number of cases subjected to observation in all civilized and uncivilized countries, and making allowance for the very imperfect methods adopted in different countries, and for the absence of efficient treatment in many, it is at once noticeable that as many grave cases are catalogued in London, Paris, New York, and Chicago as among the degraded classes in Italy or Spain, or among the negroes of America, all of whom are little likely to be influenced in their diseases by scientific treatment. As a matter of fact also, in the gravest of galloping cases, as every candid observer must admit, it is idle to assert that there has been time for even the amplest and best-directed treatment to save the patient from malignancy, or for the very poorest or the absence of all medication to be responsible for the grave result. An efficient and demonstrable cause should be best declared when the result is immediate and striking.

Again, it has been surmised by authors of repute that the difference in these cases is explicable by a difference in the activity of the germ, or by a variation in the intensity of the virus. But to this a negative is clearly set up by the citation of innumerable cases where, of several individuals infected from one person, no two exhibit the same degree of virulence in the character of the symptoms induced. The same is shown by confrontations in a series where the individual infected from the gravest types of the disease has mild syphilis, and another contracting the disease from this mildly affected patient pays a heavy forfeit for the occurrence of the accident.

Critically examined, the problem speedily resolves itself into a question concerning chiefly the soil in which the germ is planted, and the favorable or unfavorable conditions under which it develops and fructifies, the first of the efficient factors above enumerated. These are causes which operate equally in all countries and under all skies. Looking at this field critically, we are at once struck with the fact that syphilis here aligns itself with all other diseases that in extreme conditions may destroy the race. Here, as in equally chronic tuberculous processes, in protracted cases of inflammation of lung, kidney, or liver, the debilitated, the exsanguine, and the congenitally weak, suffer more seriously than the men and women of brawn, of blood, and of vigor. Here operate with impressive energy the causes catalogued in the etiological chapter of every work on special diseases—alcoholism, debauchery, pauperism, hospitalism, "misery," in the large sense in which the French use that term, and the wasting effects of all precedent illnesses and injuries. With other diseases, let it be noted in passing, there is small tendency in syphilis to combine. All have noted the smallness of the number of cases in which syphilis has coexisted in one individual with tuberculosis, carcinoma, or sarcoma. One might almost assert that it is with lepra alone that the disease has been in the history of medicine mingled to confusion.

Apart from the causes suggested above, it is well known that very fleshy persons, the aged, and very young, are exceedingly liable to suffer from severe forms of the disease. Young adults of both sexes, neither fleshy nor thin, with good development, fair inherited vigor, and not debilitated by any acquired vices or exposures, commonly escape the serious issues of lues. It is an interesting commentary on the preponderance of causes effective in the production of grave syphilis, that decidedly the simplest cases, as regards the evolution of the malady, are those of persons accidentally infected where knowledge of the nature of the accident is speedily acquired.

It is then, by the operation of the several causes suggested above, rather than by the activity of the acquired virus, that the infected cases range themselves in the categories of evolution briefly described above. In the fourth, which includes the destructive and formidable ravages of the disease, there will always he inscribed the largest number of names of the cachectic, the dissipated, the aged, the impoverished, the filthy, the neglected, and the weak.

This all admitted, it is scarcely necessary to further affirm that there are few triumphs of mind over matter to be compared with the brilliant results obtained in a systematic and skilful treatment of this disease—results sufficient in many cases to determine whether any given subject shall be exchanged from one to another of the several classes here described; or be in fact so slightly infected as scarcely to deserve recognition in any one of the four.

The Relations of the Syphilodermata alike to the Process of Systemic Intoxication and to the Accidents of Environment.—The view was once generally held, and is still largely entertained, that the several eruptions observed in the course of evolution of syphilis are due solely to the constitutional malady. This position, viewed in the light of modern science, is seen to be wholly untenable. The eruptions so minutely described and definitely catalogued in the treatises upon this subject, can, without difficulty, be assigned etiologically to several categories.

In the first are grouped syphilodermata due solely, so far as can be ascertained by our present methods, to the influence of the toxine of the disease. These eruptions constitute probably the smaller number of all with which the physician needs to be familiar. If an infected person of either sex, of average health and weight, could be kept under proper treatment during every moment of the duration of the disease, the body in a perfectly aseptic condition, its functions performed according to a physiological standard without the operation of any unfavorable external influence, it is probable that from first to last the sole eruption visible would be a generalized macular exanthem, after whose fading the skin would present no further morbid efflorescence. What other among the exanthemata of syphilis may be as strictly related to the natural evolution of the disease, it is difficult to decide. Certain it is that this is the sole eruptive feature of many cases; and one may suspect that when others follow, if we were wiser, the accidental cause could be appreciated. Even in this as with some others, we do not find the cutaneous symptoms pointing to an effort on the part of the system to eliminate a peccant humor, but as can be recognized in the circinate grouping of many of the earlier syphilodermata, rather to an irritative condition of the nervous centres as a result of which the eruptive phenomena are awakened.

In a second category are to be recognized a number of syphilodermata due wholly to externally operating causes, the accidents of environment. Many of the pustular eruptions should be here included, where manifestly the pyogenic staphylococci are the efficient factors in the production of the lesions, some of them resulting from inoculation, others from auto-inoculation. It is quite noticeable of the pustular syphilodermata, that they are nowhere seen so abundantly and in such typical expression as among the filthy, the impoverished, and the neglected. They are decidedly among the rarer complications of the evolution of the disease among the cleanly, the well fed, and the comfortably clad. It is further interesting to note that specific treatment so-called, being for the time abandoned, the pustular syphilodermata as a rule respond rapidly to the treatment indicated by the existence of such lesions, viz., bathing, disinfection, antisepsis, proper clothing, and shelter of the body. Some of the pustulo-crustaceous and bullous lesions acknowledge similar causes. It is an error to disassociate syphilis in all cases from the category of the filth diseases. The worst varieties of the malady, without any question, are to be found in the lowest class of patients in the out-departments of Public Charities, both in Vienna, Paris, London, New York, and Chicago, where attacks are daily made upon the unwashed skin by micro-organisms, animal and vegetable parasites, the "Flora Dermatologica" of Unna, and the finger-nails of the wretched sufferers.

In a third class are to be recognized the eruptive phenomena due without question to the operation of an internal cause, but brought into existence, or encouraged, or precipitated, by externally operating accidents. This includes an enormous number of all the syphilodermata, and there are few that may not acknowledge influences of the sort to which attention is here directed.

The mouth of the tobacco-chewer and smoker is often

freed from mucous patches when relieved of the irritation thus aroused; the anus of the infant is no longer surrounded by a group of condylomata when its surface is properly cleansed and disinfected; the palmar plaques of the toiler with material or tool cease to ulcerate and begin to heal when labor is suspended, or the hands, when thus engaged, are protected from injurious contacts.

In a fourth class are to be placed a small number of supposed syphilodermata due to causes operating internally, and to be attributed only in part to the infective process. Here should be described all the medicamentous eruptions due to the iodine compounds properly and improperly administered for relief of the disease, chiefly the acneiform lesions (acne artificialis, acne varioliformis). With these should be enumerated eruptions of the class represented by the pigmentary syphiloderm which refuses to succumb to the action of the remedies commonly effective in syphilis, and which is in reality a pigmentary disorder only very indirectly associated with the toxic condition of the system.

In a fifth class are represented a number of the cutaneous pictures of syphilis due to the commingling of syphilodermata with simpler dermatoses. Chief among these is the combination of syphilis and seborrhœa seen so often about the nose, the brow, and over the scalp of the subjects of the two disorders.

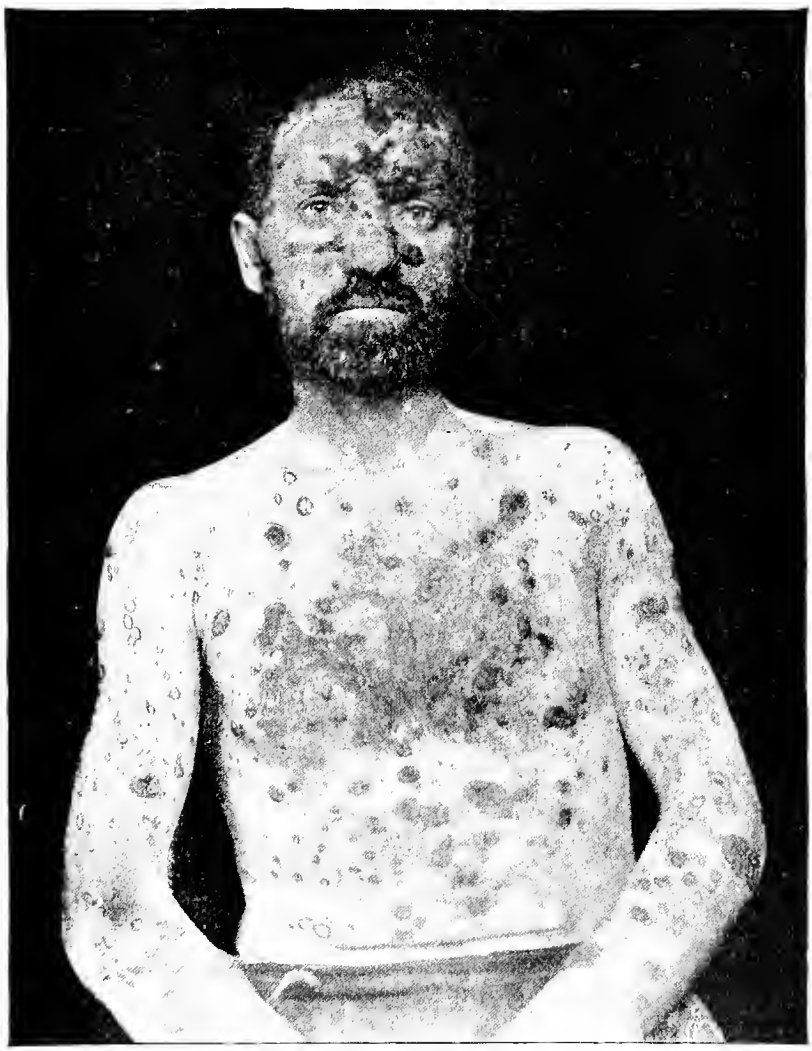


FIG. 597.—Pustulo-crustaceous Syphiloderm as exhibited upon the skin of a neglected and filthy subject of the disease. (Rupia.)

THE BEHAVIOR OF THE SYPHILODERMATA IN THE PRESENCE OF OTHER INFECTIVE PROCESSES.—The knowledge had respecting the relation of syphilis to other diseases, was of the vaguest character prior to the date of an exact appreciation of the etiological importance of micro-organisms in disease. The mutual antagonisms of the latter in several of the infective processes are made apparent in many of the morbid conditions presented in syphilis. Erysipelas may affect the skin which is the seat of syphilodermata, but then the result, far from suggesting a complexus of two disorders with a confused picture of each, is a typical erysipelas having an issue which leaves the skin, after relief of the later infection, free from the lesions first occupying the ground. Similarly, in observation of a series of cases of typhoid fever occurring at the moment of an abundant eruption of syphilodermata of an early type, the cutaneous symptoms wholly disappear with all other traces of syphilis, only to return, usually in milder expression, after the conclusion of weeks or months of illness and protracted convalescence, when the bodily weight is again nearly approaching its normal standard.

VALUE OF THE CICATRICES OF SYPHILIS FROM THE DIAGNOSTIC POINT OF VIEW.—Every physician should be thoroughly familiar with the scars left by syphilis. When perfectly typical, they resemble nothing else in the entire scope of pathology than a relic of the syphilitic process.

First. They are often elegant rather than clumsily wrought. The ulcers of late syphilis are often so formidable and threatening that he who is not expert will not foresee how delicately and beautifully repair will be accomplished and the evidences of mischief smoothed away after the lapse of five, eight, or ten years.

Second. As syphilitic ulcers are commonly rounded in outline, so these peculiar scars are in circles or parts of circles, giving the semi-lunar, quarter-moon, and gibbous outlines, with combinations representing the figure of three, or of eight, the letter "S," the form of the kidney, of the horse-shoe, and of the dumb-bell.

Third. The pigmentation they exhibit is peculiar. It is best studied naturally in the lower extremities, where, as in the cicatrices following traumatism and healed varicose ulcers, the staining from coloring matters brought thither by the blood effused in excess in and about the part, is most conspicuous and persistent.

There is no question but that individual and race peculiarities influence the degree of this staining. It is marked in many deep brunettes; it is rarely as disfiguring in very light blondes. In the scars of syphilis, the color in the cicatrices following freshly healed ulcers, is at first that simply of hyperæmia, dull-reddish, purplish-red, occa-

sionally even pinkish-red. As the infiltration subsides, the color becomes more apparent, till there is every variation from the deepest chocolate to the lightest brown, evenly tinting the scar-tissue and staining, in some cases more than others, the integument beyond the outer wall of the cicatrix, forming a species of pigmented halo, half or a full finger-nail in width, and corresponding in shape to that of the ulcer which preceded, semi-lunar, kidney-shaped, etc.

After a period lasting from a few months to as many years, the process of decolorization begins in these singular-looking stigmata, the difference of time stated depending largely upon the general vigor of the patient, and upon his or her occupation, a prolonged observance of the erect posture, as in wheelmen of vessels and tramdrivers, being unfavorable to rapid removal of these coloring matters.

The entire process of decolorization may be concluded in three or four months, but may require a much longer period. It is rather more rapid in women than in men. A completely decolorized scar of the leg, wholly destitute of undue pigmentation in a male patient of average weight and vigor, commonly points to a syphilitic infection from six to twelve years before, unless the decolorization has been completed and the scar has remained practically unchanged for some time. Then, of course, one can often verify the fact that fifteen, twenty, or twenty-five years have elapsed since the date of infection.

This wholly decolorized scar is perfectly distinct texturally, though suggesting to the scientific eye that can read its past history, that it is faded. It is smooth, unattached, occasionally picked out in points, as though one had treated it with the tool of the engraver or the burin of the etcher. Its color is that of the familiar dead-white of an old scar; but very rarely indeed is it rigid, puckered, or elevated as in spurious or true keloid. Occasionally, even when quite ancient, there is an appearance at one or more points of a thin scale which may be detached from its surface. Its conspicuous features are its delicacy and its thinness. It may be with great readiness plucked up from the tissue beneath, between the thumb and finger. It is best compared with a thin sheet of mica lightly let into the skin. It is very slightly depressed beneath the general level of the integument.

Repair has been so finely wrought in such a case that as one sweeps the fingers over the surface, it can scarcely be recognized by the touch where the new-formed tissue exists; and the movements of the limb may not cause the slightest puckering of the skin where the scar is formed. It answers admirably all the needs of the part, save that it does not furnish in normal measure sweat or other secretion, and but few, if any, hairs appear upon its surface. Few would suspect upon examination of this superficial and at first sight insignificant patch, that it had been once the seat of a deep, exquisitely painful, and even formidable ulcer, boring within to the very lowest stratum of the panniculus adiposus, and causing in some patients more apprehension than a fractured leg or an apicial pneumonia.

There are some variations of this typical portrait which must be studied. Almost every syphilitic cicatrix of the size of the section of an egg or larger, if examined with care, will be found to be made up of a congeries of smaller lesions, each of which is possessed of the characteristics of the larger. The mode of grouping of these smaller scars, each perhaps as large as a thumb-nail, is quite in accordance with the law of the circle suggested above.

Sometimes, rather more rarely than in the other forms to be noticed, a large central lesion is surrounded by a circlet of the smaller, suggesting the familiar arrangement seen in a brooch set with pearls. Again, we have the so-called "satellite" figures, a larger patch with one or two of the smaller set on the edge; or the figure is strikingly like that of a trefoil or quatrefoil slightly distorted from the strict architectural pattern. At times the patch is made up wholly of these small finger-nail sized circlets, compactly gathered within an oval, roundish, or circinate outline, the componnd lesions conforming in every detail to the description attempted above.

Studying these combinations, whether in the figures selected for illustration or in the S-shaped, kidney-shaped, or often variously shaped figures, each component element of the group may be recognized as to age by its separate decolorization process. In a patch of this kind, one may at times see that the process of whitening is going on at nearly the same rate in each scar, all being, for example, at the moment of observation, provided with a tolerably clear or clearing centre, and a reddish or purplish rim outside the latter.

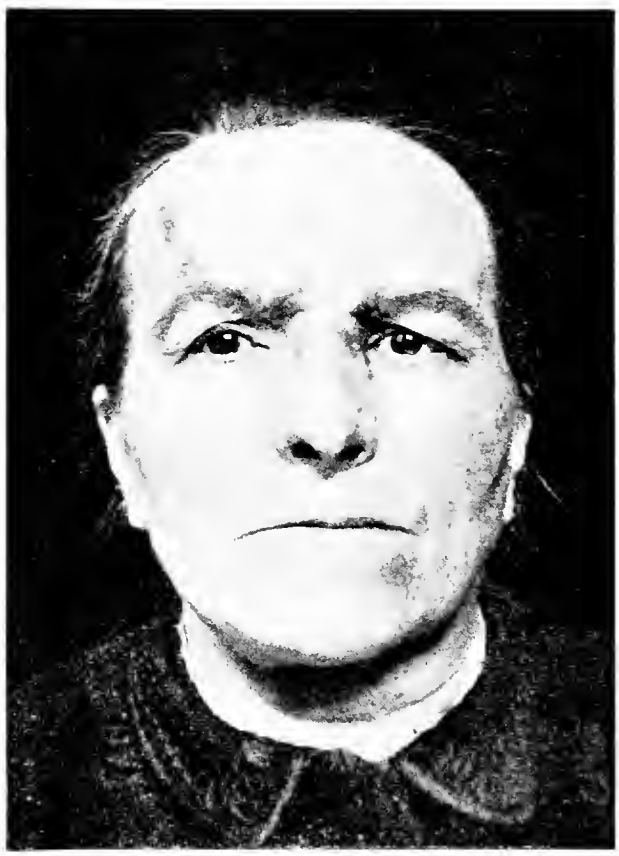


FIG. 598.—Large Compound Cicatrix of the Brow, immediately after healing of syphilitic gummata.

The still highly tinted and not wholly decolorized cicatrices of syphilis are often seen in combination with or in close juxtaposition to the ulcerative or resolutive lesions whose process originally produced them all. Thus in a circinate group a cluster of finger-nail sized scars may form the crescentic border of a patch whose corresponding incurved border is made up of healing ulcers where gummata have softened, each a miniature as to outline of the scar that will succeed.

In other regions than the lower extremities, there are always the same general characteristics with differences due largely to peculiarities of situation. On the upper extremities, for example, scars of the same type occur, with, however, very much less pigmentation, and this latter, when at all conspicuous, is removed in a far shorter time than elsewhere. Thus a group of shallow and depressed, circular, bean-sized scars, a dozen or more in number, may be seen over one or both of the olecranon

processes (a common site) quite destitute of color in six months after their first development; and the same may be said of a large saucer-sized and -shaped patch which may be seen over the point of a shoulder, near the clavicle, in the front of the upper chest, or, not rarely also, over one hip, all favorite sites of this peculiar disfigurement.

It is over the face where the type characteristics are first lost, and where confusion is most apt to arise. The causes are, first, the frequent absence for more than a few months at the most, of pigmentation; second, the configuration of the folds of the skin of the face making irregularities in the surface; and third, the interference with the natural progress of repair often mischievously directed in order to overcome at an early hour the too evident impairment of personal comeliness. The chief variations from type are as follows:

1. The multiple and almost symmetrical small-sized (pea and larger) scars left by resolving or ulcerating tubercles. These are apt to be confounded with the scars of variola, on account of their great number and the absence of the typical features of the scars we have been studying on the lower limbs. They are often no larger than pease or beans, are somewhat symmetrically, at times very irregularly, strewn over the face, and are set into the skin about as deeply as the cicatrices of the same region left by small-pox. But the differences between the two, however close may seem the resemblance, are apparent on careful observation.

The syphilitic scars of this order are seen more often and more abundantly over the upper half of the face; while the variolous relics are more generally and impartially diffused. In syphilis the scars affect the brow preëminently; and after this the temples, the outer nares, and the outer angles of the lips; often the point of the nose and the centre of the upper lip and the entire chin are spared. The marks of small-pox are often conspicuous over these last-named regions, and in well-marked cases are thickly and uniformly spread over the whole countenance, an exceedingly rare occurrence in syphilis.

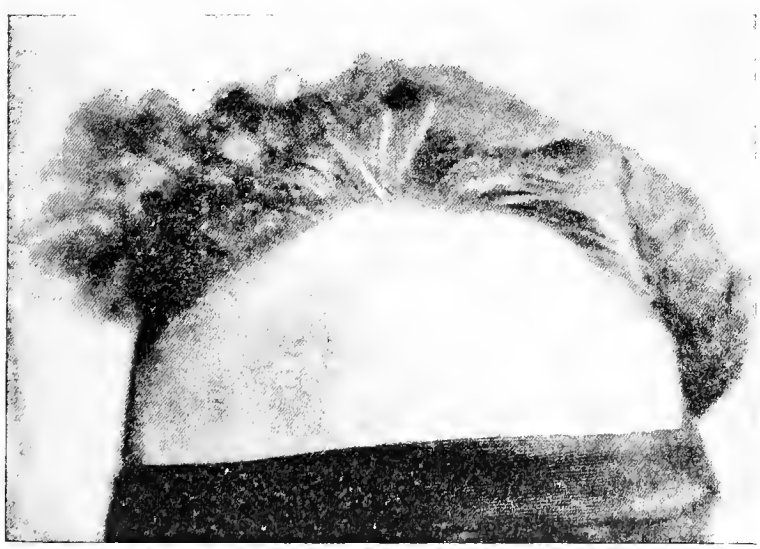


Fig. 599.—Multiple Cicatrices of Syphilitic Tubercles, one year after healing.

2. The single small, or relatively few larger deforming scars of the face, more nearly approaching those of the type studied on the lower extremities. These are illustrated by the crescentic cicatrices occasionally visible a short distance from the angles of the mouth, set into the skin of the cheek, the convexity turned toward the angle of the jaw, the concavity or plane outline next the mouth. These may be half an inch or more in diameter, and when closely studied exhibit the traces of the gummatous ulcer in outline and superficial erosive action. Such scars, too, are not very rarely displayed over the lower brow as if one had taken for a centre the point of exit of the supraorbital nerve from its foramen on one side and swept a semicircle over the brow with a radius of half an inch or more. A smaller scar of this type is formed in some patients in front of the ear, looking something like the outline of a sea-shell, semi-crescentic in contour and not larger than a thumb-nail.

3. And lastly, the wholly irregular scars of the face whose difference in type from all those previously described is due either to traumatism or the influences of special traction in the performance of the functions of the facial organs. Here may be named the strictly linear scars vertically directed along the brow where scratching has occurred or the finger-nail has torn off a crust and with it a portion of the integument directing the ulceration in a peculiar line; this is of the rarer type. Much more common, and much more important for the purposes of diagnosis, are the so-called lines of puckering at the outer angles of the lips. These, when typical in the adult, are not one whit less significant than when seen in the infant affected with inherited disease; and are usually due to the same cause, viz., the occurrence of ulceration as a complication of mucous patches in the muco-cutaneous folds about the angles of the lips. They are always radii from the long axis of the oral cavity, rarely proceed to any distance from the verge of the mouth and present an odd-looking, puckered appearance which persists through life. They are absolutely diagnostic of syphilis, being never seen with characteristic features, and especially when affecting both angles of the mouth, in any other disease.

In this same group may be named the exceedingly irregular small-sized isolated scars of syphilis found upon the face. Such are the jagged single depressions, one or two of which exist in some patients on the sides of the root of the nose, in one cheek or both, or in the region of the beard of the male subject.

The alopecias of late syphilis are all due to cicatricial lesions, or those going on to the production of cicatrices. Here is a distinct recurrence to the type presented in the leg. On examination the scar does not at first sight stand out so conspicuously as upon a non-hairy surface. One has to separate the adjacent hairs in order to gain a view of it. There is the crescentic border, the reddish or purplish hue of the surface not long healed; the deeper purple for a brief time after the healing; then the relatively rapid decolorization; lastly, the dead-white or dull-white scar, with perhaps one or two hairs only growing in the centre of the bald patch, as large as a silver dollar, or the section of a hen's egg. This is the seat and explanation of the remediless alopecia of authors, due to late gummatous involvement of the scalp.

The immense majority of chancres on the progenital region of the male subject leave no scars. The initial sclerosis is usually resolved, leaving no trace behind it of the primitive accident. The majority of cicatrices left in this region as sequels of venereal accidents are those of chancroids, the so-called "soft" or contagious, auto-infective, pustular, and ulcerative lesion of this region.

It is well known, however, that continued irritation of the initial sclerosis of syphilis may cause it to ulcerate so deeply that it will erode the connective tissue of the derma to an extent sufficient to leave a scar. Savin-cerate, caustics frequently applied, and spontaneous gangrene (rare indeed of occurrence) may induce this

erosion. There is, however, one initial sclerosis that is the seat of well-nigh constant irritation till its usually long-deferred healing is completed, and that is the infecting chancre seated immediately within the meatus urinarius. On every emission of the urine its surface is traversed by a fluid highly charged with urinary salts, and the pain in micturition is correspondingly great. The diagnosis of this lesion when in activity is made with the greatest ease without the aid of the endoscope. When the tip of the glans is manipulated by the finger and thumb of the surgeon, the sclerosed mass of the chancre is distinctly felt as though a cylindriform mass no larger than the stem of a common clay pipe and scarcely as long as a digital phalanx had been substituted for the normal urethral channel. The incessant irritation at last produces scarcely so much ulceration as it does a deeply seated erosive action which results in reaming out the meatus urinarius. When all is healed, the apex of the truncated cone, represented by the point of the glans, is seen to be lost. The acorn-shaped body is destitute of its delicately finished tip. It has an obtuse or blunt apex; and the perfect accuracy of adaptation of the lips of the meatus is forever lost. Instead, there is an odd-looking funuel-shaped gap of the mouth of the conduit, with the flaring end of the funnel directed toward the eye of the observer. This, too, is produced only by the syphilitic chancre. The gangrenous or deeply ulcerating chancroid will mutilate the glans in the most lawless manner, remove one-half or more, or even the whole of that organ, in the most irregular way, will gouge out one side or the other and leave the urethral orifice as a chasm where once the frenum stretched its slender arm for the suspension of the scrotum. But almost never will the process cease with the delicate reaming described above. Cicatrices in the groin of one side or both have no significance for the most of cases, as regards the diagnosis of syphilis.

Syphiloma of the Subcutaneous Glands.—(Gummatous involvement of the lymphatics; so-called "tertiary bubo.")

In those periods of syphilis, whether early or late, when gummatous material is deposited in any of the bodily tissues, the subcutaneous glands may suffer. This complication of the disease is far more common than is generally supposed, and when the glands of the neck are involved, presents a condition which is often mistaken for tuberculosis.

The subjects of the disease are not always in what has been termed the "late" stages of the disease. They are often the recently infected, even within a few months of the date of that accident; and as a rule are of the type formerly described as strumous. They are usually individuals of weak constitution, under weight, and poorly nourished, or severely taxed in daily toil. The glands are recognized as round or oval, dense and at times elastic swellings, involving one or a group of several glands ("pleiades," of French writers) which may pursue a gradual course terminating in disintegration, or undergo resorption of the deposit in any stage of development. The glands are at first in a purely irritative condition, thus probably resenting the entrance of either bacilli or toxine of the same in their meshes; later, there is well-marked cell proliferation with degeneration of the central pulp of the gland, pus formation, and exit of the same, either spontaneously or by means of surgical interference: in other subjects caseation results, the cell proliferation decreases *pari passu* with increase of the intercellular tissue, and fatty metamorphosis eventually takes place.

The glands most frequently involved are, first, those of the neck (submaxillary, infraclavicular); next, those of the inguinal regions; lastly, the axillary, cubital, and popliteal.

The tumors vary in size from small nuts to large eggs, are both painful and tender; and soften when about to break down at or about the central point of the mass. They are exceedingly indolent, and even when converted into an abscess have little or no tendency to burst, but retain for weeks at a time, even longer, their pulpy and ill-conditioned contents. They are at first covered by a movable and normally colored integument; later, this becomes dark-hued and livid. When spontaneously bursting the rent of the gland-capsule reveals a discolored grayish-yellow or darker admixture of thin pus and detritus of tissue, a healthy looking wound being produced after scraping, which in well-managed cases proceeds without delay to repair. The scars left in either event strongly resemble those resulting from the similar process in tuberculous involvement of the lymphatic glands.

Actinomycosis should always be differentiated by the aid of the microscope; tuberculosis, if not by the same means, at least by the relative rapidity of evolution of the process, for though at times a few months are required for the entire career of the syphilitic lesion, the tuberculous are even slower of career and soften centrally only after long delay. The lymphoma of syphilis rarely requires a twelvemonth for its completed curriculum. Carcinoma of the regions named is exceedingly rare; sarcoma even more rare of occurrence.

Gummata of the Lung.—Smaller and larger gummata, when of occurrence in the lung, are encircled by peripherally distributed connective tissue with clearly defined limits. The result, as regards the lung-tissue, is, according to Councilman, a pneumonia with fibrinous exudation, accompanied by fibrous thickening of the alveolar walls, the whole undergoing caseation. Where the action of the virus is intense, necrosis of tissue occurs before there is time for the development of the protecting connective tissue.

The analogy between tuberculosis and syphilis of the lung is shown by the fact that in both processes a caseous pneumonia results; but in the former instance the inflammatory process is the direct result of the presence and irritative effects of tubercle bacilli; in the latter, the primary process is an atrophy of the alveolar walls, most probably due to a hyaline degeneration of the capillaries.

The diagnostic differences, as given by Delafield, are, in syphilitic disease of the lung, dyspnœa on inspiration; a varying degree of supra- and infra-clavicular retraction; on percussion, marked dulness over the affected parts; on auscultation, prolonged and high-pitched respiratory murmur, with a pause between it and a prolonged and almost equally high-pitched expiratory murmur. Sibilant, sonorous, crepitant, and subcrepitant râles are often wanting; vocal fremitus on coughing is increased.

The more lately devised methods of treatment in syphilis have not yet supplanted the older and approved devices, nor do they contain the promise of so doing. Tommasoli has employed intramuscular injections of a fluid obtained by keeping the blood of lambs for twenty-four hours on ice, separating thus the serum. From two to eight cubic centimetres of the latter are injected for a dozen or more times. The lesions of syphilis are reported to have rapidly and permanently disappeared under this treatment; and the reactive effects from these injections were in no case severe.

Wellander, of Stockholm, has employed for injections a mixture of the acetate of thymol-mercury, one and one-half grain in liquid paraffin, injected every fourth day till six or seven injections have been made. Indurations and abscesses at the site of the operation were minimized in number and severity; the reactionary effects were reported mild, and the symptoms of the disease yielded with varying but satisfactory promptness, some relapses occurring.

The other mercurial salts lately employed beside hydrargyrum thymolicum (thymoloaceticum) are salicylicum succinimidicum, alaninicum benzoatum, oxycyanatum, formamidatum. The basis employed by Schadek is an emulsion of gum arabic. The oxycyanide is used in injections of one quarter of one per cent. The benzoate is employed in solution as follows:

Hydrarg. benzoat.....	0.30
Sod. chlorid.....	0.10
Aq. destillat.....	40.

The succinimidicum is used also in one per cent. solutions.

Moncorvo and Ferreira report the treatment of a large

number of young children affected with syphilis by hypodermatic injection, preferring the corrosive sublimate for this purpose. The doses were exceedingly well tolerated by the children, who exhibited but little tendency to the after occurrence of stomatitis, salivation, or intestinal colic. *James Nevins Hyde.*

TASTE, DEVELOPMENT OF THE ORGANS OF.

The development of the organs of taste in the mammalia has been studied in the rabbit and in man. According to Hermann, the development of the gustatory papillæ in the rabbit takes place during the latter period of embryonic life, and in the first few days following birth. In a rabbit embryo 54 mm. long this observer was able to distinguish, with the unaided eye, the circumvallate and foliate papillæ, but the trenches of the former and the furrows of the latter were wanting (Fig. 600). The papillæ are developed from simple proliferations of the epithelium, which penetrate the mucosa at various points. From these proliferations arise secondary shoots or processes which ultimately form the lateral lamellæ of the papilla foliata. The primary epithelial ingrowths may be seen in rabbit embryos of 54 mm. in length (*i.e.*, of twenty-three days and upward). The secondary processes, on the other hand, which arise from these, do not appear till a day later, and at birth the lateral lamellæ which are formed from them are still incomplete. The complete differentiation of the circumvallate papillæ and the folds of the papillæ foliatæ, is for the most part accomplished by the end of the first week of life. The serous glands, so intimately connected with the organs of taste, are formed about the same time as the gustatory papillæ. The primary epithelial ingrowths penetrate still more deeply the mucosa and submucosa, and, probably through atrophy of the axial cells, are converted into ducts from which radiate smaller ones to form the acini.

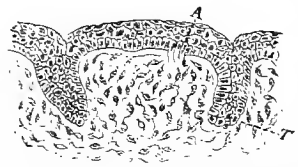


FIG. 600.—Vertical Section through the Circumvallate Papilla of a Rabbit Embryo 54 mm. long. (After Hermann.) *A*, early stage in the development of a taste-bulb. The trench (*T*) is undifferentiated.

In rabbit embryos 54 mm. in length, taste-bulbs in the first stages of formation are perceptible in the basal layer of epithelium of the free surface of the circumvallate papillæ (Fig. 600. *A*). In embryo rabbits 70 mm. long the bulbs of this area are fully developed and numerous (Fig. 601, *T.B*). In the secondary lamellæ of the foliate organs and lateral wall of the circumvallate papillæ of embryos 95 mm. long the forerunners of the definite bulbs are perceptible in the groups of modified basal cells of the epithelium. In embryos of a still later period these fusiform cells traverse the entire thickness of the epithelial investment of the papilla. At birth a few of the bulbs have matured, and by the sixth day of life their development is completed. The development of the bulbs of both gustatory areas is not fully completed till the beginning of the third week after birth, when they are no longer distinguishable from those of the full-grown animal. With the appearance of the bulbs of the lateral area those of the free surface (having attained their completion during intra-uterine life) undergo degeneration, and by the third day there is scarcely a vestige of them remaining.

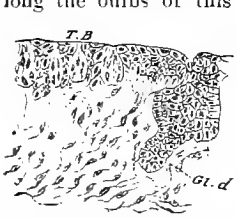


FIG. 601.—Vertical Section through a Portion of the Circumvallate Papilla of a Rabbit Embryo 70 mm. long. (After Hermann.) *T.B*, taste-bulbs of the free surface: *Gl.d*, developing gland-duct.

In man the gustatory papillæ begin to develop early in the third month of intra-uterine life, while the filiform papillæ do not appear till a week or two later. The first indications of taste-bulbs are seen at the end of the third and beginning of the fourth month of fœtal life. The bulbs develop simultaneously or nearly so at the upper part of the circumvallate and fungiform papillæ, but they have not been observed in the lateral organs of taste till a somewhat later period. The hinder portion of the dorsal surface of the tongue of a human embryo early in the fourth month is more or less marked by papillary elevations of the mucous membrane. The elevations vary greatly in size and shape, and the spaces between them are filled for the most part with epithelium. The epithelium covering the elevations averages in thickness about 0.020 mm., and does not differ very greatly in character from that investing the lingual papillæ of later embryos. It is composed of three rather indistinct layers. The superficial layer consists of somewhat flattened cells, which at its deepest part become blended with those of the middle layer. The middle layer is much thicker than the preceding, and is composed of cells spheroidal or polyhedral in form with prominent nuclei. Below this is a deep layer consisting usually of a single row of elongated, but not invariably true, columnar cells. The mucosa beneath the basal epithelium of the papilla is quite homogeneous in appearance, and very rich in nuclei and delicate fibrils. In the stroma of the submucosa, which is somewhat looser in texture than that of the mucosa, are scattered here and there minute bundles of striped muscle-fibres; but their transverse striæ are exceedingly faint and require a high power to define them. The stroma, both of the mucosa and submucosa, is penetrated quite deeply at different points by the proliferations of the inpushing epithelium. These proliferations of the epithelium indicate the future position of the mucous and serous glands and their ducts, the incipient stages in the development of which are at this period already perceptible. The process of development of the papillæ is similar in the main to that already described in the rabbit. Chains of epithelial cells penetrate the mucosa at intervals, and form the walls of the papillæ. The cells composing the middle layer of the chains gradually undergo atrophy, and thus give rise to the trenches of the circumvallate papillæ and the furrows of the foliate organs. Here and there also in the basal epithelium and underlying connective tissue of the papillæ the taste-bulbs are beginning to form. By the middle of the fourth month a few papillæ of the circumvallate type in the early stages of development are present at the basal portion of the dorsum. The more advanced of these measure 0.11 mm. transversely, and are 0.096 mm. in height. Their upper surface is flattened or slightly convex, and they project but slightly from the adjacent lingual area. The trenches are not yet differentiated, although their future position is in most instances clearly indicated (Fig. 602). Fungiform papillæ in various stages of growth are scattered irregularly over the dorsum, and the lateral gustatory organs (the papillæ

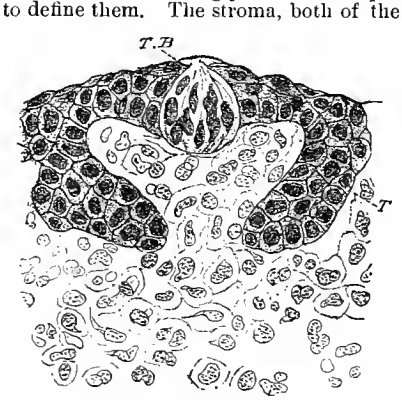


FIG. 602.—Vertical Section through the Circumvallate Papilla of a Human Embryo of the Fourth Month. (× 300.) The papilla bears a single taste-bulb (*T.B.*) the base of which rests in a depression of the mucosa. The trench (*T.*) is undifferentiated.

foliatæ) are clearly recognizable in the irregular elevations of the mucous membrane at the sides of the base of the tongue. Both the circumvallate and fungiform papillæ bear isolated embryonic taste-bulbs in early stages of development. The more advanced of these measure 0.016 mm. in length and 0.012 mm. in breadth, and lie vertically in the axis of the papilla, with their basal portion resting in a cavity of the mucosa. In general appearance the bulbs of this period are not unlike those of the soft palate and epiglottis, which probably develop later. The bulb shown in Fig. 602 is of this period. The superficial layer of epithelium having become detached, allows the bulb to project slightly above the surface of the papilla.

At the end of the fourth month the papillæ have increased in number, but there are no trenches and but a slight increase in the number of embryonic bulbs. By the middle of the fifth month the circumvallate papillæ have increased to six, and others can be seen in process of development. The trenches are not yet differentiated, the structural continuity between the epithelium of the free area of the papillæ and that investing the general lingual surface being still unbroken. The foliate organs consist of a few folds of the mucous membrane, the place of the future sulci being indicated by the epithelial ingrowths, which at irregular intervals penetrate the mucosa. The serous glands have advanced somewhat, and here and there are beginning to take definite shape. The majority of the circumvallate papillæ, and also many of the fungiform papillæ, bear embryonic bulbs on their exposed area (Fig. 603 *T. B.*). Of these, the more advanced are mainly epithelial in position, while the less mature are largely embedded in the stroma of the mucosa. Medullated nerves are fairly shown in these papillæ. Directly beneath the basal cells of the epithelium is a fine, delicate, reticulated network, from which non-medullated nerve-fibrils pass upward, penetrating the bulbs and neighboring epithelium.

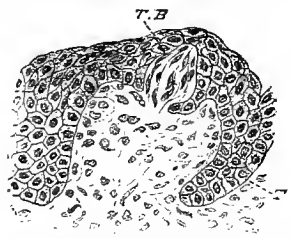


Fig. 603.—Vertical Section through the Circumvallate Papilla of a Fœtus Four and a Half Months Old. (× 310.) *T. B*, taste-bulb; *T*, trench, undifferentiated.

By the end of the sixth month all of the circumvallate papillæ are present, some of them, however, being much more advanced than others. The papillary wall and the outer wall of the trench have for the most part separated, leaving a very narrow fissure. Bulbs are beginning to develop on the lateral area of the papillæ, and are still abundant on their upper surface. In the foliate organs the furrows at their upper part are quite free from epithelium, and bulbs, partly sub-epithelial in character, are present at the upper portion and sides of the folds. At the seventh month, in some instances, the trenches and furrows contain epithelial débris, vestiges of which remain till after birth. The bulbs have increased greatly in number on the lateral area of the papillæ, and have not decreased apparently on their upper surface (Figs. 604 and 605). Many of them lie partly in the mucosa, and the ultimate nerve-fibrils, which constitute their sensory elements, can be seen within the epithelial shell where the cells of the latter have been but partially reflected over them, or where the imbrication is still incomplete. Small, spheroidal, rudimentary bulbs, deeply embedded, may also be found at this period on the anterior and posterior surface of the epiglottis, and in the epithelium of the soft palate and uvula.

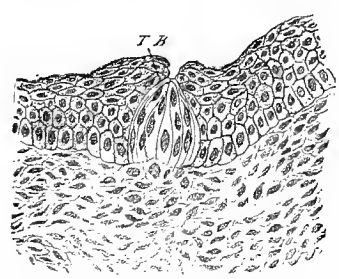


Fig. 604.—Vertical Section through a Portion of the Circumvallate Papilla of a Fœtus of the Seventh Month, showing One of the Bulbs of the Free Surface. The base of the bulb is concealed in the mucosa. (× 280.)

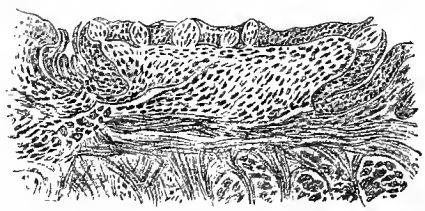


Fig. 605.—Vertical Section through the Circumvallate Papilla of a Fœtus of the Seventh Month, showing the Bulbs of the Free Surface. (× 85.)

By the end of the first month of life all of the circumvallate papillæ are completely differentiated, and their expanded summits are subdivided into many secondary papillæ. The serous glands are also developed, and their ducts open at the usual places. The bulbs have increased in number, and are quite uniformly disposed at the sides of the papillæ; those of the lower tiers, however, are less regular in arrangement and smaller, and lie partly in the mucosa. There is a marked decrease in the bulbs of the free upper surface, though for several months after birth isolated ones still occur there. In the circumvallate papillæ of the adult the bulbs do not appear to have decreased in number on the lateral area, but they have disappeared almost completely from the upper surface. In the adult foliate papillæ bulbs are far less numerous than in early life, and occasionally are wholly wanting. They still occur on the upper area as well as at the sides of the folds.

The bulbs of the circumvallate papillæ always make their appearance first at the upper part of the papilla, the more advanced among them being epithelial in position, while the less mature are to a greater or less extent embedded in the stroma of the mucosa. After the sixth month of fœtal life, the trenches are more or less differentiated, and bulbs begin to appear on the lateral area. In the new-born child and until the fourth month of life isolated bulbs are still present on the upper area of the papilla; at a later period they occur but rarely there. What purpose the temporary taste-bulbs (for such they appear to be) of the free upper surface of the circumvallate papillæ subserve in the embryo is difficult to comprehend. With the appearance of the bulbs of the lateral area they gradually disappear, and, from all indications, perish. By the time the bulbs of the free surface of the papillæ have attained their full development, bulbs in early stages of formation make their appearance on the wall, the lowermost ones being the most elementary. In the present state of our knowledge, there seems to be no better way than to accept Hoffman's hypothesis, that "the bulbs of the free surface perish through the proliferations of the ordinary epithelium." It is not improbable that, after the bulbs have once disappeared from the upper surface, certain altered conditions of the epithelium prevent, save in rare instances, their recurrence there.

From a study of the gustatory papillæ of different embryos it appears that the nerve-fibrils given off from the network beneath the epithelium of the bulb-region of the papilla terminate either as specialized end-organs of taste, or penetrate the epithelium, to all appearances unchanged. The first signs of the future bulbs are to be seen in the basal layer of epithelium and underlying tissue. The ultimate nerve-fibrils which are to constitute the future sensory terminal element, form themselves into loose fasciculi of delicate filaments, the latter becoming more or less modified before penetrating the epithelium. While these changes are taking place in the mucosa there is an increased activity manifested by the contiguous basal cells of the epithelium. These become swollen and elongated, and gradually apply themselves

to and enclose the newly formed terminal structures, of which they constitute the supporting elements.

Griffini's quite recent researches on the regeneration of the gustatory papillæ and taste-bulbs in the rabbit and dog are of especial interest in this connection. From his experiments it appears that after incision of a foliate papilla of the rabbit, the area corresponding to the

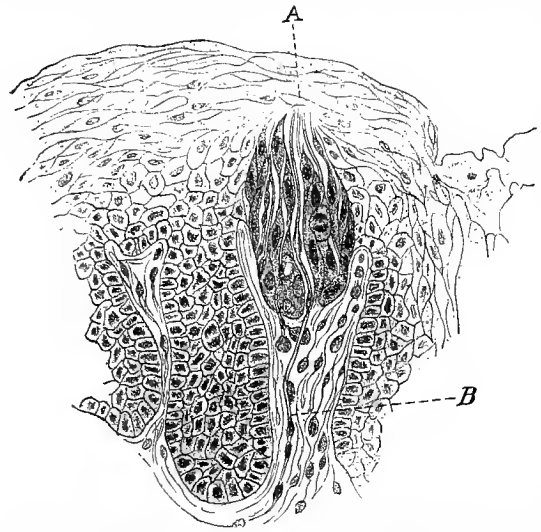


FIG. 606.—Vertical Section through One of the Newly formed Mound-like Papillæ of the Foliate Region in the Rabbit, Fifty Days after the Complete Removal of the Foliate Organ. (Reduced from Griffini; ×300.) *A*, taste-bulb in process of development. *B*, nerve-fibril with many nuclei.

part removed is shortly reinvested with pavement epithelium. Later, from the sixteenth to the twentieth day, a few small hemispherical elevations make their appearance, and these subsequently increase in size and number. During this period, also, many of the injured gland-ducts undergo repair, and communicate with the free surface of the epithelium. Within the secondary papillary processes of the elevations above referred to, taste-bulbs, lying partly in the mucosa and in process of formation, first make their appearance (Figs. 606, *A*, and 607, *T.B.*). Ten days after the complete excision of a circumvallate papilla of the dog, the area of removal is reclothed with epithelium, and the ducts communicate with the free surface. Twenty to thirty days later a slight, and more or less rounded elevation of the mucosa is discernible, analogous to the newly-formed mounds of the foliate organ. The outer enclosing wall of the trench is not regenerated, the newly-formed papilla having the characters of the fungiform type. At the fortieth day (in a single instance only) a few bulbs, situated at the lateral margin of the new papilla, were seen. Following section of the glosso-pharyngeals, the papillæ are changed but slightly, but the bulbs begin to degenerate within twenty-three hours. The taste-cells are first destroyed, disappearing completely by the fifth day; the supporting cells soon after undergo atrophy, and by the twenty-eighth day no bulbs are visible. At the seventy-sixth day after the division of the nerves, bulbs in various stages of formation were observed; but by the two hundred and ninth day their development was still incomplete.

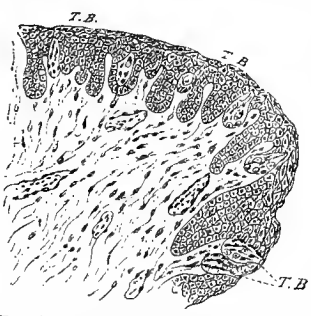


FIG. 607.—Vertical Section through One of the Newly formed, Mound-like Papillæ of the Foliate Region in the Rabbit, Ninety Days after the Complete Removal of the Foliate Organ. (Reduced from Griffini; × 100.) *T.B.*, taste-bulbs in more advanced stages of development.

All of the Mammalia, as far as known, possess gustatory organs. The most primitive form of these structures may be seen in the highly ancestral *Ornithorhynchus*. At the posterior region of the tongue of this animal are two pairs of gustatory areas. The anterior pair lie below the surface in a furrow, the floor of which is invaginated upward into a ridge. The ridges of the posterior pair reach the surface. The ridges of both areas bear taste-bulbs over their entire convexity, and the ducts of serous glands open into the spaces round them. The centre of the ridges is nearly filled by non-medullated nerve-fibres, which radiate outward to end in the bulbs, the latter being developed at the end of long papillary processes. In some of the Marsupialia, notably in *Halmaturus*, *Macropus*, *Petrogale*, and *Dasyurne*, the circumvallate papillæ might very justly be termed gustatory ridges, from their general shape and concealed position. In the arrangement of the bulbs they also resemble quite closely the ridges of *Ornithorhynchus*. In other genera, as *Phalangista*, *Belideus*, *Acrobates*, *Bettongia*, *Phascolaretos*, and *Didelphys*, the posterior papilla follows more closely the type characteristic of higher mammals, while the anterior pair possess structural characters that are common to both the circumvallate type of taste area, and the primitive bulb-bearing ridge. In *Phascolomye*, *Perameles*, and some species of *Didelphys*, all three papillæ follow closely the type common to higher animals. The circumvallate papillæ develop quite independently, and are not, as maintained by some observers, modified fungiform papillæ. In some of the higher forms, however (*e.g.*, in some of the Cervidæ and Bovidæ), it is highly probable that the number of circumvallate papillæ may be increased by direct development from the fungiform type.

In the bandicoots, kangaroos, and phalangers of Australia, the lateral gustatory organs (papillæ foliatæ) may be studied in their simplest form. In *Halmaturus*, according to Poulton, the organ consists of a row of gland-ducts, in the walls of which scattered bulbs are developed. In *Macropus*, *Petrogale*, *Dasyurus*, and *Phascolaretos* the organ is more advanced, the ducts opening at the bottom of depressions. In *Perameles*, it consists apparently of a single epithelial-lined furrow, in the walls of which are several tiers of bulbs. In *Phalangista*, *Belideus*, *Acrobates*, and *Didelphys*, the organs are less simple in structure, and the ducts open at the bottom of the furrows, as in the higher mammals. Between the complex lateral gustatory organs of rodents (in which there is but little to suggest its true origin) and these simple types there are many intermediate stages.

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Frederick Tuckerman.

TELLURATES. The tellurate of potassium and the tellurate of sodium are recommended as remedies for the profuse sweatings due to phthisis and other causes. They are given in doses of one-third to one-half grain daily. In some cases this quantity requires to be increased, but generally the second or third dose is followed by a cessation of the sweating. It produces no evident effect on the system and the disease is in no way influenced. It is supposed to produce its effect by an inhibitory action on the nerves of the sweat-glands. In some cases it causes a loss of appetite and nausea, and in some advanced cases the sodium salt has produced a profuse liquid diarrhœa which is very difficult to check. The most serious obstacle to its general use is the persistent garlicky smell which it communicates to the breath and to the perspiration. It is noticed after the second or third dose, but is not very evident to the patient; to the friends, however, it is very objectionable. The salts are generally given at night in the form of pill or in an alcoholic julep. *Beaumont Small.*

TERATOLOGY: A RARE CASE OF HETEROPAGIAN MONSTER. The birth of a well-developed child upon whose anterior surface at the lower portion of the sternum is appended an immatured fœtus, in the vicinage of the umbilicus, constitutes a rare class of monsters to the history of which the attention of the reader is specially invited in this article.

The inert, insensitive, motionless, undeveloped, and deformed fœtus, sustaining a simple vegetative life at the expense of its perfectly matured, self-supporting twin, is a product so dependent upon the active vitality and healthful condition of the latter that, ever since Burdach first called attention to the subject, it has been recognized as a veritable parasite. These parasitic growths present types of configuration so different by contrast with the symmetrical and normal development of the self-supporting twin, or autosite, as this latter has been termed, that Geoffroy Saint Hilaire gave the name of Heterotypia to the entire class, a term derived from the Greek, *ἕτερος*, and *τυπος*, pattern or plan of development.

Grouping together the varieties presented in the sequence of frequency and of asymmetrical conformation, Saint Hilaire arranged these defective products into three orders, to which he gave names that, in their derivative significations, do not appear to have been happily chosen, viz., Hetero'pagus, Heteradel'phus, and Heterod'ymus.

When, for example, the accessory subject consists of only a head and neck, perhaps of a partially developed thoracic limb or two, it constitutes the species which Geoffroy Saint Hilaire designated as his first class of Heterodymus.

If the subject consist of a small, imperfect, accessory appendage, representing an ill-defined pelvis with abortive pelvic limbs, but without head, thorax, or upper extremities, this he called a Heteradelphus.

Now, when the accessory subject presents an imperfectly evolved head and body, an abortive pelvis with rudimentary limbs, both pelvic and thoracic, this exceedingly rare species obtains the name of Heteropagus.

The parasitism of such abortive products is apparent, and their existence as growths, or tumor-like excrescences from the body of a perfect twin would naturally associate them in forming a class of peculiar malformations united by this common recognizable character of *parasitism*. These rudimentary outgrowths of greater or lesser development, and their inconstant attachments to any part of the body of the supporting twin, seem scarcely to justify attempts at a complete classification of all the possible complexities that may occur, so that the writer is inclined to ignore any special effort in this direction which some have endeavored to accomplish. It is sufficient to recognize in such eccentric anomalies the fusion at any region of the autosite's body of abortive developments of any portion of a vertebral axis, or of the dependencies thereof, in the imperfect form of thoracic or pelvic limbs attached to the anterior surface of the perfect child, without separately describing these as so many distinct and invariable conditions of separate varieties of a special class of monsters. It is far more profitable, perhaps, to consider the physiological principles of embryogenesis that may explain such aberrations of development, and to search for the governing influence of that autonomy of cell-genesis which in all these varied and apparent caprices of evolution is found never to infringe the *lex proprietatis* or the *lex topicorum*. Under each of these organogenetic laws it is indeed instructive and significant to note that we never discover dissimilar organs fused indiscriminately into one another unless in their embryonal condition they once pertained to the same blastodermic layer. For example, the liver is never found confluent with the heart, nor shall we ever see the brachial artery anastomosing with the median nerve, because the visceral, organic or hypoblastic layer evolves the one, while the mesoblast and epiblast produce the other of these several organs; such is the observance of the *lex proprietatis*. Again, the conjunction of regional parts always is an instructive illustration of individuality in the life-history of the cell; like cells producing like parts in their proper localities, so that similar parts become always blended with similar parts—thorax with thorax, pelvis with pelvis. Thus, never does the cranium of one monster become united with the pelvis of the other; while the inherent power of the cell to beget its kind always evolves the determinate tissue, structure, organ, or part in its proper locality, wholly independent of any influence or impulse growing out of some centralized emporium of developmental cell force. Thus it is that peripheral distributions of nerves may exist through portions of a parasite's body in which there is present neither spinal cord nor brain, perhaps scarcely an indication of a vertebral axis; and here again we have a perfect fulfilment of the *lex topicorum*.

Classification, if attempted at all in the science of teratology, must rest upon a natural arrangement based upon the laws of morphology and embryology, or we run into an artificial classification of no scientific value. Indeed, complicated irregularities in organic development formed in earlier times an incongruous assemblage of unmeaning events that were indiscriminately recorded without the vaguest conception of an embryological perspective. Anomalies transmitted to us by the graphic pen of illustrious names in science, with accuracy of description and wealth of anatomical details, were marred by the deception of imagination in attempts to explain the multifarious morphological defections in the general drift of endless complexities. No recognition existed in those days of an order of succession in the phases of development that foreshadowed unity in the plan of organization and resolved deflections in structure into one fundamental law. No basis existed then upon which to rest a scientific hypothesis that could reasonably account for eccentricities of development; these, therefore, were frequently referred to some catastrophic revolution in the order of nature. However ingenious may have been the arrangement, through similarity of external appearances, for classification, yet no interpretation could be offered for such deformities, no rule devised for their affiliation, as they were simply regarded as freaks of nature.

The ignorance that prevailed as to the origin of the human embryo, and the consequent non-existence of such a science as organogeny, deprived the teratologist of the means of bringing these abnormalities together into affiliated groups expressive of stages of progressive evolution, and all efforts at their systematic arrangement into orders, genera, and species were left to the arbitrary influences of preconceived opinions.

Little more than sixty years ago, von Baer discovered in the Graafian follicle a protoplasmic element within which the subsequent detection of a germinal vesicle, by Coste, revealed that this bit of microscopic protoplasm was identical with the egg of all animals; that it was in reality the human ovule or germ, holding the unseen mystery of life within itself. This great discovery of the nineteenth century inaugurated the science of embryology and opened a field of inquiry into the fascinating and marvellous researches of embryonal development. The study of embryogenesis and organogeny

detects the law of ontogenetic development, unfolds the archetypal plan of structure, interprets homologies in the vegetative repetition of parts, and thus explains every possible anomaly, whether dependent upon excess or arrest, constructive or destructive development, asymmetrical aberration in the process of bilateral evolution, or deviations in synthetic or diplogenetic malformations. With this science of embryology as the key opening to view what hitherto have been mysteries of teratology, we now are able to relegate to the limbo of traditional demonry and mediæval vagaries the theories that have so long dogmatized upon the subject.

Conversant as we now are with the primordial tracings of the marvellous operations of cell-work within the limits of the germinative area—that title-page of embryonal life—we now can read in the caudal or cephalic cleavage of the primitive streak (*nota primitiva*), or in the yet more complete dichotomy of the neural axis within the blastoderm and vitellus of a single ovum, every form of teratologic manifestation. Interrogating these operations as they occur within this primitive notochord, how indispensable becomes the knowledge of the general homologies growing out of this engaging inquiry, in apprehending intelligently the meaning of parts and interpreting the signification of abnormal anatomy. How readily do we discern those duplicative developments that severally occur amid the *teratа katadidyma* and *anadidyma*, where this primitive streak divides above or below at its cephalic or caudal pole and thereby generates a dicephalus or a dipygus through extreme vegetative polaric growth at either or both ends of the neural axis; producing two heads to one body or one body with two distinct pelves with or without their respective limbs. But again, should a complete longitudinal division cleave the axis into parallel halves, whose formative changes should progress through the serial homologies of two perfect vertebral columns in axial relation to each other, then two organisms would become fused into two more or less symmetrically formed individuals presenting the maximum type of a diplogenetic monstrosity. This, too, would be accomplished not by any deviation or abrogation of the laws of natural evolution, but strictly in conformity with the order and rule and sequence of embryonal formation; and dependent as these organisms would be upon a common vitellus as the proper pabulum sustaining them through their ovular stage of progress, they will become necessarily blended at some contiguous point on the common route toward an ovo-uterine attachment established finally through one common umbilicus. With such a placental prospective the union between such future beings would necessarily be of variable extent; confined alone to the xiphoid appendix or entire sternum or gastric region they would constitute respectively such anomalies as are termed xiphopagus, sternopagus, gastropagus, as the case might be. As monomphalic monsters united, therefore, by their anterior surfaces, and more or less vitally interdependent through organic connections of essential import (that is, an umbilical cord), they would belong to one generic class known as omphalopagus.

Without any great tax upon the imaginative faculty every variety of abnormality reaching out on this line of development, finds its ready explanation.

Pursuing no further than we have done these principles of embryology as elucidating the pathogenesis of development, we shall now discuss that phase of duplex formation which it is the object of this article to explain, and which the reader is prepared to understand.

To appreciate the extreme rarity of this specimen of a heteropagus, or indeed of any of the class of parasite monsters, we must recall the fact that plural births are of themselves very rare. We are told that at the Maternity Hospital in Paris, Madame Lachapelle met with only 444 cases of twins among 40,000 births, which gives but about one twin case to every one hundred deliveries. If this be the ratio of plural births, then how exceedingly rare must be conjoined twins of the diplogenetic order, the most common of all forms of monstrosities? But a monstrosity of any kind is exceptionally of rare occurrence. Unitary monsters do not occur perhaps but thirty times annually among the 30,000,000 births throughout the world.*

Compound monsters are even less frequently met with, while the still more remarkable modification of conjoined twins resulting in the production of a parasite monster becomes so extraordinarily infrequent that but few examples are to be found in the annals of our science, and of these very few the particular instance of a heteropagus such as we here shall describe, is yet more specially rare.

It was in July, 1875, that a summons to Millet Station, on the Port Royal Railroad, afforded an opportunity of examining a monstrosity of the sternepigastropagus parasiticus variety, which is here faithfully represented in different positions in the accompanying figures. Sarah Crittenden Jones, a negro woman, thirty years of age, mother of eight children, had given birth, on June 29, 1875, at Robin's Depot, Barnwell County, in South Carolina, to a well-developed female infant at full term. The uneventful delivery of this child in a natural vertex presentation required no other assistance than that which a monthly nurse had been able to furnish. The child was at the breast nursing vigorously, while the parasite attached to its anterior surface at the lower part of the sternum, encroaching upon the upper portion of the epigastrium, remained motionless, neither breathing nor pulsating in any portion of its frame, presenting the appearance and relationship of a simple growth appended to the otherwise perfect and well-formed body of the sister-twin. The parasitism of this product was the more evident as no excitation of any part of its surface, or of the buccal opening, the only presumably sensitive mucous surface that was accessible, evoked the slightest evidence of reflex action. There being no cerebrum there was no cortical localization for cutaneous or sensorial impressions, and the absence also of any development, or even, perhaps, existence of an automatic nerve-centre in the form of a spinal axis, and the abortive formation of a vertebral theca, with the fragmentary elements of an imperfect cranium served fully to account for this absence of all sensation.

FIG. 608.

The genitalia were scarcely traced out sufficiently to determine the sex, though an urethra and an attempt at the formation of a clitoris seemed to indicate the female sex in conformity with its gemellar origin. It was said that urine had been voided on one occasion, of which we had no proof, but had every reason for doubting, as the urethra was imperforate and there was no evidence of an anus.

The cranium was degraded to an abortive fabric of a few of its basal pieces, as seen in Fig. 608; no brain existed, and the absence of sensorial organs, excepting the external ear, showed a most imperfect facial formation. Of the fourteen bones of this region those were but partially formed which should have completed the

* Ordinary deformities, such as hare-lip, club-foot, sixth finger, etc., are not included as monsters.

orbital and nasal cavities, and neither upper nor lower jaw had reached union on the mesial line.

The thoracic limbs were imperfect also, as only the shoulder girdle and humeri were formed to an equal degree on both sides. The right forearm was complete to

FIG. 609.

the wrist, and both radius and ulna were well developed (see Fig. 609). But on the left side there was no trace of an elbow; the humerus appeared not entirely formed, therefore neither bone of the forearm is recognized on this left side. Here, as is often observed in fetal life, the upper parts of the child's body appear somewhat further advanced than other portions, especially the lower limbs (Fig. 610).

The lower portions of the parasite's frame were conspicuously either deficient or incomplete; for, besides the absence of the genitalia—at least the external organs of

FIG. 610.

generation,—the pelvic limbs suffered nearly complete arrest of development. For example, on the right side it will be seen that there is no vestige of the formation of a right lower limb, the only appearance on that side being the nipple-like protuberance without any osseous formation, as may be verified in two of the above figures.

The opposite side, however, exhibits a partial manifestation of an abortive growth containing something like a bony fabric, but more particularly of a fleshy piece of simple integument permanently curved upon itself—an apologetic effort at the evolution of a left pelvic appendage.

The umbilicus was situated entirely beneath the bond of union, and so removed from ready access that it could not be exhibited in the photographs taken immediately after death, but it pertained specially to the autosite; no real common omphalo-mesenteric connection existed, such as is so easily recognized in almost every diplogenetic monster. Here, on the contrary, the parasite had to be raised up and sustained in this position to bring the navel into view, which was then discovered to be on the abdominal surface of the perfect child; no direct intercommunication obtained between the abdominal cavities of the two organisms. The sister child had during its life enjoyed perfect health, taking and assimilating its nourishment well, as was shown by the regularity of its alvine dejections.

The absence, then, of direct placental support indicates the true parasitic character of this unnatural formation; a most imperfect organism that could only sustain a vegetative existence so long as the life of the perfect twin continued to nourish it, growing slowly as might some adventitious excrescence which appropriated metabolically whatever nourishment it derived from the parent organism.

This kind of life was prolonged through three months, for the expenditure incident to the demands of so conspicuous a growth, so to speak, exhausted rapidly the best directed activities of an otherwise healthy and perfect child. During this period no phenomenal occurrence claimed any special notice; the parasite presented the same inert, motionless, insensitive, vegetative existence, neither secreting nor eliminating any product which careful observation could discern. We must always regret that an unforeseen casualty interdicted the dissection of this specimen, which might have revealed yet greater deviations of evolution of such internal organs as might have been found, yet the contemplation of these life-like representations perpetuated in such well-executed figures as are here appended to its history, will certainly satisfy more than a simple curiosity, as the reader is in the presence of one of the rarest of heterotypic monsters.

Middleton Michel.

TETANUS, BACILLUS OF. The etiology of traumatic tetanus has been thoroughly established by Kita-

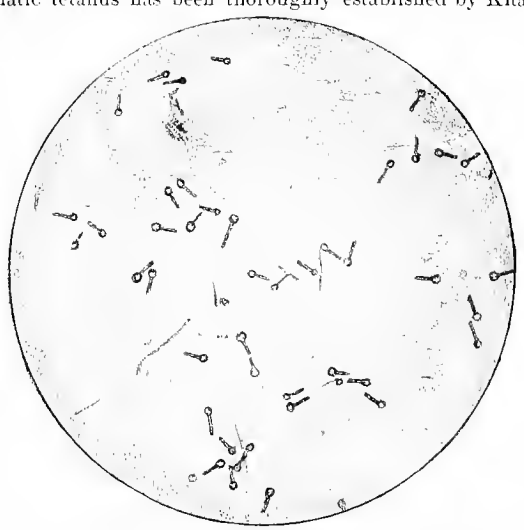


FIG. 611.—Bacillus Tetani. Preparation made from a very virulent gelatine culture in hydrogen. 1,000 times. (From a photograph.)

sato.* The organism first observed by Nicolaier, but not

* Ueber den Tetanusbacillus, Zeitschrift für Hygiene, etc., 1889, vol. vii., p. 225.

obtained in pure cultures by him, was isolated by a special method by Kitasato, and subsequently by several others with Kitasato's method. I also have obtained it in this way.* The method consists in smearing the pus from the wound of a human being, or animal, suffering from tetanus, upon the surface of an oblique agar tube, which is then placed in the incubator at 35° to 37° C. In order to produce the disease in the first place, it is only necessary to inoculate an animal under the skin with a small amount—several pinches of the forceps—of rich garden earth ; † barren sand or wood mould will not produce the disease. Cover-glass preparations from one of the oblique agar tubes described above, made in twenty-four hours, show a number of different organisms, among others the peculiar drumstick bacillus of tetanus. These latter, being exquisite anaërobic organisms, do not grow on the surface of the agar ; but those of them which are contained in the pus go into the spore formation. If the culture is kept in the incubator for two days or more, the spore-bearing bacilli will be found in larger numbers than after twenty-four hours. These spores are very resistant ; they stand a temperature of 80° C. for an hour or more, and the method of isolating them depends upon this quality.

The oblique cultures above described are heated in a water-bath at 80° C. for three-quarters of an hour or more, and this kills all the vegetative cells which are present, and often kills all the spores of the organisms other than tetanus which happen to be present. After heating, inoculations are made in flat, round, sterilized vessels containing sterilized agar or gelatin previously melted. These vessels are of peculiar construction, having a narrow inlet tube and a wider outlet, both plugged with cotton previous to sterilization. A series of these vessels are inoculated, as for making Esmarch tubes or plates, and the narrow tube connected with a hydrogen apparatus, and hydrogen allowed to bubble through till all the oxygen is driven out, when the outlet and inlet tubes are melted off in a Bunsen burner in the order given. Colonies appear in about ten days in gelatin anaërobic plates of this kind, and in one or two days in agar. The vessels are then cracked open, and the colonies transplanted to deep agar or gelatin tubes. I have substituted for this apparatus a modified form of the Liborius hydrogen tube, which can be made without much trouble. The tube I use is made by blowing a small hole in the bottom of a test-tube, and melting on a small glass tube ; this tube is bent up against the side of the test-tube for about two inches, and is then bent out at right angles. These tubes are used just in the same manner as Kitasato's plates, the top of the test-tube and the narrow tube being melted off after the hydrogen is run through. To facilitate this sealing of the tube, the test-tube and the narrow tube should be drawn out somewhat before the hydrogen is bubbled through. After the colonies appear a file scratch is made, and a piece of red-hot glass rod applied so as to crack the test-tube open at any point desired. Stab-cultures must be made by inoculating into tubes containing a large amount of gelatin or agar ; or better still, by inoculating a tube containing a smaller amount of agar, and pouring the melted contents of another tube on top, thus excluding the air. The colonies have a small, dark centre by transmitted light, with a fluffy zone around. Fresh cultures of full virulence liquefy gelatin but not agar ; old cultures, or those which have lost virulence, do not liquefy gelatin. The bacilli grow out into long threads at ordinary room temperature, but form the characteristic spores at 35° to 37° C. in the incubator in about twenty-four hours. They then appear as short, fine rods, with a large round knob on one end, the knob constituting the glistening, resistant spore. The bacilli have independent but slow motion ; flagella have been demonstrated. They stain by Gram's method. *Meade Bolton.*

* Bolton : The Amer. Jour. of the Med. Sciences. June, 1892.
† Compare this Handbook, Bacillus tetani, under Schizomycetes, vol. vi., p. 339, 2.

TEUCRINE. This name is given, by Professor von Mosetig-Morhof, to an extract of *Teucrium scordium* which he recommends for the treatment of local tuberculosis. In announcing his method of treatment at the Medical Club of Vienna, February 1, 1893, he stated that for five years he had been searching for a substance which, when introduced into the organism, had the property of provoking an hyperæmia of the morbid tissue. Teucrine was found to possess this action, and he reported a large number of cases of tuberculous abscesses, enlarged and diseased glands, lupus, and actinomycosis in which it was used with very satisfactory results. In the diseased tissue an acute inflammatory action is set up which is followed by a breaking down and destruction of the affected tissue. In abscesses the chronic became converted into acute in twenty-four hours, and could be treated as ordinary acute suppuration. Generally speaking, the chronic abscess could be cured in this way in eight or ten days, providing it was not connected with diseased bone. Dr. Mosetig has watched the cases for months, and no recurrence has taken place. In glandular disease the enlarged glands are rapidly absorbed if the disease has not advanced. The therapeutic effects in these cases vary with the presence or absence of caseous degeneration. When it is present the injections give rise to an acute inflammatory action ; when the disease has not advanced to that stage the material becomes rapidly absorbed.

The reaction produced by the subcutaneous injection is both general and local. The constitutional symptoms, whether the system be healthy or diseased, show themselves as a rise in the temperature, which is often preceded by a chill, and may last for ten or twelve hours ; the patient, however, does not feel ill, the skin is moist, the appetite is preserved, and the secretions are unchanged. The local symptoms, when there is no disease, consist in a slight redness and swelling about the site of puncture, but when there is diseased tissue a very active hyperæmia is induced, and the swelling, pain, etc., are in accordance with the extent of the disease. The method of employing the remedy is very simple : three grammes of the fluid are injected in the neighborhood of the disease with an aseptic syringe.

The extract is prepared from the dried plant by lixiviation with hot water. The liquid obtained is evaporated to the consistence of honey, it is then washed with alcohol and concentrated until its specific gravity reaches 1150. It is a brownish-black liquid with an acid taste and an odor that is somewhat like cabbage. It has an acid reaction and is soluble in water. Taken internally in doses of eight grains, no other effect was noticed beyond a tonic action on the stomach and appetite.

Teucrium scordium, the water germander, or wood sage, is a member of the Labiatæ, or mint family. It is a common wild plant in Southern Europe, and is also found in England and other temperate countries of Europe. It is a creeping marsh plant, with a disagreeable garlic-like odor when bruised. In this country the genera is represented by a single species, the *Teucrium canadense* L.

The various species have always had a reputation as remedies of some value, but have long been discarded from the Materia Medica. As an antidote for various poisons they were much esteemed, and were also used as an anthelmintic. The *Teucrium scordium* also has a local value as a remedy for the early stages of hemorrhoids. Dr. I. H. Brinton (*Therapeutic Gazette*, January, 1892) publishes a paper in which he praises it for this condition, and states that it affords rapid relief to pruritus ani arising from this cause. He administers the powdered leaf in doses of ten or twelve grains, three times a day, half an hour before meals. It acts as a stomachic and stimulates the appetite, resembling pepper in its action. The beneficial effects are noticed in ten or twelve days and are very satisfactory. Other observers have recommended a local application of an ointment prepared from the extract.

Beaumont Small.

THIERSCH'S SKIN-GRAFTING. The chief value of this method of skin-grafting lies in the fact that it prevents the deformities that would result from the natural healing of the wound by granulation and the subsequent contraction of the scar. A second advantage, in some cases one of extreme importance, lies in the fact that even very large surfaces may be healed promptly.

The grafts consist of shavings of the superficial portions of the skin removed by a razor, and are applied so as completely to cover a wound surface which is free from granulations and presents only normal tissues. A special dressing is applied. The grafts adhere, and by the end of two days they are receiving blood from their new site. The formation of granulation tissue ceases, the wound is healed, and no contraction takes place. A soft, pliable integument is provided, of good vitality and well able to withstand the wear and tear to which a cutaneous surface is exposed. In removing the grafts, the razor does not cut deep enough to include the hair bulbs. No hair will grow from the grafts. Grafts from a hairy thigh may be planted upon the face or hands without fear of transplanting hairs.

This form of skin-grafting has a very wide sphere of usefulness. Where there is extensive loss of skin in the vicinity of a joint, as may follow a burn or other injury, it will entirely prevent cicatricial limitation of motion. Similarly, where the healing of a wound by granulation would result in a distortion of soft parts, it will prevent the deformity. Large areas of malignant disease may be freely removed and rapid healing secured. Thus, extensive areas of tuberculous skin may be dissected off, leaving a healthy wound surface, and the defect covered at once by grafts. Cancerous breasts may be radically removed, regardless of flaps, and the large raw surface, consisting of fat, muscle, and periosteum or bare bone, all covered by a good integument. A thick graft contains a sufficient supply of anastomotic vessels to allow the graft to bridge over a slight interval, independently of nutrition from beneath. For example, after a burn involving the outer half of the little finger, causing superficial necrosis of the bones and opening the first joint, the author applied rather a thick graft so as to bridge over the interval from bone to bone and close the joint. The graft retained its vitality perfectly, and the joint is neatly closed and capable of a little motion. Congenital deformities which could be relieved by making an incision, drawing the edges of the skin apart and covering the wound surface with integument, can be remedied by this method. In cases where scar contraction has already caused deformity, the scar tissue should be freely and completely excised, the parts brought into their natural position, retained by splints if necessary, and then the wound covered by grafts. If the faulty position has not caused grave damage to the deeper structures, deformity can be relieved and lost function restored. In short, Thiersch's method of skin-grafting finds application wherever it is desired to interpolate an area of soft and healthy integument and normal tissues can be provided for its reception.

FIG. 612.—Represents a microphotograph of a transverse section of a skin graft taken from the upper arm.

Certain details of the operation are of the first importance. The excellence of the results obtained and the extent of surface that can be covered in a given space of time depend much on the skill and experience of the operator, but the operation is not a difficult one, and no surgeon should hesitate to undertake it.

The following is a condensed description of the technique which the author has chiefly used:

As was said above, the surface to be grafted should be one of normal tissues. An operative wound usually needs no preparation for the reception of the grafts. A granulating surface may be washed every other day with soapsuds and with sublimate solution and dressed with iodoform gauze saturated with balsam of Peru, until it presents a smooth, firm, and red surface. Preparatory to operation it may be dressed with sublimate gauze. If the patient has syphilis, it is well to give iodide of potassium or mercury for a week or two before operating; otherwise the grafts are liable to perish.

If there is freedom of choice as to the place from which the grafts shall be taken, the thigh should be chosen. The day before operation it should be shaved, scrubbed with soapsuds, and with 1 to 1,000 sublimate solution and wrapped in sublimate gauze. Shortly before operation it should be washed again with sublimate solution. Time will be saved at the operation if two sublimate towels are applied as follows: Let the lower edge of one come below the knee, wrap it round the limb, and secure its lower border by a sublimate gauze bandage round the knee; let the upper edge of the other towel encircle the thigh as high as possible and secure it similarly by a bandage. When the second towel is turned up and the first down, the thigh is at once exposed and is neatly bordered by sublimate towels. Wrap the thigh in wet sublimate gauze, and secure the towels over it.

Select a razor ground flat on one side. It is well to be provided with two. The edge must be very keen. For scraping away granulations, any instrument with a blunt edge will serve. Cicatrized borders can be removed by the Volkmann scoop or the knife. A probe aids the fingers in nice adjustments of the grafts. A pair of rough bathing mittens are a help to the assistant in getting a proper grip upon the skin. The mittens should be boiled or baked before using. The razors may be soaked in five per cent. carbolic solution for fifteen minutes and dipped in salt solution before being used.

During the operation the only solution to be used is one of sodium chloride of the strength of 6 parts to 1,000 of water. This is the so-called "physiologieal salt solution" and does a minimum of damage to the grafts. A large tin-pail of this solution should be boiled for an hour, and then kept at blood heat by being set in a vessel of larger size and surrounded by water which is kept lukewarm. At the operation four sterilized bowls should be filled with this solution, one for the hands, one for sponges, one for gutta-percha strips, and one to receive the grafts as they are cut.

Prepare strips of gutta-percha tissue three-quarters of an inch wide, and long enough to reach across the wound and lap over on each side. These should be washed with soap and water and with sublimate solution and placed in salt solution before being used. Sublimate gauze and sublimate gauze bandages should be wrung from salt solution to serve as the inner dressing. Sponges should be taken from carbolic solution and wrung out in salt solution for use.

Much depends on the position of the patient on the operating-table. Build up the table by pillows placed beneath the body and head, and a smaller prop under the foot, so as to elevate the patient half a foot above the table, and allow the thigh to form a bridge, and thus be readily got at from all sides. If the surface to be grafted is on an extremity, it should be suspended vertically, in order to check hæmorrhage and to permit of free handling without altering the position of the limb.

Unless the operation is a very trifling one, and in a patient of especially good endurance, ether or chloroform should be given.

This operation is performed not with antiseptic, but with aseptic, precautions. The field of operation must be sacredly guarded from the ingress of germs. The hands must be scrupulously disinfected with soap and water and with sublimate solution, and the operative field surrounded by bichloride towels. The first step of the operation is to remove any abnormal tissues. Granulations may be scraped away and cicatrized borders cut away or removed by the Volkmann scoop. Then wash with salt solution and apply at once a compress of gauze. Bind it on, or have an assistant maintain the pressure. Next throw back the towels from the thigh, take off the gauze, let an assistant grasp the skin with both hands and draw it tense transversely. Place the thumb of the left hand

on the tense skin at one end of the thigh, to make a little longitudinal tension, and apply the razor to the skin at a moderate angle. Make a short sawing motion, and at the same time increase the angle at which the razor meets the skin until the edge bites into the skin and begins to raise its upper portion. This angle is then maintained, and with the continuance of the short sawing motion a graft is cut whose length is limited only by the length of the thigh. The tough corium is of great assistance in preventing the razor from cutting too deep. In width the grafts will vary from half an inch to two inches, according to the locality from which they are taken and the skill of the operator and his assistant. Very wide grafts may be got from the comparatively flat surface over Scarpa's triangle. As fast as cut, the grafts should be dropped into a bowl of salt solution.

The manner of cutting the grafts is illustrated in Fig. 613.

In about ten minutes oozing will have ceased, the compress may be removed, and the grafts applied. It will be found that they have curled, with the cut surface inside. To uncurl them, place one end on the surface to be grafted, uncurl it, and keep it uncurled by pressure with a finger of the left hand. The whole graft may now be uncurled by making a rapid to-and-fro motion with a finger of the right hand, and carrying it along the entire length of the graft. The graft is now flat upon the surface and can be moved about with the fingers or probe. The grafts should be made to meet or overlap each other, and also the surrounding skin. Overlapping does no harm, for the superficial edge of a graft will die from lack of nutrition and come away, leaving a mere line of union visible. If not enough grafts have been cut, more should now be cut and applied directly. When the whole surface has been covered, douche it gently with salt solution, and apply the gutta-percha strips in the following manner: Lay one end upon the sound skin at one side of the wound and secure it by a thumb, then, with a winding motion, lay the strip across the wound and out upon the sound skin beyond. In this way the strip is laid on without in any way disturbing the grafts. Let the next strip slightly overlap the first. Continue imbricating each upon the last till the whole surface is covered by the tissue. If the surface is on an extremity, take a wet gauze bandage and apply a snug spiral to hold the tissue and grafts firmly in place. Next apply damp salt gauze, a sheet of gutta-percha tissue to maintain the moisture, sublimate gauze, cotton, a bandage, and a splint suitable to the region. The surface from which the grafts have been taken may be covered with gutta-percha tissue and moist gauze. This is a particularly comfortable dressing, but any simple dressing will answer.

It is advisable to change the dressings every two days for the first eight days. At the end of six days the gauze had best be allowed to dry, by omitting from the dressings the sheet of gutta-percha tissue. This will obviate too great maceration of the horny layer of the grafts, and fit them sooner to withstand the wear and tear of exposure. At the end of ten days the gutta-percha strips are no longer needed. If there are any spots of granulation from faulty adjustments of the grafts, they had best be covered with yellow adhesive plaster. If the surface is uniformly covered with grafts, it needs only to be protected for a few days by a piece of cloth spread with lanoline or vaseline.

FIG. 613.—Taking the Grafts.

FIG. 614.—Shows the Condition of the Knee (in Case C. A.) in May, 1892.

To illustrate the value of Thiersch skin-grafting, the citation of a single case where it was particularly called for and achieved its fullest function will suffice.

In August, 1889, C. A——, a girl, aged twelve, met with an injury by which a very large skin flap was torn from about the right knee. It involved the inner side of the thigh, knee, and leg, and extended outward beyond the ligamentum patellæ and crest of the tibia. In the following November I grafted the surface. Her general condition was poor, and I did not think it wise to continue anæsthesia long enough to cover the large area completely; a portion was only partially covered with grafts, and intervening spaces about half an inch wide were left to cicatrize. In four weeks healing was firm. The limb had been in splints for more than a third of a year, and, when they were left off, there was scarcely any motion at the knee. A cylinder of cloth, stiffened by a covering of oiled muslin, was spread with vaseline and suspended about the limb for a few weeks to guard it from harm. Exercise of the limb was encouraged, and occasionally moderate force was used to aid flexion. In March, 1890, the knee came to a right angle, and she went upstairs one foot after the other. Freedom of motion became progressively greater until it was as perfect in the right knee as in the left, and the limb as useful as before the injury. The accompanying Figure (614) is from a photograph of the case taken in May, 1892, and shows how the grafted area offers no hindrance whatever to complete flexion. *Theodore Dunham.*

THILANIN. This title is given to a compound of sulphur and lanoline, which is said to contain three per cent. of sulphur, but whether in combination with the cholesterine or with the fatty acids is undetermined. It is a yellowish-brown, unctuous body of the consistence of lanoline. It was introduced by Dr. Edmund Saalfeld, at the third Congress of the German Dermatological Society, as being devoid of any irritating properties and useful in cutaneous affections. The author had used it with success in acute, subacute, and chronic eczemas, acne, and various forms of skin disease. Its further use has not been reported upon. *Beaumont Small.*

THIOL. This sulphur compound has been introduced as a substitute for icthyol, to which it is closely allied. Icthyol is prepared from fossiliferous remains which are rich in sulphuretted hydro-carbons and complex organic compounds. Thiol, which is described as an artificial icthyol, is prepared by treating with sulphur the hydro-carbons, with a specific gravity between 0.890 and 0.900, that are obtained from coal tar. The latter differs from icthyol by the absence of much organic matter that supplies its objectionable qualities, their presence, it is claimed, being of no therapeutic value. The method of preparation consists in the sulphuretting of the hydro-carbons and then acting on them with concentrated sulphuric acid. This, when cooled, causes the impure thiol to separate in a distinct layer, which is drawn off, purified by washing to remove excess of acid, and then evaporated to an extract—*thiolum liquidum*, or to complete dryness—*thiolum siccum*.

Liquid thiol is a thin, brownish, neutral liquid, with a specific gravity of 1.080 to 1.082 at 60° F. It has a feeble bituminous odor, not disagreeable. It forms a clear solution with water, especially if glycerine be added. It is not very soluble in alcohol or ether. Aqueous solutions froth abundantly when shaken ; they are not affected by the addition of strong alcohol, but soda, dilute acids, or metallic salts cause a precipitate. Dry thiol, which forms forty per cent. of the liquid form, is a dark-brown or blackish mass, sometimes formed in scales, which, when heated, burns away entirely, leaving no residue. The advantages claimed for thiol over icthyol are, that it is really a purified form of the latter, that it is devoid of the disagreeable odor, and does not stain the linen or clothing, is less irritating, and more definite in composition. It, however, does not contain numerous hydro-carbons and combinations of sulphur which are present in icthyol and are supposed to be indispensable to it as a therapeutic agent.

The therapeutic value of thiol is said to be due : (1) to a contractile effect upon the vascular system by virtue of which its application is of value in conditions of the skin due to or associated with dilatation of the vessels and capillaries, as in hyperæmia, erythema, and inflammatory processes generally ; (2) to a desiccating and "horn-forming" action upon the skin, which is of importance in the treatment of moist, papulous diseases, and wounds, burns, etc.; (3) to a certain antiseptic power ; (4) to an action in promoting the absorption of exudations when locally applied. It has been used with success in eczematous affections ; in acute, moist, inflammatory processes, as erysipelas, herpes, herpes zoster, acne ; in the ulcerative processes of syphilis and tuberculosis, and in simple ulcers. In articular infiltrations and œdema, due to rheumatism and other causes, the application of thiol hastens the absorption and dispersion of the fluid and inflammatory deposits. In gynecology this same action is made use of in para- and peri-metritis accompanied by exudation. Endometritis, erosions of the os, and similar conditions are reported to be rapidly improved by this treatment.

Although the pure drug may be applied without causing any irritant action, a ten per cent. preparation is generally sufficient for all purposes. The powder may be combined with powdered starch ; or aqueous or glycerine solutions may be prepared. For wounds a five or ten per cent. solution in collodion is very serviceable. An ointment may be made with vaseline or lanoline.

Internally it is without toxic action, and unirritating to the stomach or intestines. For inflammatory diseases, and in gynecological practice, its action is increased by internal administration in addition to its local use. The dose is one and a half grain, which may be repeated up to five times a day. It is given in sachets, in pill form, or in solution in wine. *Beaumont Small.*

THIOPHENE. C_4H_4S. This is a sulphur-holding hydro-carbon, contained in coal-tar benzine. In the pure state it is a colorless, clear, volatile oil, boiling at 184° F., of slight odor, and will not mix with water. Thiophene itself is not employed as a therapeutic agent, but two preparations have been introduced—*sodium thiophensulphonate* and *thiophene di-iodide*.

Sodium thiophensulphonate, $C_4H_3SNaSO_3$, is a white crystalline powder, containing thirty-three per cent. of sulphur, and having a slight but unpleasant odor. Used as a dusting-powder, or applied as an ointment, ten per cent., with equal parts of lanoline and vaseline, it has proved of much service in all forms of prurigo. A lead salt has also been prepared and used with success in the same disorder.

Thiophene di-iodide, $C_4H_2I_2S$. In this salt two atoms of hydrogen are replaced by two of iodide; it contains seventy-five per cent. of iodine and 9.5 per cent. of sulphur. It forms in fine crystalline plates, insoluble in water. The di-iodide has been proposed as a substitute for iodoform, as it has a less unpleasant odor. It has been employed in all conditions in which iodoform is used with success, and experiments have shown that it possesses an antibacterial power very similar to the older drug. It has not yet received much attention.

The pure powder is used by dusting in the wounds, and covering with ordinary gauze, or a medicated gauze may be prepared with the following solution : thiophene di-iodide, fifty parts ; alcohol and ether, of each five hundred parts ; glycerine, ten parts. It has a slightly aromatic, and not disagreeable odor, which is much less persistent than that of iodoform. No toxic effects have been detected after the free use of the powder.

Beaumont Small.

THIOSINAMINE. This long-known chemical compound has been recently introduced as a drug possessing valuable therapeutic properties. It is obtained by the action of alcohol and ammonia upon the ethereal oil of mustard, which forms a basic compound with the following formula, C_3H_6, NH, NH_2, CS. It forms in colorless and odorless prismatic crystals, having a bitter taste, and is readily soluble in water, alcohol, and ether. The solution should not affect test-paper.

Thiosinamine has attracted attention on account of its reputed resolvent action upon scar tissue. When injected into tissue causing deformity and disability by contracture, it is said to produce a softening and relaxation which allows the part to become free and pliable. Numerous cases of fingers and limbs that were beyond the use of the knife, are reported to have been almost perfectly restored. This effect was announced by Dr. H. v. Hebra, Jr., of Vienna, in 1892, at the International Congress on Dermatology. He recommends that a fifteen per cent. alcoholic solution be prepared, and two injections a week be used, of two to four drops. No effect is produced upon the system, but the tissue rapidly becomes soft and relaxed. It has also been used with success for the purpose of relaxing the cicatricial tissue of urethral strictures. (*La Semaine Médicale*, March 3, 1893.) In three cases the patients were able to pass their urine freely on the day following the first injection ; the stricture, however, recurred upon the cessation of treatment. It has also been used in gynecological practice (*La Semaine Médicale*, February 3, 1893) to relieve the distressing symptoms arising from the effects of peri-metritis and inflammatory troubles about the appendages. Two and a half to ten drachms of a fifteen per cent. solution were employed, and a decided improvement noticed in all the cases treated. In addition to its action on cicatricial tissue, it causes a decided increase in diuresis and diaphoresis, and exerts a powerful tonic effect upon the system, in consequence of which it is thought to have a beneficial resolvent action upon local tuberculosis. Upon chronic enlargement of lymphatic glands its effect was very marked. In a number of cases of lupus it was noticed to exert a beneficial action ; a few injections changed the aspect of the disease, the nodules became smaller, the diseased tissue and ulcers improved, the edges became flat, and the surface healed in a few weeks. No complete cures were effected, but improvement was noticed in every instance. The injections were made in the back. No constitutional effect followed the injections, but a local reaction set in after a few hours, causing redness, tension, and swelling of the affected part. *Beaumont Small.*

THOUGHT-TRANSFERENCE.—Since the foregoing article (by Dr. Morton Prince) on Thought-Transference was written, various series of records have been published which materially increase the strength of the evidence for Thought-Transference. We shall mention the most important of these in the order of their publication, not attempting to summarize them all, and shall also notice some other series of which no accounts were given in Vol. VII. of this work.

In Part XII. "Proceedings S. P. R.," Professor Charles Richet published a detailed account (pp. 18–168) of his own experiments, under the title "Relation de diverses expériences sur la transmission mentale, la lucidité, et autres phénomènes non explicables par les données scientifiques actuelles." In this article Professor Richet apparently goes beyond the acceptance of mere thought-transference, which he regards only as a special case of a more general phenomenon which he calls by the name *lucidité*—implying, by this term, the existence of some faculty of knowledge which is independent of our normal faculties of knowledge. In the same "Proceedings S. P. R.," Part XII., is an article confined to "Experiments in Thought-Transference," by Messrs. A. Schmoll and J. E. Mabire, these being a continuation of some experiments reported in the previous number. These experiments were conducted with a small circle of friends; "all the investigators," say the authors, "were aware of the scientific scope of the attempts, and vied with each other in their zeal in excluding all source of error and in obtaining conclusive results." Their experiments were chiefly with diagrams and cards, the former trials being more numerous and more successful. We reproduce four consecutive trials made on March 4, 1887, and two selected trials on April 8, 1887.

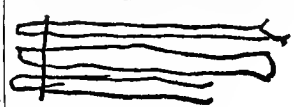
In the above series the experiment began apparently by the percipient's seating himself blindfolded in an arm-chair in the corner of the room. The drawing was placed on a table in the middle of the room and the persons present directed their looks toward it, facing also in the general direction of the percipient's back.

"The percipient drew nothing while seated in the arm-chair. If at the end of ten or fifteen minutes he announced that he saw a figure, the original was hidden and he was requested to come to the table and draw what he had seen. He then did so under our eyes, but in the midst of perfect silence. If the reproduction thus obtained bore more or less resemblance to the original, the percipient was replaced in the arm-chair and the experiment was continued; only in the most successful cases did this repetition not take place. If, on the contrary, the figure produced by the percipient was without any resemblance

March 4, 1887.

Percipient.	Agents.	Original Drawing.	Result.
M. Mabire.	Mme. D. Mlle. Marthe. Mlle. Jane. Mme. Schmoll. M. Schmoll.		"I see a Y," said M. Mabire at first. Toward the end of the experiment the image had changed a little, and M. Mabire drew the following figure: Duration of experiment, 10 minutes.
Mlle. Jane.	5. M. Mabire in place of Mlle. Jane.		"I see a triangle, with its base below. The triangle appears to me to be filled up; but the darkness, very pronounced at the angle, disappears at the base—which is itself not represented at all." Then Mlle. Jane drew this figure: Duration, 12 minutes.
Mme. D.	5. Mlle. Jane in place of Mme. D.		"I see something like a flower with four extended leaves." "Now, there are two ellipses placed together horizontally, like an 8 lying down; a descending stroke separates them." Duration, 12 minutes.
Mlle. Marthe.	5. Mme. D. in place of Mlle. Marthe.		1. "An extended curve, convex upward." 2. "Three curves, horizontally united, and a white spot above." The following are the two drawings made one after the other: 14 minutes.

April 8, 1887.

Percipient.	Agents.	Original Drawing.	Result.
Mlle. Louise.	5. (plus Mr. Myers).	 This figure was drawn by Mr. Myers.	At the end of a few minutes, Mlle. Louise said: "I see three fish on a skewer." Not being well understood, she explained: "Three fish held by a skewer, that is as they are sold in the fish markets; but everybody knows that!" Then she took off her bandage and drew: 
Mlle. Louise.	5. (plus Mr. Myers).		

to the original, it was passed by, and the trial regarded as a failure."

Later on, the percipient made his drawing where he sat in the arm-chair, and still later the match used for sketching the original designs, which as making "no appreciable noise," had been chosen "in preference to a pen," was replaced by "a sable-hair brush." The whole series of experiments adds distinctly to the evidence for thought-transference, unless we impugn the good faith of the investigators; who seem to have imposed more and more stringent conditions upon themselves for the purpose of rendering their experiments more evidentially valuable.

The next batch of evidence comes from Professor and Mrs. H. Sidgwick and Mr. G. A. Smith, whose experiments were recorded in Part XV., Proceedings S. P. R. The general results are summarized by the writers as follows, in the beginning of their paper:

"The experiments in thought-transference about to be described have been carried out with four different percipients while in the hypnotic trance, Mr. Smith, who hypnotized them, being the agent. The experiments were usually directed and arranged by Mrs. Sidgwick, who also took the notes which form the basis of the present paper. On two or three occasions, however, she was absent and her place was taken by Professor Sidgwick, who was also present on most other occasions in July and August.

"Most of the experiments were in the transference of numbers of two digits, Mr. Smith looking at the numbers and the percipient guessing them. The number of experiments of this nature tried with Mr. Smith in the same room as the percipient was 644, of which 131 were successes; and the number tried with Mr. Smith in another room was 228, of which only 9 were successes. In these numbers an experiment in which two percipients were at work at the same time is counted as two. By a success we mean that both digits are correctly given, but not necessarily placed in the right order. Of the 131 successes with Mr. Smith in the same room the digits were reversed in 14; and of the 9 successes with Mr. Smith in a different room the digits were reversed in 1. We had no numbers above 90 among those we used. If the percipients had been aware of this the probability of their guessing the right digits in the right order in one trial by pure chance would have been 1 to 81, and the probability of their guessing the right digits in any order half that. But, as at different times they guessed all the numbers between 90 and 100, we believe that they were not aware that our series stopped at 90, in which case their chance of being right in a single guess was 1 to 90. No one will suppose therefore that 117 complete successes in 664 guesses was the result of chance. Good days and bad days alike are included in the numbers given, though, as will be seen in the sequel, on some days no success at all was obtained. It was clear that the power of divining the numbers was exceedingly variable, but whether the difference was in the agent or the percipient, or on what circumstances it depended, we have so far been unable to discover.

"Eight persons, at least, besides Mr. Smith, tried to act as agents, but either failed to hypnotize the percipients, or to transfer any impression. Nor did others succeed in transferring impressions when the hypnotic state had been induced by Mr. Smith. Mr. Smith himself did not succeed except when the percipients were hypnotized."

The numbers used belonged to a game of loto, and in some of the experiments they were drawn out of a bag by Mr. Smith, "between his finger and thumb, which effectually concealed the figures, and placed in a little box, about an inch deep, which he held in his hand with its back to T. T.'s eyes were apparently closed, and he kept his head very still, and we ascertained by experiment that he would have had to move it several feet to see the number." In other experiments a curtain separated Mr. Smith from the percipient, or Mr. Smith stood behind the percipient. Sometimes the number was drawn from the bag and handed to Mr. Smith by another witness. The whole series of experiments are classified very carefully, with full information as to the positions of agent and percipient. When two subjects, P. and T., were both hypnotized, it was found that the guesses of P. influenced those of T. to a certain extent—unconsciously as far as T. was concerned; and the authors concluded that "for evidential purposes in psychical research no reliance can be placed on the fact that a person—whether hypnotized or not—is entirely unaware that an impression has reached him through his senses, if by any possibility it could so have reached him. It is, therefore, necessary to examine the experiments dealt with in this paper with anxious care, in order to see whether there was any possible channel of sense through which the agent's impression could have reached the percipients.

"The eye is, we think, absolutely excluded. There were a sufficient number of successful experiments with Mr. Smith behind the percipient and with the percipient's head covered over, to make it unnecessary to consider the various possibilities of careless handling of the numbers, reflection in the cornea, or changing facial expression and gesture.

"The sense of touch may also, we think, be regarded as excluded. There was never any direct contact between agent and percipient, except in one or two cases where it was purposely tried and did not produce success; and it seems absurd to suppose that vibrations of the floor caused by rhythmical movements of the agent, of which he was himself unconscious and which were invisible to others, can have been powerful enough to affect the percipient.

"We are reduced, then, to the sense of hearing."

The question whether any indications could have been received by the percipient through the' sense of hearing, even assuming hyperæsthesia on the part of the percipient, is discussed in much detail, and the authors conclude that the conditions of success "were, at any rate, independent of unconscious auditory indications."

In Proceedings S. P. R., Part XVII., Baron von Schrenck-Notzing, M.D., Munich, has given an account of "Experimental Studies in Thought-Transference." He divides his experiments into two series—experiments in thought-transference with drawings, and experiments in guessing objects, persons, etc., thought of. The second series is hardly of sufficient importance to summarize here. In the first series are recorded twenty-six experiments with drawings. In one of these trials the percipient drew nothing, getting no impression, and in the other cases, regarded as complete failures, the drawings are not reproduced by the author. The remaining twenty-two drawings are given here, *O* representing the original drawing, and *R* the reproduction by the percipient.

In the following five trials, Graf S., aged twenty, was percipient. In 1 and 2 Dr. Notzing was alone agent; in 3 and 4 Baron von Welden assisted as agent; in 5 Baron von Welden was alone agent, Dr. Notzing being a passive witness. The method of experimenting was as follows: Graf S. sat in an arm-chair while the agent went into the next room, and the door being closed, made the original drawing. The agent returned with the drawing, holding it so that "it was absolutely impossible for the percipient to see anything of it," and took his seat almost directly behind the percipient (the author gives a detailed plan of the rooms), and thought as vividly as possible of the drawing, holding it "so that Graf S. could have seen nothing of it, however he might have turned himself." Regarding 3, Dr. Notzing states: "Just as I am leaving the room to make the drawing, I think of a square but draw a triangle."

For the next four figures, Fräulein E., a patient of Dr. Schrenck-Notzing, "twenty-four years old, suffering from hysterical troubles," was the percipient, Dr. Schrenck-Notzing the agent. General conditions of drawing similar to those in the previous experiments. In giving reproduction 6 to the agent, the percipient remarked: "I see a cross which persists, and is sometimes surrounded by a square, sometimes by a circle, some-

times by a border or frame. The frames wavered, but the cross remained." In experiments 8 and 9 the percipient was told that the first reproduction was wrong.

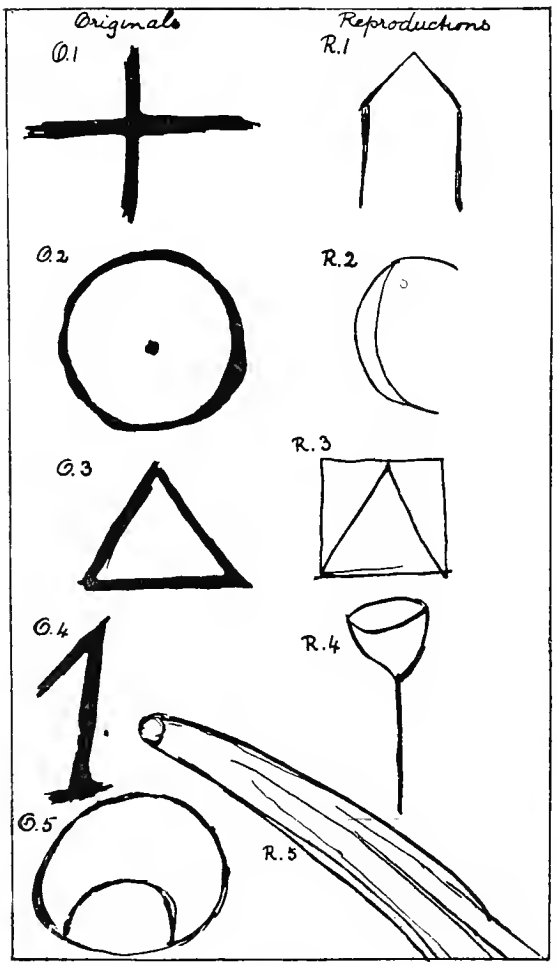


FIG. 615.

In figures 10 and 11 Fräulein A. ("a patient of a rather hysterical temperament") was the percipient, Dr. Schrenck-Notzing the agent. In these and the later experiments, the percipient sat on a chair with her back to the door, the agent sat in a chair opposite the percipient, "holding the paper on a book, the book held perpendicularly to the floor, with its back toward the percipient and the paper toward the agent." Is it perhaps hypercritical here to suggest that the author makes no reference to the possibility of indications by corneal images? In experiment 12 the agent "drew a 3 on a sheet of paper *under* the table, which was covered with a large cloth," this being "the only experiment where the drawing was made in the same room." For figures 12 to 15 Frau Eug., a Pole, aged twenty-seven, was percipient. Percipient was informed that 13 was "not a number." "The percipient now draws reproduction 13 (*a*). I look at her hand, and when she has done, say, 'Right, but it is not finished; draw larger.' The percipient draws 13 (*b*). I say nothing, but picture the original very clearly and vividly to myself. The percipient now draws reproduction 13 (*c*)."

After making reproductions (*a*), (*b*), (*c*), (*d*) for figure 14, the percipient asks: "Is it not a number, a zigzag, a letter?" Dr. Schrenck-Notzing says: "It is possible that as this went on I made some negative gesture. Suddenly she says, 'It is a square.' I say, 'Right.' She now draws unexpectedly under my eyes 14 (*e*), which completely reproduces the original. She might have guessed the square. But it is certain that there was absolutely nothing to suggest that the figure was to be completed by four small squares at the corners."

In making the reproduction of 15, the percipient remarked: "It is like a tower, square at the bottom—a ball. . . . It is like a pedestal." For the next three trials Fräulein A. was again percipient, but during each experiment "*agent and percipient are in different rooms, separated by a closed door.*" *O.* 16 represents "the staff of Æsculapius with the serpent." Dr. Schrenck-Notzing thinks that there is no object in the study "which could have led up to the idea," and that "corresponding association of ideas is excluded." As described by Dr. Schrenck-Notzing, with diagrams of the rooms, it seems exceedingly improbable that Fräulein A. could have obtained a glimpse of the drawings through, say, the keyhole of the door; but it is unfortunate that Dr. Schrenck-Notzing has not referred specifically to the possibility or impossibility of this, in connection with these three experiments. About figure 18, Dr. Schrenck-Notzing writes: "I began with the triangle, and then drew the

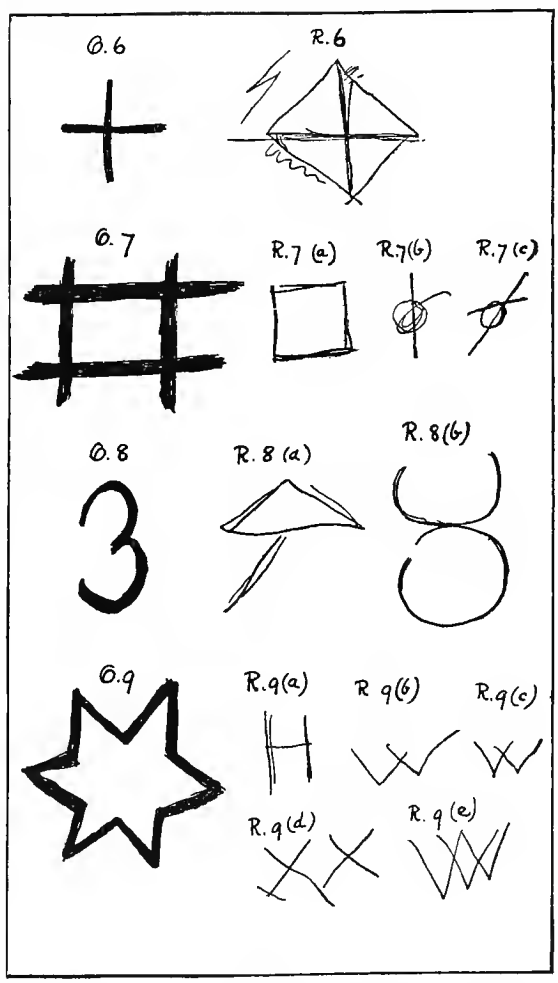


FIG. 616.

perpendicular as the base. The idea that thereupon occurred to me, that the figure was too simple, induced me to add a circle and to prolong the perpendicular to the circumference; finally I added the horizontal diameter."

For figure 19, the reproductions 19 (*a*) and (*b*) were

drawn with the same agent and percipient in different rooms, with the door closed. Agent says "Wrong,"—and continues experiment in same room with percipient under conditions similar to those of the carlier experiments. The percipient afterward makes reproductions 19 (*c*) and 19 (*d*). The author lays special stress on those four experiments 16–19, which "were done one after another in half an hour, with the same percipient and almost the same conditions throughout."

For figure 20 Graf S. was percipient, and 20 (*a*) was drawn with the agent in the other room. He is told that it is "wrong," and the trial is continued with the agent standing behind the percipient and looking at him while he draws (*b*)—(*e*).

In experiment 21 the percipient was Fräulein A., who gets no impression while the agent is in the other room. "I re-enter the study, and make the task easier for the percipient by saying 'Letters,' upon which she writes 'A, H,' I standing behind the chair. She then says, 'They are entwined,' and makes reproduction 21 (*b*), then 21 (*c*), which approaches the original still more. This experiment is a half success, but with a probability of guessing right by chance alone of one in twenty-four;

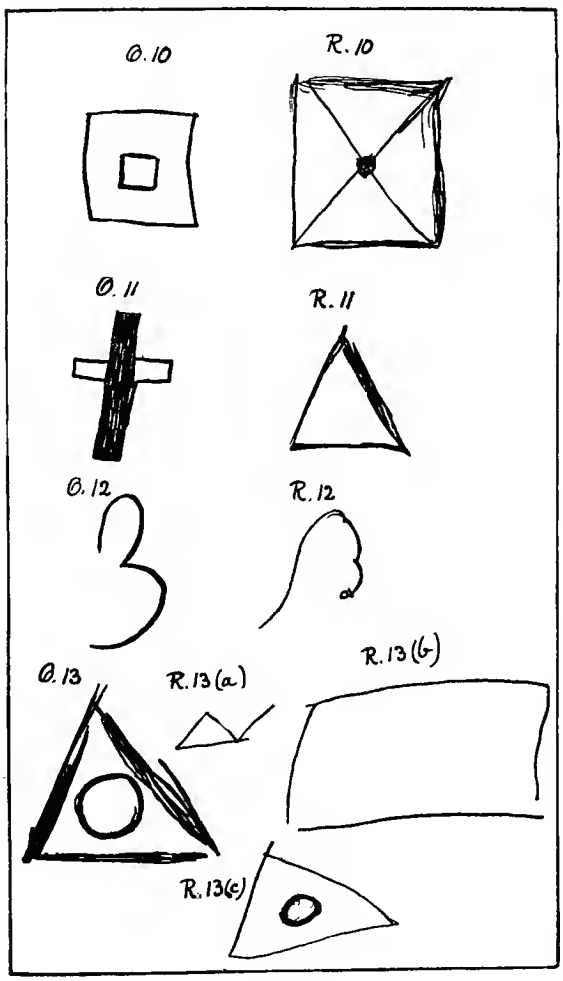


Fig. 617.

and subject to the need of making due allowance for the natural association of ideas, since the percipient would be likely to think first of the initial of her own name. As a failure, this experiment is interesting and instructive; regarded as a success, it would not prove thought-transference."

For the last trial Fräulein K. was percipient. 22 (*a*) was drawn while the agent was in the other room. "On

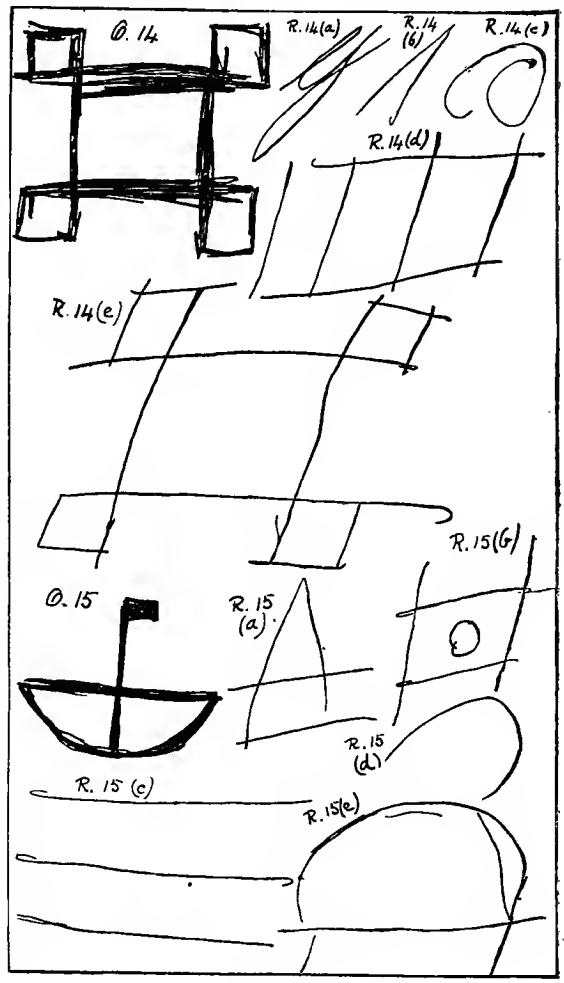


Fig. 618.

my return I look at the drawing—and say 'wrong,' and go on thinking intently of the original. She then draws reproduction 22 (*b*), I standing behind her chair and looking at her paper. I say 'Wrong, try again.' The percipient now draws a circle. I say 'Right, but not finished.' She now draws reproduction 22 (*c*), I keeping perfectly still, and giving her no further hint whatever." The author seems on the whole to be a careful experimenter and fully alive to the ordinary sources of error. The above experiments were made on various dates during 1890, and the author suggests that "it is advisable to experiment often, and little at a time." His general conclusions from his experiments, including the guessing of objects, persons, etc., as well as drawings, is that "after full allowance for possible sources of error, there remains, in the way in which the results were obtained, and in the amount of coincidence, something inexplicable which calls for further investigation, and seems to indicate with some certainty the operation of a factor not yet perceptible to our senses."

Professor Oliver J. Lodge gives an account (Part XX., Proc. S. P. R.) of some experiments (chiefly cards and diagrams) made with "two adult daughters" of Herr von Lyro, at Pörtschach am See, Carinthia. The sisters were

successful taking one as agent and the other as percipient alternately, but were not successful without contact or with other persons as agents. After describing "how clearly the effect seemed to depend on contact, and how abruptly it ceased when contact was broken," Professor Lodge says: "It is perfectly obvious how strongly this dependence on contact suggests the idea of a code, and I have to admit at once that this flaw prevents this series of observations from having any value as a test case, or as establishing *de novo* the existence of the genuine power." And although Professor Lodge was satisfied himself that no code was used, he states that none of the evidence which he can "offer against a prearranged code is scientifically and impersonally conclusive, nor could it be accepted as of sufficient weight by a sceptic on the whole subject." We need not therefore enter into any details here concerning this series.

Further experiments along the same lines as those made by Professor and Mrs. Sidgwick and Mr. Smith (*vide supra*) are recorded in Part XXIII., "Proc. S. P. R." by Mrs. Sidgwick and Miss Alice Johnson. Their object "was in the first place to obtain more complete evidence of thought-transference with agent and percipient in different rooms, and, if possible, at greater distances. We also varied the experiments, partly with a view to

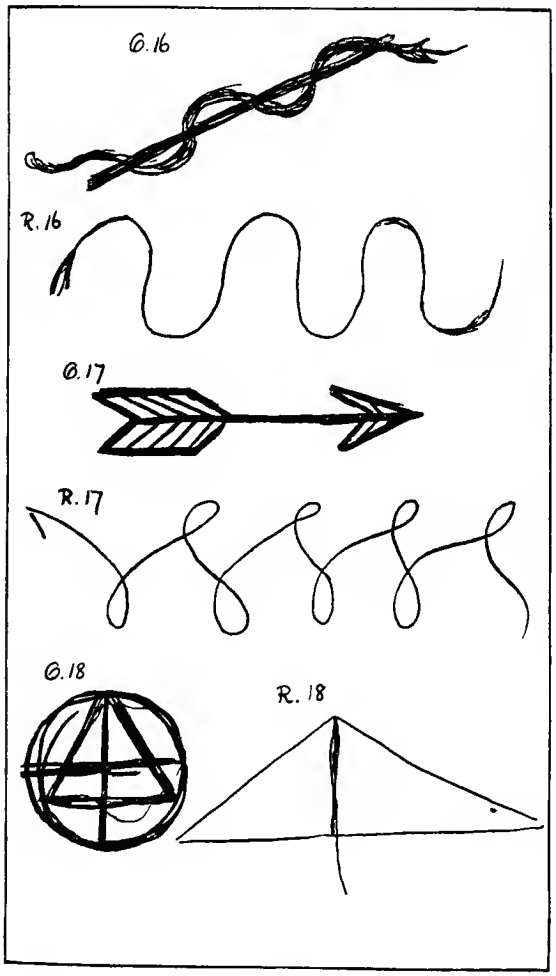


FIG. 619.

obtaining additional proof that no physical indications reached the percipient consciously or unconsciously, and partly in the hope of learning something about the conditions necessary to success. With these objects, we made experiments in the transference of ideas other than numbers, and sometimes employed automatic writing, table-tilting, and hallucinations as a means of getting at the percipient's impressions. In addition we

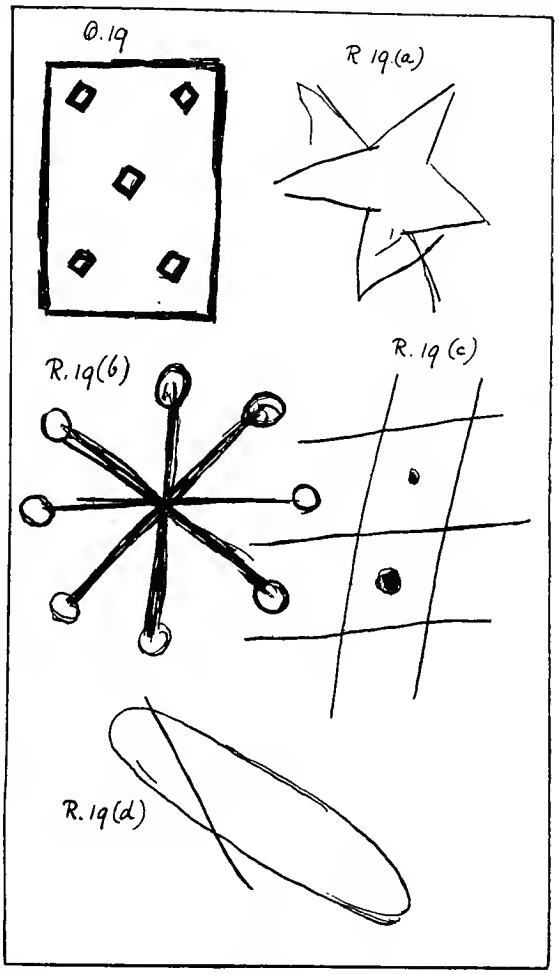


FIG. 620.

carried out a series of experiments in producing local anæsthesia and rigidity by, as we believe, mental suggestion."

It would occupy too much space here to describe even the conditions of these experiments in detail; as regards the numbers it must suffice to quote the general description of a few of the first experiments made with the agent on a ground floor and the percipient upstairs, the two rooms being, however, connected by a staircase "closed at the bottom by a door."

"The first experiments of this series with Miss B. were made on January 6, 1890. The persons present were Miss B., Professor Barrett, Mr. Smith, Mrs. Sidgwick, Miss Johnson, and T.; but T., with whom we had been experimenting, was hypnotized and not attending to what was going on. Mr. Smith hypnotized Miss B. and tried three numbers while in the room with her and speaking to her. There was some success with these, and then Mr. Smith and Miss Johnson went downstairs to the lobby. Miss Johnson drew a number at random out of a bag containing all the numbers from 10 to 90, and handed it to Mr. Smith, who then tried to communicate it mentally to Miss B. A little bell or gong was rung upstairs by Mrs. Sidgwick as soon as a guess had been made, and again when the party upstairs were ready to

begin another. As the bell was rung, Mrs. Sidgwick, who had previously been put *en rapport* with Miss B., said: 'There's another, Miss B.,' or words to that effect; and Miss B. began to look out for an impression, which usually came to her in a visual form. Mrs. Sidgwick noted down her guesses and remarks, while Miss Johnson noted the numbers that she drew from the bag, and at intervals we compared notes.

"Eight guesses were made in this way. The first two were failures, but in the remaining six the first digit was right in each case. Moreover, in two out of the six, Miss B. first gave the completely right number, but then changed her mind as to the second digit. Thus, the

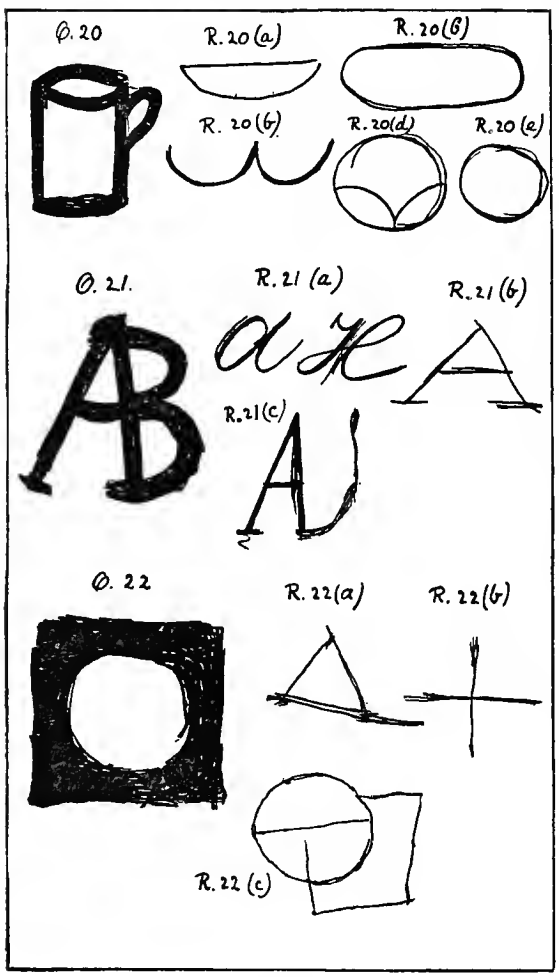


FIG. 621.

number being 21, she said: 'It's never another 2, is it? 2 and a 1? 8—28.' And again, with the last of the six, which was 41, she said: '4—better not go on doing any more, or I shall never be right, I'm sure. 4—1? Looks like a 1 : 46.' This occurred on other occasions also.

"It is hardly necessary to say that, as Mrs. Sidgwick was herself wholly ignorant of the number, it was impossible for her remarks to give any indications to Miss B."

The summary of the three first series of experiments—(1) Percipient upstairs, agent downstairs; (2) percipient downstairs, agent upstairs; (3) percipient in room and agent (12 to 17 feet distant) in passage, with closed door between—is given as follows:

NUMBER OF TRIALS AND DEGREE OF SUCCESS.

Quite right.	Digits reversed.	First Digit only right.	Second Digit only right.	Wrong.	Totals.
27	8	85	23	109	252

There were thus 27 complete successes in 252 trials, whereas chance alone would give only between 3 and 4.

A few words need perhaps to be said about the experiments in the production of local anæsthesia and rigidity by mental suggestion. These experiments, as the authors point out, are an extension of some experiments made originally by the late Edmund Gurney, who did so much valuable original work in connection with the hypnotic trance. The general method of experimenting was as follows:

"The subject, who was always in a normal condition at the time of the experiments, sat with his hands passed through holes in a screen which extended sufficiently above and on each side of him to prevent his seeing the operator or his own hands. The hands were spread out on a table and the finger to be operated on was silently indicated to Mr. Smith behind the screen by one of ourselves, either by signs or in writing. Mr. Smith generally said nothing while an experiment was going on, and he remained behind the screen until the testing was finished. The subject was frequently engaged by one of us in conversation on topics outside the matter in hand during the process of making the finger insensitive, but sometimes we encouraged him to attend to his own sensations, with results which will be described below."

It does not appear that the finger to be operated upon was chosen at random.

The methods of testing for anæsthesia were "touching all the fingers at various points in varying order, many times in succession, the subject being asked to say whenever he felt the touches," and the application of a current from a small induction coil through two wire terminals. The following is a summary of these experiments:

	Number of			
	Successes.	Partial Successes.	Failures.	Trials.
(*a*) With Mr. Smith pointing at the selected finger	19		6	25
(*b*) A glass screen placed over P.'s hands, Mr. Smith pointing at the finger	18		3	21
(*c*) Mr. Smith not pointing at the finger, in the same room with P., from 2½ to about 12 feet off	19	2	16	37
(*d*) Mr. Smith in another room across a passage, both intervening doors open, looking through an opera-glass at the finger	8		3	6
(*e*) Mr. Smith in a different room from P., an intervening door closed		2	12	14
(*f*) Mr. Smith pointing, but willing that no effect should be produced	4			4
Totals	63	4	40	107

The student must, however, be referred to the original record to obtain an adequate idea of the precautions taken by the authors to avoid not only ordinary, but extraordinary, sources of error. Taking the whole article, it seems to be the most valuable contribution to the evidence for experimental thought-transference that has yet appeared.

In considering generally the evidence for Thought-Transference, it is obvious that different students will doubtless form different opinions from the same records, and this is especially the case, perhaps, as regards experiments with diagrams or in the descriptions of objects, where no precise estimate of the probabilities can be made. It should, therefore, be continually borne in mind

that the value of the evidence does not depend exclusively upon several prolonged series of experiments with a few special subjects. In some cases, indeed, a greater value attaches to a shortly summarized and at first sight insignificant series, and this value attaches, on the one hand because the persons concerned are themselves investigators whose good faith is unimpeachable, and on the other hand because an accurate calculation can be made of the chances. A particularly good instance is that of the Misses Wingfield ("Phantasms of the Living," vol. i., p. 34), where the object to be guessed was a number of two digits (one of the numbers from 10 to 99) chosen at random. Out of 2,624 trials, there were 275 complete successes, whereas chance gives but 29. "In the last 506 trials, the agent (who sat some six feet behind the percipient) drew the numbers at random out of a bowl; the odds against the accidental occurrence of the degree of success—21 right guesses—obtained in this batch are over 2,000,000 to 1." A later series of 400 trials by the same ladies is described as follows ("Phantasms of the Living," vol. ii., pp. 653–4):

"The ninety numbers which contain two digits were inscribed on ninety slips of paper, and placed in a bowl. Miss M. Wingfield, sitting six feet behind the percipient, drew a slip at random, and fixed her attention on the number which it bore; Miss K. Wingfield made a guess at the number, and the real number and the guess were at once recorded in the table. The slip of paper was then replaced, the contents of the bowl shuffled, and another draw made at hap-hazard. The most probable number of right guesses for accident to bring about in the 400 trials was 4. The actual number of completely right guesses, was 27; in 21 other cases the two right digits were given in reverse order; and in 162 others, one of the digits was given rightly in its right place. The probability which this result affords for a cause other than chance is represented by 47 nines and a five following a decimal point; *i.e.*, the odds are nearly two hundred thousand million trillions of trillions to one!"

It does not, of course, immediately follow that Thought-Transference is the solution of the successes. It may be urged, for example, that the agent may have unconsciously sounded the numbers, and the percipient unconsciously interpreted the sounds. Such an explanation may appear the most probable to any person approaching the subject as a complete sceptic. It would, however, by no means account for the successes in all the shorter records scattered throughout even the Journal of the S. P. R., issued for private circulation among members and associates only, to which references may be given for the sake of the student: Journal S. P. R., vol. i., p. 318; vol. ii., p. 183; vol. iii., pp. 147, 179–191; vol. iv. pp. 33–37; vol. v., pp. 21–30, 111–126, 182–191, 276–279.

In some of the experiments recorded in volume v. the agent and percipient were in different houses, at a distance of 400 yards apart.

The most recent additional evidence that has come before us in favor of Thought-Transference, consists in a series of experiments conducted by A. Blair Thaw, M.D., of New York. The experiments were made with relatives and friends, and all conscious fraud was completely excluded. The trials were chiefly with cards, numbers, colors, and miscellaneous objects. The following extracts, are taken from Part xxiii., Proceedings S. P. R. We quote here only the first series of experiments, which seems to have been rather the most successful. Dr. Thaw writes: "It is manifest that in experiments intended to prove thought-transference all possibility of perception by the senses must be excluded. With this object the following rules were adopted in the experiments about to be described, and any infringement of them is noted in its proper place.

1st, with regard to the Muscular sense: there must be no contact between the person who is to take the active part and the person who is to try to receive the impressions.

2d, as to the sense of Sight: the percipient must have his eyes carefully covered with a dark bandage, and the object must be outside his field of vision, supposing no bandage were used.

3d, as to Hearing: The agent or agents must maintain perfect silence, speaking only when it is necessary, for the purpose of the experiments, as for instance, to tell the percipient what kind of objects he is to look for, as colors, numbers, etc. All cards, numbers, and colors should be chosen at random. . . .

The first series of experiments was made with the percipient in a light trance. The objects looked at by the agent being of a miscellaneous character, and taken from different parts of the house without the percipient's knowledge. The house happened to be rented, furnished, of friends, who left their bric-à-brac, etc.

The report, made verbatim, at the time of the experiments, is as follows:

First Series.

"New York, April 3, 1892.

"Mrs. Thaw, Percipient. Dr. Thaw, Agent. Witness, Mrs. Dow.

"Aftereach experiment, the agent touched the percipient's forehead to help her into the passive state, but never selected an object for the next experiment until after the contact was discontinued.

"Agent holds first two objects against white paper.

"1ST OBJECT. *Bronze Statuette, Classic Bust, Helmet and Beard.*—Percipient in one or two minutes says: '*Is it a picture?*' At this point, referring to percipient's putting it in form of a question, witness says impulsively, 'That's not quite right.' But this remark would hardly suggest what follows. After long pause, percipient continues: '*A reproduction of the human face. Dark. A statuette. Bronze. Beard. Hat on it. Slouch hat, cap. Has a ruff.*' (Back of bust suggests a ruff.) (Experiment took ten minutes.)

"2D OBJECT. *A Pair of Scissors.*—Agent writes above report on paper in his hand. Percipient says: '*Something white.*' Agent says 'No.' '*Writing on it.*' Agent puts away paper here, as it was evidently in percipient's mind. Percipient continues: '*If not white, shiny. A white shine, not a gold shine. Roundish. Engraved. A pair of scissors.*' (Percipient says something long and sharp was in her mind from the beginning.) (Experiment lasted four minutes.)

"3D OBJECT. *A Cabinet Photo of 'X.,'* brought by agent from upstairs before sitting.—Percipient says: '*Something square. A picture. A picture of a brass bed.*' Agent says 'Wrong.' '*Photograph of X.*' (Experiment took two or three minutes.)

"4TH OBJECT. *An Old Soiled* $10.00 *Bill.*—Percipient says: '*Square.*' (Percipient on being asked what she means by 'square,' says 'Square-cornered.' *It is a book with corners. Dark in color. Made of two colors. It is a kindergarten mat made by a child.*' Agent says, 'Wrong.' '*It is another picture. Has letters on it. A picture not of something human, but of something in nature. Has a big G on it, or like an O or two O's together. It is a picture in color. The color darker than the thing. The color like ink.*' (Experiment took ten to fifteen minutes.)

"5TH OBJECT. *A Red-covered Book*, with Black Cross and Letters on cover, 'Saint Paul,' by F. W. H. Myers. Percipient says: '*I think this is something dark in color. Is it anything square? Square and dark. It is a paper-covered book.*' Agent says, 'No.' Percipient continues: '*This time it is a book. It has writing on the outside. Reddish, brownish color. Capital E on outside. Is it the book on evolution?*' 'Wrong.' '*Is there anything stuck on it?*' 'No.' (Experiment took from five to ten minutes.)

"Percipient was told the name of the book and insisted that the name of Mr. Myers was in her mind all the time, but connected with the paper-covered Proceedings of the S. P. R., and when told the book was not paper-covered, gave up the name of Mr. Myers.

"6TH OBJECT. *Agent's Watch* (with Chain).—Percipient says: '*Bright. White Bright. No, gold bright. Either a watch or chain.*' (Experiment took two minutes.)

"7TH OBJECT. *Spectacle Case.*—A shining black with letters and arabesques and an eagle in gold on it. Percipient says: '*It's square; has corners. There's writ-*

ing on it. If not writing, has a picture on it. I think it's a book or a picture on a paper. I see it reddish. Long rather than square. Like a pencil or paper cutter, or knife. It shines. White shine or silver shine.' Agent asked color of letter. *' Gold, with one or two arabesques.'* (Correct.)

"8TH OBJECT. *Long Round Brass Wire Helical Spring.* Larger at one end.—Percipient says: *' This is dark colored. No shine. Black or brown. It's hard. It shines, white shine, metal. A silver thing. It's long. It's roundish. Is it a spoon? Is it a knife? I wonder if it has any glass on it. I think it's part silver and part cut glass. Maybe it's a steel shine. Is it a hat pin?'* (The outline of the object very much resembles that of an ordinary straight hat-pin.)

"*April* 4, 1892.

"Mrs. Thaw, Percipient. Dr. Thaw, Agent. Mrs. Dow, Witness.

"9TH OBJECT. *Small China Cup,* flowers painted on it.—Percipient says: *' Round. Bright. Steel. Top of mucilage. Rather flat. Money. Has another part. Perhaps something of glass. Partly glass or crockery. Ink-bottle.'* ' Color?' *' Greenish.'*

"10TH OBJECT. *Tortoise-shell Napkin Ring,* with name in script on side.—Percipient says: *' Not bright. Not light color. Square. Writing on it.'* (This object was familiar to agent not so much as a ring as for the writing on it, and from that point of view it, of course, appears square.) *' A book. Dark with white rim.* (Rim reflecting light.) *Bottom has corners. Something breakable.'*

"11TH OBJECT. A *Small Brass Key.*—Percipient says: *' Small. Smaller than the other object. Shines. Shines white.'* (True in some lights. A light-colored brass.) *' Is it sharp? Roundness of some kind.'* Agent asks: ' What kind?' *' Roundness, flat. Roundness also of a long thing. It has a handle. It is silver. Is it a toilet article?'* ' Color?' *'It has a gold shine.'*

"12TH OBJECT. *A Small Ear Syringe. Round Bulb.*—Percipient: *' Dark. Brownish. Flat. Corners. Long. A book.'*

"13TH OBJECT. The last object of this series is a book of Mother Goose's Melodies, with a picture of Mother Goose playing piano on the cover. Percipient: *' No shine. Not dark. Not white.'* At this point, agent being a little tired, stopped actual visualization of the book as an object, leaned back in his chair, and for the first time noticing Mother Goose was playing with her claws on the piano, being amused by this, fell to thinking of the general intellectual conception of the book. Percipient suddenly says: *' It has something to do with the mind.'* Agent in surprise exclaims: ' With the mind?' in a tone which discouraged percipient at first. Percipient continues: *' It has to do with library rather than bedroom. It has to do with Art.'* Agent asks, ' What art?' (This is an error of an impulsive character such as sometimes is made.) *' It is one of my crayons. It has something to do with writing, composition. Music too. It has been in the library. Either with something done in Art or with somebody doing something in an Art.'* Agent looking at Mother Goose at this time. *' Either work done or person doing it. It has something to do with a book. It has something to do with a book with a picture in it. It has something to do with a book of pictures or of music. It is a book. It is the Mother Goose book.'*

"The Mother Goose book was in percipient's mind from the beginning, but she wanted to see if it would persist. It continued to appear at times. The image was so clear that percipient was afraid of its being a conscious thought or guess, and so put it off.

"Thus of thirteen objects six were correctly named, the fifth object being called a book correctly, though the particular book was not named. (Five of the eight objects on the first day were named correctly.) In five of the remaining seven objects, the answer indicated that the percipient was on the right track, and only two of the experiments can be regarded as complete failures."

The account thus far given we trust will enable the reader to form some estimate of the more recent results achieved in experimental thought-transference. The evidence, however, for the general theory of telepathy is not confined to such experiments as we have been considering. Hundreds of spontaneous experiences depending on first-hand testimony have been published in the records of the S. P. R., the best explanation of which appears to be that one mind can be impressed by another independently of the recognized channels of sense. These two groups of occurrences, spontaneous and experimental, cannot but be regarded as mutually confirmatory of the general theory to which the name of telepathy was given by the Literary Committee of the S. P. R., in 1882. This view was put by Mr. F. W. H. Myers, as follows, in the introduction to "Phantasms of the Living:"

"I. Experiment proves that telepathy, the supersensory transference of thoughts and feelings from one mind to another, is a fact in nature.

"II. Testimony proves that phantasms (impressions, voices, or figures) of persons undergoing some crisis, especially death, are perceived by their friends and relatives with a frequency which mere chance cannot explain.

"III. These phantasms, then, whatever else they may be, are instances of the supersensory action of one mind on another. The second thesis, therefore, confirms, and is confirmed by, the first. For if telepathy exists, we should anticipate that it would exhibit some *spontaneous* manifestations, on a scale more striking than our *experimental* ones. And, on the other hand, apparitions are rendered more credible and comprehensible by an analogy which for the first time links them with the results of actual experiment."

The quality of the evidence for the first of the above theses has already been illustrated in these pages. It would be impossible here to convey to the reader any adequate notion of the second thesis, for the details concerning which the reader is referred specially to "Phantasms of the Living," published in 1886, and the Proceedings and Journal of the S. P. R., issued since that time.

The answer to the question whether the remarkable authenticated coincidences between phantasmal experiences and events occurring at a distance may not be due to chance alone, depends on "the frequency of phantasms which *have* markedly coincided with real events, and the frequency of phantasms which have *not.*" For the purpose of ascertaining this the late Mr. Edmund Gurney conducted a Census of Hallucinations, the result of which appeared to show, on the basis of his statistics, that there was unquestionably some causal relation between the coincidental experiences. Mr. Gurney received some six thousand replies to his inquiry, and it might be alleged that this was an insufficient basis for his conclusion. A much larger census has since been made under the auspices of the International Congress of Experimental Psychology, which met at Paris in 1889. The final results of this census, which was instituted in several countries, have not yet been completed. The only definite statement on this particular point which has been announced, was made at the meeting of the Congress in London, in 1892, by Professor Henry Sidgwick, who conducted the inquiry in England. On the basis of seventeen thousand answers, Professor Sidgwick concluded that "the actual proportion of coincidental to non-coincidental cases, after all deduction for possible sources of error, was in fact such that the probability against the supposition of chance coincidence became enormous, on the assumption of ordinary accuracy on the part of informants." The details of Professor Sidgwick's inquiry will be published this year (1893) in the Proceedings S. P. R. *Richard Hodgson.*

THYMACETIN. A new analgesic, prepared and named by Hoffman, of Leipzig, and brought to the notice of the profession in 1892 at a meeting of the Berlin Association for Psychiatria and Nervous Diseases, by Professor F. Jolly. It is closely allied to phenacetin, bearing the same relation to thymol that the older drug

does to phenol. It occurs as a white crystalline powder, only slightly soluble in water. Professor Jolly described the results of a series of experiments upon animals, and its use in a number of cases of nervous and mental diseases. He did not find that it had any antipyretic action, but its analgesic and hypnotic properties were undoubted. He found it of most service in headaches and pain of a purely nervous character, but when there was any organic disease it failed to produce any beneficial effects. He considered its action equal to that of phenacetin. As an hypnotic it was administered to twenty-six patients: in sixteen, it quickly produced a refreshing sleep; in ten, it failed to relieve the insomnia. The dose ranged from 3¾ to 15 grains, the usual hypnotic dose being 7½ grains. No toxic action was noticed, but it produced an acceleratian of the pulse and a complaint in some cases of a fulness, beating, and noises in the head.

Dr. Marandon de Monteyel has given particular attention to the physiological action of this drug (*Bulletin Gèn. de Thérap.*, January, 1893) and has formulated the following conclusions:

1. Thymacetin does not seem to exercise any action on sleep, the intellect, the vaso-motor system, the genital organs, the secretions, or the intestines.
2. Without influencing any of the other reflexes, it produces in a few instances a marked double dilatation of the pupil, but without disturbances of vision, the symptoms appearing during the first hour, and lasting from thirty to forty minutes.
3. It sometimes produces immediately after its administration, but only for a short time, however, dizziness associated with a slight degree of intoxication.
4. In three-fourths of the cases thymacetin causes a slight headache, this lasting several hours, appearing usually at bed-time, and, rarely, next morning on awakening.
5. It always increases for about two hours muscular force, as measured by the dynamometer.
6. It increases the bodily temperature to about one degree, the elevation like the decline of the same occurring gradually, returning to the normal point in about two hours.
7. During a period of two hours it increases the number of inspirations without modifying their rhythm.
8. The drug also causes, during the same period of two hours, a rise in the arterial pressure and an increase in the number of pulsations, but without producing cardiac palpitations.
9. Thymacetin, in two-thirds of the cases, causes toward the afternoon great lassitude, which often persists till the following day, even after waking; but there are no concomitant physiological or psychological disturbances produced.
10. It, in all cases, modifies micturition in three ways: (*a*) it accelerates or delays the desire of urinating; (*b*) it causes a urethro-vesical spasm, a momentary retention and dysuria, but these disturbances soon disappear; (*c*) occasionally during the passage of urine a scalding sensation is felt, which also soon disappears; these occur singly or in combination.
11. Exceptionally, before micturition, thymacetin produces shooting urethral pains.
12. In two-thirds of the cases it causes a bitter taste, accompanied with a sore mouth and a coated tongue, but no special odor of the breath.
13. In most individuals it produces, during an hour or more, a burning gastric pain more often localized, but sometimes felt all over the body; rarely a scalding sensation is felt along the œsophagus.
14. It is capable of producing a marked thirst, anorexia, and also gastric disturbances, which disappear on the suspension of the drug.
15. In a general way the organs become rapidly accustomed to the action of thymacetin, especially the bladder and the urethra, the stomach, however, is the only organ to become more and more susceptible to the remedy.
16. All the preceding physiological actions are produced by small doses; still, the sensation of dizziness, the temperature, the digestion, and micturition are influenced in direct proportion to the amount of the drug ingested.
17. Of all nervous disorders, general paralysis is the least susceptible to the action of thymacetin; in such cases dilatation of the pupil, or dizziness, was never observed, and in them urethro-vesical spasm was less frequent and less marked than in cases of insanity; on the other hand, in paralytics the spasm occurred more frequently than in epileptics. *Beaumont Small.*

THYMUS GLAND, DEVELOPMENT OF. The first statements regarding the development of the thymus gland contradicted each other completely. Arnold [1] asserted that it arose in common with the thyroid from the entoderm of the pharynx, while Bischoff [2] in general denied this. Remak,[3] in his great work, confirmed Arnold, and added that this gland arises from one of the branchial clefts; but he was placed in doubt after Ecker had described the large gland in the neck of the chick as the thymus. From now on, the prevalent view continued to be that the thymus was mesodermal in origin.

We can well understand why these various views should be entertained when we consider that, for studies of this sort, the methods at that time were very crude; but in spite of all this we are under obligations to Remak for so much light regarding many problems in embryology, and it really seems a pity that his own view, which later on proved to be correct, should have been abandoned on account of his over-caution. By the more improved methods, both Kölliker [4] and His [5] observed that the thymus must be of epithelial origin, and therefore accepted the old view of Remak. It may be added that at this very same time two elaborate papers were published by Afanassiew [6] and Watney,[7] in which they attempted to demonstrate that the gland arises from the mesoderm. More accurate methods were now introduced, and it soon was demonstrated by Stieda [8] that in many animals the thymus arises from the third branchial pocket. This was also confirmed by Born [9] (and many others, [10], [19]), who in this study introduced his celebrated method of reconstruction.

In the third part of his "Anatomie Menschl. Embryonen," His [5] brought forth the view that the thymus arises from the sinus præcervicalis, and is therefore purely ectodermal in origin. This view he attempted to strengthen in a later publication,[20] and it was quite generally accepted. Later, however, in a response to a paper by the author,[14] His [21] retracts his older view and admits that the bulk of the thymus has its origin from the entodermal lining of the third branchial cleft. He therefore considers the origin of the thymus still an open question, and until more careful researches are made, accepts the view of Fischelis [22] and of Kastschenko,[23], [24] that is, that it arises from both ectoderm and entoderm.

Shortly after the branchial arches are formed there appears at the dorsal side of each cleft a thickening of the entodermal cells, which soon separate from the entoderm to form distinct groups of glands. This is the condition of things in low vertebrates, and as the scale is ascended certain groups become more and more prominent, until man is reached, when only the two groups from the third branchial pocket remain to form the thymus.

In the fishes the general relation of these glands to the branchial clefts is shown in Fig. 622. These individual glands are soon united into one large gland on either side of the pharynx; in the bony fishes these groups unite into one gland before they have separated from the pharynx. In the reptiles the number of glands are reduced (Fig. 623) to correspond with this number of branchial clefts. Van Bemmelen discovered in the elasmobranchs that the posterior cleft, or rudimentary cleft, produced a distinct body which did not unite with the thymus. This he has termed the supra-pericardial body, and later its homology was found in many classes of vertebrates. In many reptiles it is unilateral, as shown in the figure. Considering their origin, they seem to be intimately related with the thymus, but in mammals it is

probable that they are added to the thyroid, and will be discussed under that heading.

In birds the third branchial pocket gives the main origin of the thymus, as shown in Fig. 624. Here we have a sharper line of demarcation between ectoderm and entoderm, as the branchial clefts do not break through neck; while this is taking place a pit is first formed, the sinus præcervicalis of His.

From the dorsal side of the first groove an invagination unites with the ganglia of the fifth nerve; from the second, the invagination is to the ninth nerve; and from the third and fourth it is to the tenth nerve. A section

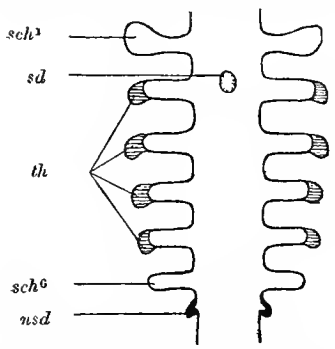


FIG. 622.—Diagram showing the Branchial Clefts and the Glands arising from them in the Shark. (From Hertwig after de Meuron.) *sch*¹, *sch*⁶, first and sixth branchial pockets; *sd*, thyroid; *th*, thymus; *nsd*, lateral thyroid.

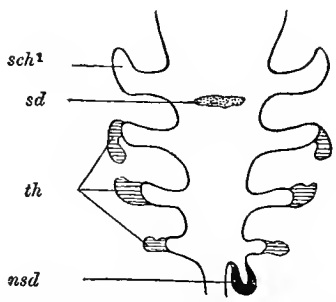


FIG. 623.—Diagram showing the Branchial Clefts and the Glands arising from them in the Reptiles. (From Hertwig after de Meuron.) *sch*¹, first branchial pocket; *sd*, thyroid; *th*, thymus; *nsd*, lateral thyroid.

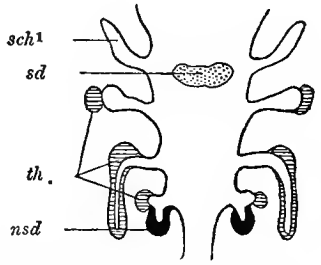


FIG. 624.—Diagram showing the Branchial Pockets and the Glands arising from them in the Chick. (Modified from de Meuron.) *sd*, thyroid; *sch*¹, first branchial pocket; *th*, thymus; *nsd*, lateral thyroid.

as in fishes. We can now state with great certainty from what embryonic layer this gland arises, provided we have good serial sections to study. Very recently Kastschenko discovered a small gland in connection with the second branchial pocket, but as yet its fate has not been determined. It is no doubt a remnant of the portion of the thymus which arises from the same place in lower vertebrates. The third branchial pocket, however, becomes very prominent, grows toward the head, and is at no time blended with the ectoderm (Fig. 625). To be sure, it comes in apposition with the ectodermal invaginations of the clefts, but recent work has shown that these have to do with the ganglia of the cranial nerves, and do not unite with the thymus as thought by His and others. Moreover, it is by no means probable that these sense-organs of Froriep and Beard should suddenly leave the nerve-ganglia in certain regions and unite with glands. Both observations and principles of development contradict this. The fourth branchial pocket, as well as a rudimentary fifth (fossa subbranchialis), gives rise to a few small bodies, the nature of which is not as yet truly known. That, from the rudimentary fifth, no doubt, gives the gland which is homologous with Van Bemmelen's supra-pericardial body.

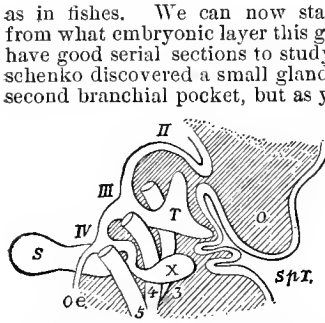


FIG. 625.—Dorsal View of a Reconstruction of a Chick 110 hours old. × thirty-five times. *II*, *III*, and *IV*, branchial pockets: *O*, operculum; *S*, thyroid; *spr*, sinus præcervicalis; *T*, thymus; *X*, body derived from the fourth branchial pocket; *oe*, œsophagus.

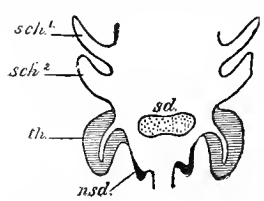


FIG. 626.—Diagram showing Branchial Pockets, and the Glands arising from them in the Human Embryo: *sch*,¹ *sch*,⁴ first and second branchial pockets: *th*, thymus: *sd*, thyroid; *nsd*, lateral thyroid.

In mammals the condition of things is much simpler (Fig. 626). The branchial grooves lie on the outside of the body, are shallow on their dorsal side and deep on their ventral. As these arches fall over one another, the grooves as well as the third and fourth arches are buried in the side of the

through these organs in the region of the vagus and of the thymus is shown in Fig. 627. The ectodermal invagination is absolutely blended with the vagus and is only in apposition with the thymus.

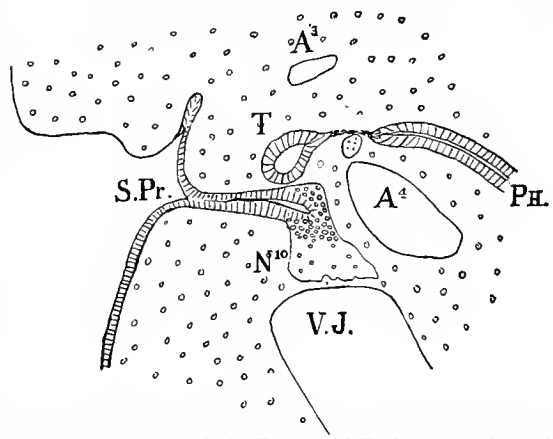


FIG. 627.—Section through the Thymus and Fundus Præcervicalis of a Dog's Embryo, 10 mm. long × 80 times. *Ph.*, pharynx; *A*³, *A*⁴, aortic arches; *S.Pr.*, sinus præcervicalis: *V.J.*, jugular vein; *T.*, thymus still in connection with the pharynx.

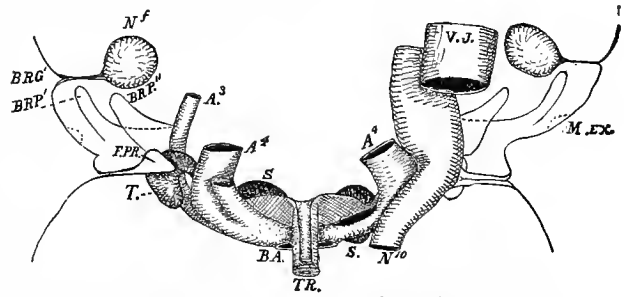


FIG. 628.—Dorsal Reconstruction of the Branchial Region of a Dog's Embryo, 10 mm. long, × 25 times. *N^f*, *N*¹⁰, ganglia of facial and vagus nerves; *BRP'*, *BRP''*, branchial pockets; *BRG*, branchial grooves; *A*³, *A*⁴, aortic arches; *BA*, aortic bulb; *Tr.*, trachea; *M.ex.*, external meatus of the ear; *S*, thyroid; *T*, thymus; *F.PR.*, fundus præcervicalis.

The pharynx-side of the branchial clefts presents about the same appearance as the external. The entodermal lining is in the form of slit-like pockets, which are better called branchial pockets, to differentiate them from the ectodermal side, or branchial grooves. As the head flexes upon the body the pharynx widens near the mouth and becomes narrower where the trachea is formed. There is a peculiar kinking of this region due to the rotation of the head. The first branchial pocket is converted

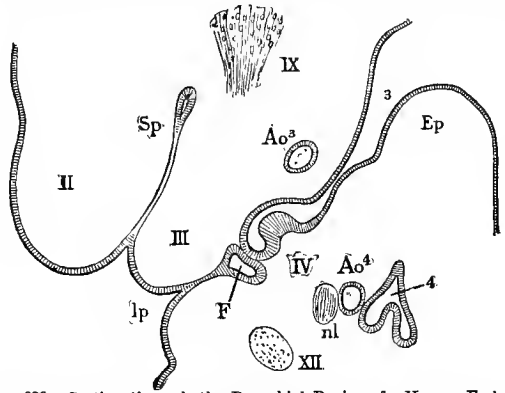


FIG. 629.—Section through the Branchial Region of a Human Embryo, Five Weeks Old. (From Minot after His.) *II*, *III*, *IV*, branchial arches: *Sp.*, second branchial grooves; *Ip.*, infundibulum præcervicale; F, fundus of the infundibulum; 3, 4, third and fourth branchial pockets, with the thymus arising from the third; *Ao³*, *Ao⁴*, aortic arches; *Ep.*, epiglottis; *IX*, glosso-pharyngeal nerve ganglion; *XII.*, hypoglossal nerve; *nl*, superior laryngeal nerve.

directly into the Eustachian tube; the second disappears completely; the third forms the thymus (Fig. 628); and the fourth becomes rudimentary and gives rise to the auxiliary thyroid glands.

The general appearance in the human embryo is quite similar to that in other mammals, as Fig. 629 shows. Already in this early stage of development, the third branchial pocket shows an ingrowth which indicates the origin of the thymus, The portion of the cleft represented by the fundus (F) is not continuous with the

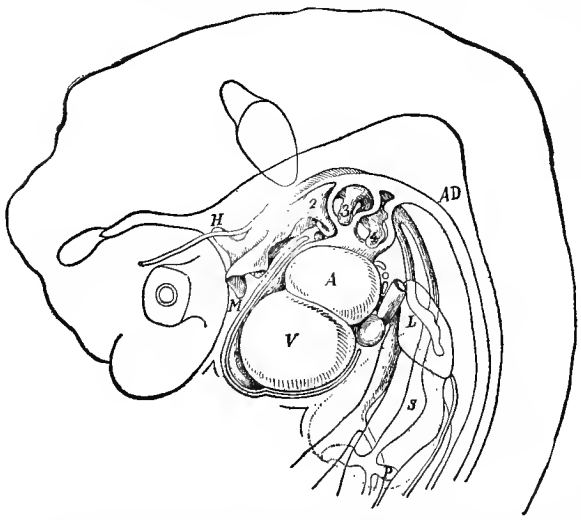


FIG. 630.—Reconstruction of a Human Embryo enlarged sixteen times, and viewed from the left side. *II*, hypophysis; 1, 2, 3, and 4, branchial pockets; *M*, mouth; *A*, auricle; *V*, ventricle; *AD*, descending aorta: *L*, lung; *S*, stomach; *P*, pancreas.

thymus tube, and no doubt never plays any part in its formation.

The general view of the branchial pockets in a human embryo is shown in Fig. 630. The whole pharynx is represented as a cast and the branchial pockets are represented by the figures 1, 2, 3, and 4. It is the one marked 3 which is destined to become the thymus. It soon becomes separated from the pharynx and then grows into the thorax.

Before the thymus is separated from the pharynx it contains a distinct lumen. This is soon lost in birds, where the thymus grows toward the head. In mammals, where the thymus grows into the thorax, the upper part contains a lumen, while the lower part grows by a mass of sprouts (Fig. 631). This continues for quite a while until the whole organ is lobulated. New blood-vessels and lymph-cells grow through the epithelial gland and change its nature. The entodermal cells become packed together into the Horsal's concentric bodies as shown by Maurer for the fishes, and by Ecker[25] and by His[26] for mammals. These bodies correspond with the "pearls" in carcinomata, which are present in cancers, that arise from the whole epidermis, as well as those from the œsophagus. The Horsal's bodies do not therefore indicate that the thymus arises from the ectoderm.

During the first two years of life the organ continues to grow and the two halves gradually approach each other more and more, until they seem as a single body. It now lies immediately in front of the heart, and often sends two horns which extend on either side of the neck to the thyroid, as is the case in the birds. From now on, the organ gradually atrophies. *Franklin P. Mall.*

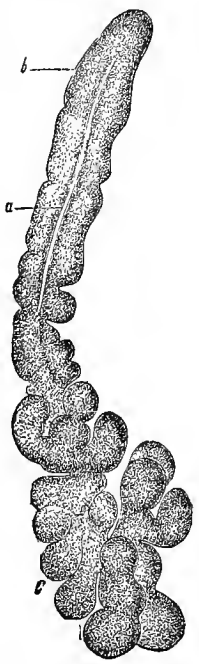


FIG. 631.—Thymus of a Rabbit Embryo Sixteen Days Old. After v. Kölliker. *a*, Duct of the thymus; *b*, head of the thymus; *c*, posterior enlargement of the gland.

[1] Arnold: Medicinische-chirurg. Zeitung, 1831.
[2] Bischoff: Entwicklungsgeschichte. Leipzig, 1842.
[3] Remak: Entwick. d. Wirbelthiere. Berlin, 1855.
[4] Kölliker: Entwicklungsgeschichte, 1879.
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[26] His: Zeit. f. Wiss. Zool., Bd. 9.

THYMUS GLAND: PATHOLOGY. In 1888 the practically discarded view that a form of asphyxia (asthma thymicum) dependent upon enlargement of the thymus, occurs in children, was revived by Grawitz. Since then a number of cases have been reported, having the clinical history of sudden death from suffocation, when the only abnormality discoverable *post mortem* was a marked enlargement of the thymus, usually associated with a more or less marked ecchymosis of its tissue. The difficulty in accounting satisfactorily for many cases of sudden death in children, and the frequency with which objective anatomical changes are absent, has perhaps

led to too much importance being attached to this lesion.

Clinically, the cases recorded have usually presented the symptoms of spasms of the glottis, with or without eclampsia. In half the cases the fatal attack was the first indication of illness; in the remainder, previous milder attacks of laryngismus had been noticed during the preceding week or fortnight. In a few cases these attacks had recurred with increasing severity.

In more than half the cases a moderate degree of rachitis is recorded. In about one-fourth no observation is recorded on this head. One-fourth are stated to be perfectly sound, and, especially, free from rachitis.

In a number of cases the fatal attack has immediately followed a bending backward of the head, as, for instance, when inserting a tongue spatula into the mouth (Pott).

The symptoms, as observed by Pott in four cases, were as follows: For several weeks attacks of laryngeal spasms had occurred several times daily. In the fatal seizure the children bent the head backward, with a noiseless gasping inspiration. The eyes were turned upward and the pupils dilated. The face, especially about the lips, became livid and swollen. The tongue, held between the teeth, became deeply cyanosed, and swelled to double its normal thickness, being pressed firmly upward against the hard palate. The veins of the neck were distended to the utmost and stood out like thick cords. The hands were clenched and the nails cyanotic. The legs were extended, the feet abducted and strongly extended. The vertebral column was curved backward. A few rapid twitches of the facial muscles followed, and afterward several gasping (*schnappend*) inspiratory movements without any audible inspiratory sound. Suddenly, the spasm relaxed, and the face became ashen-gray, with livid tongue and lips. Death ensued in one or two minutes from the onset of the attack. The heart's action ceased at the beginning of the seizure. Cervical reflex was lost immediately. No sounds of coughing or choking were heard. Artificial respiration, tracheotomy, and stimulation of the phrenic nerves produced no result. Urine and fæces were sometimes extruded on commencing the artificial respiration.

The post-mortem changes showed the heart distended, with dark cherry-red (?) blood. The vessels throughout the body moderately full. Lungs pale red, crepitant, sometimes with subpleural ecchymoses. In only a few of the cases, extensive areas of collapse, broncho-pneumonia, etc., were present, but these cases cannot be regarded as quite typical. Small emphysematous spots of distention beneath the pleura were commonly present. Larynx and trachea unaltered. Brain moderately full of blood, apparently normal. No alteration in phrenic or vagus nerves. The *thymus gland*, of a bluish-red color, often with ecchymoses. Size usually five to seven ctm. long, five to six ctm. wide, and two to three ctm. deep. Often extends over the right auricle, and in one case extended as far as the apex of the right ventricle. The lymphatics throughout the body were usually enlarged.

The explanations given as to the manner in which the thymus enlargement may be supposed to induce death vary with the different authors, and are in no case very convincing. It has been maintained that death is due to sudden pressure on the trachea, the space between the posterior surface of the sternum and the vertebræ being only about two ctm. in diameter in growing children. On the other hand, Scheele has shown that a considerable force (about 1,000 grammes) is necessary in order to compress the trachea; and the trachea never showed any post-mortem appearance of having been compressed. Another explanation given is that the pressure acts upon the right auricle or pulmonary artery. It is generally assumed that an acute venous congestion of the thymus is the main cause of the enlargement, and that the bending backward of the head, by disturbing the relations of the organs in the neck, tends to aid this. The original hyperplasia of the thymus is considered only to act as a predisposing cause.

It cannot be said that satisfactory mechanical grounds have been established for this cause of death. The clinical history seems to point to a disturbance of the venous system, possibly in the respiratory centres, rather than to mechanical suffocation. A. Paltauf denies the influence of the thymus hypertrophy, and considers the asphyxia as due to œdema of the bronchial mucosa.

The importance of the subject is due to the large number of otherwise unexplainable cases of sudden death from asphyxia in children, and in forensic cases the condition of the thymus should always receive attention.

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Wyatt Johnston.

THYROID EXTRACT. The treatment of myxœdema by the reintroduction, into the organism, of the gland itself, or fluids obtained from the gland, has been the natural outcome of the numerous experiments to determine the nature of that curious disease, and the relation between it and the thyroid gland. It was very clearly demonstrated that the absence of the thyroid, whether by disease or removal, resulted in all the phenomena characteristic of myxœdema, and further experimental work showed that, in animals, the grafting of a gland into the tissues prevented the onset of these symptoms, or if the degeneration had begun it was at once arrested and a normal state renewed. The first operation on the human subject was performed in Paris by M. Lannelongue, who reported the case to the Biological Society, March 7, 1890. The patient was a cretin, fourteen years of age, in whom the disease was well marked. About two-thirds of the thyroid of a young sheep was removed and immediately transplanted into the subcutaneous tissue below the right breast. The operation was done aseptically and the wound united without fever or suppuration. This was followed by numerous other cases, and the first successful performance in England is recorded by Dr. W. J. Collins, on May 2, 1892, at the Temperance Hospital, Hampstead Road. In all the cases reported the beneficial effects were remarkable. Within twelve hours some of the most distressing symptoms, such as menorrhagia, headache, and melancholia were relieved, and the improvement continued until, in some cases, the patients were apparently cured. The ultimate results, however, have not been recorded. The hope of the operators was to have the gland "vitalized" and restored to its functional powers in its new position. That this may occur is believed, as the beneficial effects were maintained for a prolonged period in many of the cases. Upon this the permanency of the cure depends, for if the graft is reabsorbed the condition of affairs that was present before the operation is likely to recur.

At the meeting of the British Medical Association in 1891, Mr. George Murray, of Newcastle-on-Tyne, proposed the subcutaneous injection of the fluid portion of the thyroid gland in the place of the transplanting of the gland, and reported his success in treating the disease by that method. He pointed out that the rapid effect produced by the older method must be due to the immediate absorption of the fluids in the fresh gland, and as for any permanent benefit, he did not consider that there was sufficient evidence to show that the gland ever became "vitalized." The good effects, he considered, were only temporary, and the operation would have to be repeated at frequent intervals. The advantages of the injections were very evident.

The following directions were given for preparing the extract: Cut the gland into transverse slices on a clean glass or earthenware plate, which has been rinsed in a five per cent. carbolic acid solution. All the utensils employed in the subsequent operations must be cleansed in the same fluid. Place the sliced glands in a mortar with some ordinary glass tubing; about two inches will be sufficient for a gland; and grind the whole up together until

the glands are thoroughly disintegrated. A fluid drachm of a mixture of equal parts of sterilized glycerine and a five per cent. solution of carbolic acid in water is then to be added, and when well triturated, transfer to a small stoppered vessel, and macerate for twenty-four hours. At the expiration of this period, squeeze out the fluid through a piece of muslin and filter through a double layer of sterilized paper under pressure. With a pressure equal to fifteen inches of mercury, a nearly clear filtrate of pale-yellow color is obtained, measuring about the same volume as the fluid added to the glands. If a pressure-filter cannot be used, it will be sufficient to pour off the supernatant fluid that separates during the twenty-four hours' maceration. In this case much less extract is obtained. Of the extract fifteen minims are employed for each injection, to be repeated every second or third day. The extract should not be used after four or five days, as it then causes some local disturbance. This method of administering the thyroid juice became general, and the same rapidly favorable results followed its employment.

The following year, Dr. H. W. G. Mackenzie reported a case in which he found the beneficial effects of the gland could be as satisfactorily obtained when administered by the mouth as by the other methods. At first he ordered his patient two fresh glands every day, but found that much less was sufficient; one gland twice a week, he stated, was quite sufficient, and, after the treatment has been continued for some time, a single gland once a week, or once a fortnight, would be all that was required to maintain its beneficial action. The gland may be given minced and mixed with a small quantity of brandy or beef-tea to overcome the nauseating taste, or the juice may be separated by allowing the minced gland to stand for half an hour with a few teaspoonfuls of water, and then straining through a piece of muslin. The extract may also be prepared by using glycerine, as in the method suggested by Dr. Murray for hypodermic use. The dose of the glycerine extract requires to be greater than when used hypodermically, twenty minims being given every day or every second day, until its influence is very decided. Priority in the internal use of the glands is claimed by Dr. Howitz, professor of clinical surgery at Copenhagen, who states that he used the glands in this way as early as March, 1892. He employed the glands of the calf, and gave them boiled, minced, and seasoned in various ways, together with the water in which they were boiled.

This internal use is followed by the same favorable results as when the extract is administered subcutaneously. In the cases reported an improvement was noticed during the first twenty-four hours, and before the third day the improvement in the symptoms and general condition was most decided. No ill effects were ever detected, except in a few instances when large quantities were given and continued for some days; in these cases an increase in the pulse-rate was noticed and the heart appeared to be enfeebled.

The internal administration is now very generally adopted, as the hypodermic medication is not without its unfavorable accompaniments. Very frequently pain and induration occur at the site of the injection, and occasionally an abscess supervenes. Great care also is required in preparing and preserving the extract, and there is always the risk of the fluid becoming impure and dangerous to use. The fresh gland is frequently employed, and it has been found that a moderate degree of heat does not lessen its virtues; but the extract prepared by macerating the gland in glycerine and water is the form in which it is preferred. A solid extract is now furnished, five grains of which represent the average dose of the gland. It is described as being prepared by extracting the secretion of the gland with glycerine and water, acidulating the liquid with phosphoric acid, and drying with sulphuric acid. Another dry extract is prepared by Dr. Howitz, by the addition of alcohol to the glycerine extract: this is given in doses of one-half to five grains.

The treatment of the disease really consists of two stages: the first, in which the disease is being overcome, and the second, in which the healthy state is being maintained. In the first period the quantity required is mentioned above, in the second the dose is not very definite. A single gland every week or every second week is thought to be sufficient, or if the extract is used, a dose of fifteen or twenty minims every second week is recommended. Dr. Murray estimates that the normal secretion is about one minim a day, and this should be supplied as nearly as possible.

It is early to estimate the value of this treatment, but it certainly gives relief and dissipates the disagreeable symptoms in a very short space of time. All observers are united in their praises of its effects, and no unfavorable reports have appeared to counteract its successes. Time and experience only can tell what the ultimate result will be.

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Beaumont Small.

THYROID GLAND, DEVELOPMENT OF. Shortly after Rathke discovered the branchial arches in higher animals, Huschke[1] advanced the idea that the thyroid gland arises from the first arch. Later, however, he states that after the arches disappear the thyroid remains as their remnant.[2] A year later, Rathke[3] asserted that the thyroid arises as a bilateral organ from the posterior part of the trachea, immediately behind the larynx. This view was affirmed by Arnold.[4] Bischoff[5] accepted neither of these views, but added a third. According to him, the thyroid arises as a bilateral organ from the blood-vessels on either side of the neck.

The first careful investigations were made by Remak[6] upon the chick. In this subject, as well as in many others in embryology, he was the first to give accurate information. He found that the thyroid is entodermal in origin and arises from the ventral median line of the pharynx. At first it appears as a single vesicle, which soon divides into two parts, each half lying on either side of the trachea. Götte,[7] Müller,[8] and Seessel[9] confirmed Remak's views in general, differing only in minor points. They discussed whether or not the organ divided is a vesicle or is a solid body, although none of them found stages in which the thyroid was dividing. Remak placed the origin of the thyroid at seventy-nine hours in the chick; Müller in the third day; and Seessel very definitely in the second day before the head flexed upon the body.

His[10] revived the old view of Rathke by discovering that certain bodies arise from either side of the pharynx; he believed them to be the thyroid and the auxiliary thyroid of Remak. According to the illustrations which accompany his paper, the gland arises from the branchial cleft between the second and third aortic arches, therefore the second cleft. Later, however, he abandoned this view and accepted that of Seessel, who worked under his guidance. Later, Kölliker[11] accepted the old Remak-Seessel view for the rabbit, as His[12] did for man.

This group of excellent workers seemed to set the subject aside for a while, but, immediately following their work, two authors simultaneously described the thyroid as being bilateral in origin, arising from a branchial cleft on either side of the neck. Stieda[13] proved definitely that a glandular organ arises from the clefts on either side of the neck, but did not know from which cleft, although he was inclined to accept the fourth. Wölfler[14] did not employ very accurate methods, and therefore got the location of the origin of the gland in the first branchial cleft—the one which later forms the Eustachian tube. He was so enthusiastic over his discovery that he denied altogether a median thyroid, although he had never seen the thyroid in connection with any cleft. Discussions naturally bring forth more accurate investigations, and in this case they bore their fruits in Born's paper.[15] The paper of Born not only threw a great deal

of light upon the subject in question, but also added greatly to our methods of investigation. He introduced a method which to us now seems so logical that it is a surprise that it was not employed earlier. He began with embryos of the pig before the thyroid appeared, and followed them stage by stage until the organ was fully formed. In each stage the enlarged sections were drawn upon wax plates of the proper thickness, then cut out and the pieces piled upon one another, thus forming very accurate models of the various specimens studied. He then followed the lateral thyroids of Stieda and Wölfler, and found that later on they were added to the median thyroid of Remak. The great difficulty was therefore solved by this method. Instead of these various authors contradicting one another, they in reality described correctly only different portions of the same story. According to Born the lateral thyroids arise from the fourth branchial clefts. Since then, Born's view has been confirmed in a variety of mammalian embryos by different writers.[16–26]

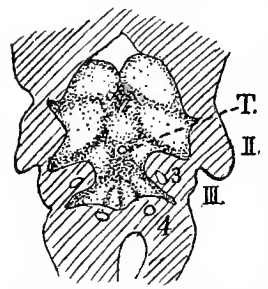


FIG. 632.—Reconstruction of the Mouth of a Chick Eighty-eight Hours Old. The floor of the mouth is exposed by cutting off the back of the head. Dorsal view. × 20 times. *T.*, tuberculum impar, back of which is the opening of the thyroid; *II*, *III*, branchial arches; 3, 4, third and fourth aortic arches.

The subject of the origin of the thyroid and thymus (see Thymus) has been greatly complicated by a group of glands which arise from the degenerating branchial clefts and form the so-called auxiliary thyroid glands. From a phylogenetic standpoint all glands which arise from the clefts must be viewed as thymus. The great bulk of thyroid arises from the ventral wall of the pharynx in the region of the second cleft. As the clefts gradually disappear in the evolution of the vertebrates, the glands from the hindermost clefts no longer unite with the main bulk of the thymus, and often remain as distinct glands—the supra-pericardial bodies of van Bemmelen, accessory thyroids of de Meuron, post-branchial body of Maurer, or as the corpus Y of the writer.[26] In the mammals the main bulk of the thymus arises from the third cleft, and the auxiliary thyroids seem to unite with the median thyroid as described by Born. In spite of the great amount of work which has been done upon this subject, it still seems to the writer that there is yet considerable darkness regarding it.

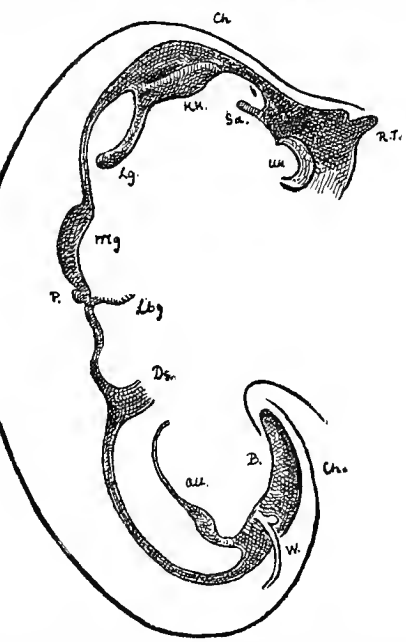


FIG. 633.—Abdominal Canal of a Human Embryo. × 20 times. (After His.) *Uk*, lower jaw; *Sd.*, thyroid; *Lg.*, lung; *Mg.*, stomach; *P.*, pancreas; *Lbg.*, bile-duct; *W.*, Wolffian duct.

The general view is that the thyroid has three distinct origins in nearly all vertebrates—a median and two lateral. The median arises from the ectoderm of the middle line in the neighborhood of the second branchial arch (Fig. 632), and the lateral from the most posterior branchial clefts; in mammals, the fourth.

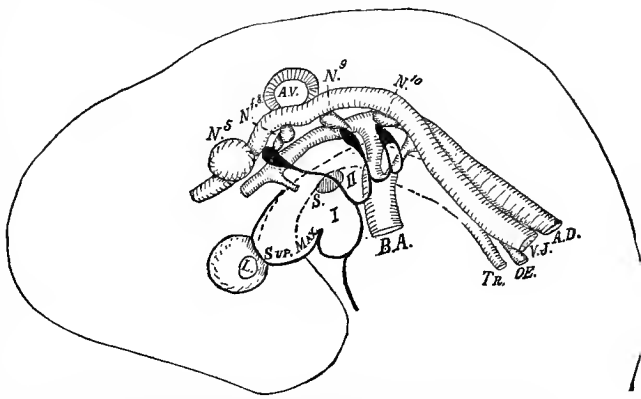


FIG. 634.—Profile Reconstruction of a Dog's Embryo, 6 mm. long. × 25 times. N^8, $N^{8'}$, N^9, N^{10}, ganglia of cranial nerves; *I*, *II*., branchial arches; *A. V.*, auditory vesicle; *Tr.*, trachea; *OE.*, œsophagus; *V.J.*, jugular vein; *A.D.*, descending aorta; *B.A.*, bulbus aortæ; *S.*, thyroid gland.

The median thyroid arises in all vertebrates from the entoderm of the pharynx shortly after the branchial arches are well formed (Fig. 632). This has been known since the time of W. Müller, and, although contradicted many a time, has of late been verified by so many careful observers that there is no longer any doubt whatever regarding it. In some mammals (the dog, for instance) it arises as a vesicle, which becomes solid before it separates from the pharynx, and when separated soon becomes lobulated. It now gradually shifts itself into the tissue of the neck, and in early stages lies in front of the aorta just as it leaves the heart (Fig. 634). The median gland now becomes constricted into two parts, one of which is situated on either side of the neck, but they remain connected by a band—the isthmus. Its origin in the human embryo is much the same (Figs. 635 and 636). According to His, it remains a vesicle for quite a long time, and the separation from the pharynx is quite late or may not take place at all. Later, however, the formation of the ligamentum hypothyroideum cuts the duct (*d. thyreoglossus*) into two, thus forming two ducts. The half communicating with the mouth has been termed by His *ductus lingualis*, and the one with the thyroid as the *ductus thyroideus*. His has found the ductus lingualis in five

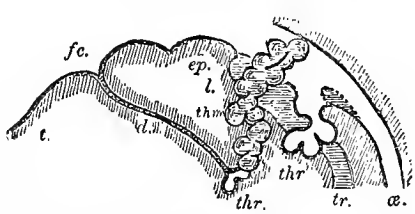


FIG. 635.—Pharynx, Thyroid, and Thymus of a Human Embryo. × 25 times. (From Quain after His.) *tr.*, Tongue; *fc.*, foramen cæcum: *ep.*, epiglottis; *thm.*, thymus; *thr.*, median thyroid; *thr'*, lateral thyroid; *d.*, ductus thyreo-glottus.

adults, and in all cases the ductus thyroideus was present also. The latter is always imbedded in a median lobe of the thyroid, and the former opens into the foramen cæcum of the tongue. The ductus thyreoglossus may be broken into a series of vesicles, as first described by Verneuil, but as a rule it disappears fully, its only remnant being the foramen cæcum.*

The lateral thyroids were first demonstrated by Stieda and by Born, although Rathke, His, and others had in

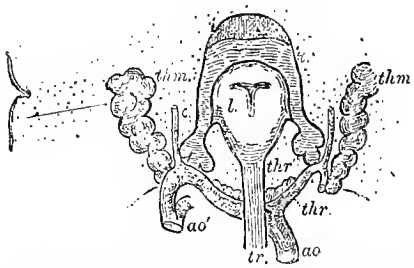
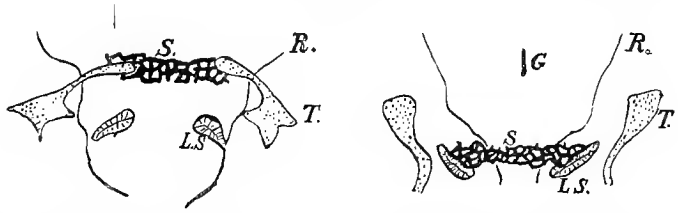


FIG. 636. — Reconstruction of the Thyroid, Thymus, and Pharynx of a Human Embryo five weeks old. (Slightly modified from His.) *thm.*, Thymus; *thr.*, thyroid; *c.*, carotid; *ao'.*, ascending aorta; *ao.*, descending aorta; *tr.*, trachea.

the neck, as in the auxiliary thyroid glands, which have perplexed so many investigators. According to Kastschenko the lateral thyroid of mammals plays a very minor part in the formation of the mature organ, while according to His it forms the major part. A true blending of the two does, however, take place, as shown by the investigations of Born and His. (Fig. 639.)

The further development of the thyroid is by means of sprouting, so that the enlarged organ is a plexiform mass of cylinders of epithelial cells. Blood-vessels grow in between them, and soon the cylinders show constrictions which cut them up again and again. They now become hollow, and at the same time there is a secretion of the colloid substance. The cut-up cylinders become more and more distended, and thus the adult thyroid is



FIGS. 637 and 638.—Diagrams of two stages of the development of the lateral thyroids. Slightly modified from Born. *R.*, border of the pharynx; *T.*, thymus; *G.*, glottis; *L.S.*, lateral thyroids.

all probability described them from time to time. The true meaning of them was fully made out by Born and by de Meuron, the former having discovered that they unite with the median thyroid in mammals, the latter having studied them from a comparative standpoint. Diagrams of the branchial pockets for some of the different classes of vertebrates are given in the article Thymus, and by them it is shown that a rudimentary branchial pocket exists in all of the classes. In certain reptiles there is but a single one on the left side, the one on the right not having developed. We can view this state of things only as an intermediate one between the reptiles (in which they develop on both sides) and the birds. In all classes the hindermost cleft gives rise to a distinct gland known as the supra-pericardial body of van Bemmelen and as the accessory thyroid of de Meuron.[28-30] In the selacians these bodies remain far away from the median thyroid, and they never unite with it. In higher animals they gradually approach the median thyroid nearer and nearer, and in mammals they unite completely with it. Fig. 636 shows the general relation of these glands in a human embryo before the lateral thyroid is fully separated from the pharynx. Figs. 637 and 638 show two stages in which the lateral thyroid is approaching and uniting with the median. This is brought about by a double shifting. The median thyroid sinks deeper and deeper into the tissue of the neck, and practically lies in contact with the lateral thyroids before they separate from the pharynx. When these in turn separate from the pharynx they are shoved into the tissue of the median thyroid instead of into the ordinary mesoderm tissue of the neck.

It will be noticed that the lateral thyroids do not always arise from the same branchial clefts: in selacians from the seventh; in reptiles from the fifth; in mammals from the fourth. It is only in mammals that they really unite with the median thyroid. Viewing the thing from the standpoint of homology, what is lateral thyroid in mammals is thymus in lower animals; in both selacians and reptiles the fourth cleft gives rise to a portion of the thymus. We must therefore view the lateral thyroid as a portion of the thymus which is now united with the thyroid. In lower animals the secondary union of the gland from degenerating clefts with the median thyroid does not take place, and they remain in the tissue of composed of a mass of hollow spheres covered with a layer of epithelial cells and filled with colloid substance. When half of the thyroid is removed by an operation or otherwise, the remaining portion soon loses its colloid and returns to its "embryonic state." It enlarges to its

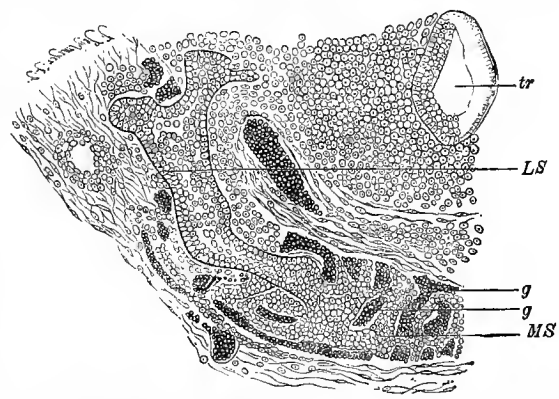


FIG. 639.—Section through the Thyroid of the Embryo of the Pig, 21.5 mm. long × 80 times. From Hertwig after Born. *tr.*, Trachea; *L.S.*, lateral thyroid; *MS.*, median thyroid; *g,g.*, blood-vessels.

former size and again forms the colloid spheres much after the fashion it did in the embryo.[31]

Franklin P. Mall.

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* From the standpoint of evolution it is interesting to note that Dohrn [27] has advanced the hypothesis that the thyroid represents a lost branchial cleft. These speculations are, of course, the natural outcome when genetic relation is taken into consideration in the study of comparative embryology.

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[28] Van Bemmelen: Kin. Akad. d. Wet, Amsterdam Afd. Nat. 1885.
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THYROID GLAND: PATHOLOGY. Goître.—In the past few years total extirpation of the gland has been practically abandoned, on account of the tendency to myxœdema observed after this treatment. Enucleation of the tumor or partial extirpation is not, as a rule, followed by myxœdema; and as the portions of thyroid tissue left tend to undergo a spontaneous atrophy, the objects of operative treatment are equally well attained by partial extirpation. Electrolysis has been also reported as successful in several cases.

Lustig has advanced the remarkable hypothesis that goître is caused by a specific bacillus present in certain drinking-waters. He claims to have produced it experimentally, in uninfected localities, in horses which were made to drink freely of certain water taken from the Aosta Valley, where cretinism and goître are endemic. He also claims to have isolated a specific water bacillus from these waters, not found elsewhere. In the absence of any experimental evidence from the employment of pure cultures, the conclusions of this author appear to be premature. Filtration and boiling of water are recommended by him as prophylactic measures.

A. Wölfler ("Zur Chirurgischen Anatomie und Pathologie des Kropfes und Nebenkropfes." Arch. der Chir., XL., 1890), in an extensive monograph on the subject of thyroid tumors, retains his classification of (a) Hypertrophy of the Thyroid (uniform enlargement); (b) Vascular Goître, of clinical significance only, without any definite histological relations to true hyperplasia of the thyroid; (c) Fœtal Adenoma; nodular insular overgrowths of imperfectly developed thyroid tissue, situated deep in the gland substance; (d) Adenoma gelatinosum —colloid goître. In the same article a large number of anomalous situations of the overgrowths are instanced (retro-sternal and intro-thoracic goître, etc.). Accessory thyroid tumors are regarded by Wölfler as sometimes arising from detached rudiments of the gland itself, at other times from the thyreo-lingual duct or accessory thyroid glands. The existence of these latter plays an important rôle in causing the goître to assume unusual forms, or to occur in unusual situations. Their origin appears to be either in the remnants of the lingual duct or in the aortic glands.

R. Paltant considers ("Ziegler's Beiträge zur Path. Anatomie," XI.) that the cylindromata occasionally found near the bifurcation of the carotid have nothing in common with accessory thyroid glands, but form a distinct group of tumors.

Intra-tracheal Struma.—R. Paltant, as the result of a careful study of the subject of growths of thyroid tissue occurring within the trachea, has come to the conclusion that the condition is not caused by the formation of isolated embryonic rudiments, which become accessory glands, but rather are simply offshoots of the main thyroid gland, and arise in extra-uterine life. The essential condition necessary appears to be a fusion of outlying portions of the thyroid with the cartilage of the trachea, or with the thyroid cartilage during fœtal life.

Myxœdema.—The Myxœdema Committee of the Clinical Society of London has published a special report upon this subject, in which 109 cases are tabulated, and which contains a number of interesting observations.

The following are the conclusions arrived at: (1) That myxœdema is a distinct disease which is (2) commonest in middle age, and affects women oftener than men, in the proportion of 6 to 1. That (3) the one condition common to all cases is a destructive change of the thyroid gland, of which (4) the most common form consists in the substitution of a delicate fibrillar tissue for the proper glandular structure of the thyroid. (5) That there is an interstitial development of fibrous tissue, which, while most frequent in the skin, is also met with in the viscera, and is suggestive of an irritative process. (6) That the anatomical observations, while showing cause for changes in the skin, hair, etc., and for the falling out of the teeth, in the alteration and gelatinous infiltration of the interstitial tissue, afford no explanation of the affections of speech, movement, sensation, consciousness, and intellect which form part of the disease. (7) That chemical examination of the comparatively few available cases fails to show the existence of an excess of mucin in the tissues, corresponding to the amount recorded in the first observations (Ord), but that this discrepancy may be in part due to the fact that liquefaction of the integuments, though generally characteristic of myxœdema, varies considerably throughout the disease and often disappears before death. (8) That in experiments made upon animals, especially on monkeys, symptoms resembling in a very close manner those of myxœdema have followed the removal of the thyroid gland, performed under antiseptic precautions and with, as far as could be ascertained, no injury to the adjacent nerves or the trachea. (9) That in such experimental cases a large excess of mucin has been found to be present in the skin, fibrous tissues, blood, and salivary glands: in particular the parotid gland, which normally contains no mucin, presented this substance in quantities corresponding to what would normally be found in the submaxillary gland. (10) That the full analysis of the results of removal of the thyroid gland in man, demonstrates, in a large proportion of the cases, that the subsequent development of symptoms corresponds exactly with those of myxœdema. (11) That in cases where the operation has been followed by no such symptoms, the immunity is probably due to the presence and subsequent development of accessory thyroid glands, or to the incomplete removal of the thyroid, or to insufficiently long observation of the patients, after operation. (12) That while injury to the trachea, atrophy of the trachea, injury to the recurrent laryngeal nerves, injury to the cervical sympathetic, and endemic influences, have been assumed to be the true cause of operative œdema, there is, in the first place, no evidence to show that, of the numerous and varied operations on the throat (neck), any have been followed by these symptoms, save when the thyroid gland has been removed; and that myxœdema has occurred in patients whose thyroid glands have been removed, but who never lived in localities subject to endemic cretinism. (13) That whereas, in spontaneous cretinism, women are more commonly affected than men, in the operative form no important numerical difference has been observed. (14) That myxœdema in adults is the same as sporadic cretinism in children; and that myxœdema is identical with cachexia strumipriva, a close affinity existing between the former and endemic cretinism. (15) That while these several conditions appear to depend upon loss of function or destruction of the thyroid gland, the ultimate cause of such loss or destruction is, at present, not evident.

Course of the Disease.—Improvement in about fifty per cent. Stationary in twenty-five per cent. Fatal in fifteen to twenty-five per cent., death being often due to some intercurrent disease. Of 12 deaths tabulated by the Clinical Society there were: Pneumonia, 3; bronchitis, 1; exhaustion, 2; coma, 2; collapse, 1; suffocation, 1; increasing slowness of mind, 1; emaciation, 1.

An analysis of the 109 cases gives the following results:

Symptoms.—Personal and family history: Tends to occur in connection with neurosis and phthisis; sometimes hereditary. No connection with syphilis. Most frequent in married women, in whom child-bearing has been excessive. Is no bar to pregnancy.

State of patients: Constant increase in bulk and weight. Swelling most conspicuous in face and head, but usually involves the whole body. Physiognomy is "cretinoid," "mask-like," "placid," or "heavy." Features puffy

and coarse. Eyelids swollen and transparent, eyebrows raised. Extremities swollen and clumsy-looking, usually cold. Nails stunted and brittle. Hair dry and brittle; tendency to baldness. *Thyroid* shows distinct tendency to diminution. Temperature subnormal; a rise to normal temperature in myxœdematous patients often indicating pyrexia. Watery dropsy sometimes present about ankles—always slight and transitory. *Sensation* retarded in about half the cases; abnormal tactile sensations common. Paresis common, especially about the neck. Severe paralysis only occurs through some complication. Incoördination common. Contractures rare. Reflexes usually normal: in a few cases delayed, occasionally exaggerated.

Intellectual changes: Slowness in thought and action almost invariably present. Writing good. Irritability usually marked, sometimes alternating with abnormal placidity. Sleep usually good, sometimes somnolence during daytime. Delusions and hallucinations in about half the cases, usually associated with insanity either as mania, melancholia, or dementia. Memory usually impaired. Speech deliberate, thick, or hesitating in nearly all cases. Eyes tend to water. Slight diminution in acuteness of vision. Exophthalmos observed once or twice in early stages. Hearing impaired in more than half the cases. Taste often impaired, smell sometimes so.

Circulatory system: Blood not altered. Heart usually normal. Arteries rarely atheromatous. Pulse weak, soft, and slow. Capillaries (!) nearly always dilated on face. Hæmorrhages from throat, gums, nose, uterus, etc., often occur in well-marked cases. Cutaneous ecchymosis rare.

Respiratory system does not present any changes typical of the disease, but intercurrent respiratory complications are often the cause of death.

Digestive system: Teeth tend to loosen and fall out, or to become carious. Gums often swollen, spongy, and bleeding. Tongue, uvula, and soft palate usually swollen. Bowels usually constipated.

Urine: Specific gravity lowered. Urea diminished. Albumin often present in later stages, absent in earlier. Sexual system not affected. Recovery noted in one instance only. Disease is extremely chronic and may last over ten years. Its general tendency is to shorten life.

Pathological changes based upon about twenty-five cases, in which autopsies were performed, the tissues and organs being examined microscopically in twenty cases.

Fat.—Subcutaneous fat abundant, and fat in other situations usually in excess. In one instance subcutaneous tissue found to be "gelatinous," and in another "œdematous." No unusual appearance noted in the remainder. Slight anasarca common.

Thyroid gland in every case reduced in size, color pale-yellow or buff-colored. Consistency tough, firm, and indurated. In some cases the affection more advanced in one lobe than in the other. In one case carcinoma of the gland was noted (Gulliver, "Trans. Path. Soc.," xxxvii., p. 511). Microscopically, nearly the whole of the gland converted into delicate fibrous tissue, here and there infiltrated with clumps of cells, replacing the gland vesicles. Adventitia of the arteries swollen and infiltrated with small round cells. In some cases, where parts of the gland still show the vesicular structure, the walls of these vesicles are seen to be infiltrated by a round-celled growth. In extreme cases the glandular structure may be altogether absent. Almost no colloid material recognizable, the sole remains of thyroid gland tissue being a very few epithelial corpuscles buried in the collections of leucocytes seen throughout the dense stroma.

Kidneys show in two-thirds of the cases more or less interstitial change. "In some not greater than might be anticipated in persons of adult or advanced life."

Heart.—Left ventricle hypertrophied in the cases in which the kidneys were granular. Arteries do not show degeneration to any unusual extent.

Skin.—Epithelium in the region of sweat-glands swollen, with nuclear proliferation, the lumen of the tubes becoming obliterated. In later stages a nucleated fibrous growth seen outside the tubes. Similar changes occur in the sebaceous glands, which become represented by irregular masses of nuclei which tend to undergo total or partial absorption. A nuclear proliferation is liable to develop around the hair-follicles. In one case thickening of the perineurium was observed in the nerve-filaments of the subcutaneous tissue. An appearance like œdema was noted in one instance only. In five cases fibrosis was present in the superior cervical ganglion, and in three others there was probably interstitial change.

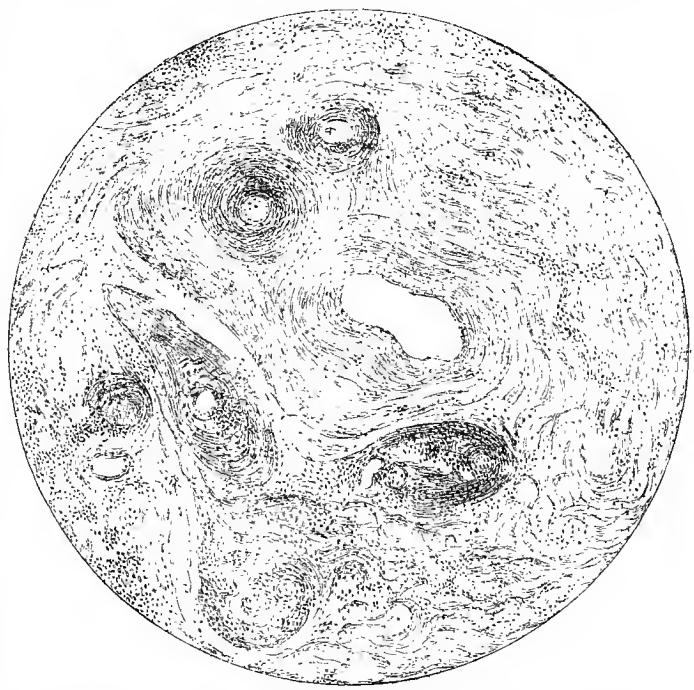

FIG. 640.—Section of Thyroid Gland, showing almost complete replacement of its vesicular structure by fibrous tissues. (Dr. Ord's case. Report on Myxœdema. Clinical Society's Transactions. 1888.)

Hun and Prudden (*American Journal of the Medical Sciences*, 1888) give a very accurate account of four cases, in two of which autopsies were obtained. The conditious described are the same as those met with in the cases collected by the committee of the Clinical Society. Chemical analysis of the skin showed no excess of mucin over the normal. Microscopically the skin showed a marked dilatation of the lymph-vessels in the zone between the corium and rete, and the interfibrillary spaces were widely open. The fat showed slight atrophic changes. Nervous tissues were unaltered. In all the cases faradic irritability was unaltered; reaction to galvanic current was diminished.

The authors have also tabulated the results of analysis of one hundred and fifty cases in their memoir, the statements made corresponding closely with those since given by the Clinical Society.

Some interesting chemical results are communicated by Halliburton as to the relative amounts of mucin found in normal and myxœdematous tissues. The methods employed were as follows:

The tissue was first finely minced and weighed, and then subjected to the action of methylated spirits for a

few days. The spirit was then poured off and either lime-water or baryta-water (diluted with five volumes of distilled water) added. After being allowed to stand in contact with the tissue for some days, the lime or baryta-water was filtered off and the mucin in it precipitated by a slight excess of acetic acid. This precipitate, granular at first, became flocculent after standing for a few hours; it was then collected in a filter, which had been dried at 100° C., and weighed; then it was washed with water, acidulated milk, acetic acid, distilled water, rectified spirit, and ether; then dried at 100° C. to constant weight, and weighed.

The following table shows the average results of these analyses of human tissues:

Tissue.	Percentage of mucin in Normal tissue.	Myxœdema.
Skin	0.374	0.385
Connective tissue	0.521	1.65
Spleen	none.	2.21
Lung	none.	0.72
Parotid	trace.	0.188
Fluids, blood, ascites, cerebro-spinal fluid, etc	.....	none.

In myxœdema, experimentally produced in animals, a much more uniform increase in the percentage of mucin was observed. The name myxœdema, as applied to the condition occurring in man, is not to be understood to signify the constant presence of mucinous infiltration. The fact that an enlargement of the pituitary body has been observed in animals after removal of the thyroid gland, has led to investigations as to the condition of that body in myxœdema; but no relation appears to exist in man which points to a pituitary enlargement, either after thyroidectomy or in cretinism. Langhans, after investigating the subject, came to the conclusion that any hyperplasia of the thyroid is connected with the original goître, and not caused by removal of the gland.

Treatment.—Up to 1890 no satisfactory specific means of treatment existed, and no general improvement could ever be attributed to the effects of treatment, though some of the symptoms appeared at times to be relieved. Warmth always appeared to have a beneficial effect, while cold usually aggravated all the symptoms. The first suggestion of a rational treatment came from Victor Horsley (*British Medical Journal*, February 8, 1891), who, from the fact that Eiselberg has been able to save two animals from myxœdema, after removal of the thyroid had been performed, by successfully grafting portions of the excised thyroid gland beneath the peritoneum, suggested the adoption of this treatment in human medicine, and shortly afterward cases were published by Horsley and Collins, where more or less improvement followed the transplantation of portions of thyroid gland of sheep in myxœdema. The permanency of the relief is thought to depend upon the vitalization of the gland, though immediate benefit was often noticed, explainable by supposing that it was due to absorption of the elements of the gland. In 1891, G. R. Murray (*British Medical Journal*, October 2, 1891) suggested the employment of thyroid juice by hypodermic injection. The juice was prepared from the gland of a freshly killed sheep, by mincing and covering with 1 c.c. of equal parts of glycerine and 0.5 per cent. carbolic-acid solution. After soaking for twenty-four hours, a turbid pink juice can be obtained by squeezing through a cloth, which is to be given in two equal doses during the week. Subsequently the dose can be given less frequently.

A number of observers, chiefly in England, claim to have had good results from the employment of this method, of which various modifications have been suggested. Recently patients have been fed with the gland minced and raw, with satisfactory results. As to the permanency of the cure, either by feeding or by transplantation, it is yet too early to speak with certainty in so chronic and persistent an ailment, but immediate benefit has been almost always marked. It has not yet been ascertained whether the thyroid treatment is of any benefit in cases of endemic cretinism and idiocy in young persons.

Tetany.—The association of this condition with myxœdema is a matter of considerable scientific interest, as the nervous symptoms of myxœdema have many points in common with tetany. True tetany has not, however, been directly traced to disorders of or operations on the thyroid gland.

Exophthalmic Goître.—A large number of clinical and pathological studies in this puzzling disease have confirmed the view that it is a disorder of the nervous system, and that the thyroid enlargement merely forms part of a wide-spread vaso-motor change. In a few cases the condition has, however, been complicated by myxœdema, pointing to a disturbance in the function of the thyroid. Whether the disturbance is a toxic one, or due to a local nervous lesion (medulla oblongata? cervical sympathetic?), is not yet determined with accuracy.

The similarity in nervous symptoms existing between Graves' disease, myxœdema, tetany, and acromegaly, has not yet received a satisfactory explanation, but it is difficult to avoid imagining that it depends upon definite disturbances of nutrition, due to the presence of an abnormal chemical product in the system.

F. X. Dercum has described a rare form of painful lipomatosis under the name of "Adiposis Dolorosa" (see page 15 of the present volume), in which there were distinct anatomical changes found in the peripheral nerves. Although in two cases the thyroid showed marked alteration, induration, and atrophy with calcification in one case, and enlargement with calcification in the other, the characteristic nervous symptoms of myxœdema were absent. *Wyatt Johnston.*

TOES, DEFORMITIES OF THE. HAMMER-TOE.—A certain number of these cases present themselves for treatment while it is yet possible to manually correct the deformity; in such cases, relief may usually be obtained, and the progress of the deformity checked, without operative treatment, by mechanical means. A stiff leather insole, the full width and length of the corrected naked foot, has slits cut in it at the divisions of the toes, and through these a ribbon, or tape, is passed, carried over the dorsum of the toe, or toes, and made fast underneath. The posterior portion of the sole is held to the foot by a ribbon, or strap, across the instep. The insole is worn inside the stocking, and its use requires a broader-toed shoe than that generally worn. *John Ridlon.*

TOLIPYRINE. This substance has been very recently introduced as an antipyretic and antineuralgic of some value. It differs from antipyrine only in the substitution of the methyl group, CH_3, for one atom of hydrogen in the phenyl group. It is a white crystalline powder very similar to antipyrine in its physical as well as its therapeutic qualities. The indications for its use are the same as those for antipyrine, the dose being somewhat less—one drachm being equal to one and a half drachm of the older drug. It has been used by Dr. P. Guttman with success (*La Semaine Médicale*, March 17, 1893), but has not yet been before the profession for a sufficient length of time to warrant the forming of an opinion as to its relative value.

A salicylate of tolipyrine has been prepared to which the name of *tolysal* has been given. It bears the same relation to tolipyrine that salipyrine does to antipyrine. It is a crystalline, almost colorless (faintly pinkish) substance, lustreless, and with a bitter taste. It is easily soluble in alcohol and acetic ether, but only sparingly in water and sulphuric ether. Tolysal has been investigated by Dr. A. Henning, of Königsberg, who describes it as possessing marked antirheumatic, analgesic, and antipyretic properties. In acute rheumatism particularly, but also in chronic articular and muscular rheumatism, it exerts a rapid and powerful influence. It should be given in doses of from forty-five grains to a drachm and a half in the twenty-four hours, fifteen grains being administered every two hours, or thirty grains to begin with and fifteen grains in the succeeding doses. It may be

continued for some days after the disappearance of the symptoms. As an analgesic the same dose was found to prove effective in various forms of neuralgia, especially those of rheumatic origin. As an antipyretic it has but little effect in lowering the temperature when it is normal, even in doses of a drachm to a drachm and a half; but in all conditions of pyrexia it rapidly brings the temperature down to normal, or even to a subnormal degree. It should be given in doses of fifteen grains every half-hour or every hour, with or without an initial dose of thirty grains, until a total daily dose of from one to two drachms is reached. It also assists in procuring sleep, both in conditions of pyrexia and apyrexia. It has no cumulative action, nor have any signs of a toxic effect been noticed, not even any disagreeable symptoms such as noises in the ears, digestive disturbance, excessive perspiration, rigors, or signs of collapse. This compound is also too recent to justify an estimate of its value.

Beaumont Small.

TONGUE, DISEASES OF THE. Since the original article, "Tongue," was written a by no means inconsiderable amount of literature bearing upon the diseases of this organ has appeared. Some of it has helped to simplify the subject, while some has seemed only to increase the confusion that already existed in regard to certain conditions. For this reason, and because several pathological states appeared to deserve more ample consideration than they had received, it was thought best to add the present supplementary text. The additions have been made as brief as possible, and for this reason they may appear somewhat fragmentary. The order followed is, in a general way, the same as that in which the subjects were originally considered.

Hemiatrophy has been found by Girard[1] to occur in dogs when the sensory portion of the trigeminus is cut through. From this he concludes that the trophic fibres run in the trigeminus and not in the facial nerve. Concerning the pathology of hemiatrophy Trevelyan[2] reports a case in which there was caries of the atlas and occiput articulation, with chronic basilar meningitis, and atrophy of the hypoglossus strangulated by the thickened meninges. The condition follows lesions of the intra-medullary and the intra- and extra-cranial hypoglossus.[3]

Progressive hemiatrophy is rarely seen, but it is occasionally observed in association with hemiatrophy facialis, to which it bears a close relationship. It probably depends upon degenerative neuritis of a low type.

TONGUE-TIE.—According to the statistics of the Good Samaritan Dispensary 315 cases have been treated during the past five years out of a total of 283,000 patients, 52,000 of which were surgical. This would make a proportion of one case of tongue-tie to each thousand patients, and six to each thousand of surgical cases. In a very large percentage of cases brought for treatment by over-solicitous mothers there is scarcely any shortening of the frenum or other abnormality requiring treatment.

Glossoplegia, associated with one-sided cephalalgia, and possibly attended with symptoms usually referred to intracranial disease, may be relieved by the free use of iodide of potassium even in the absence of any specific history. It may be secondary to bilateral lesion in the cerebral hemispheres, when it goes by the name of pseudo-bulbar paralysis. It is the first symptom in true progressive bulbar paralysis. Speaking becomes indistinct, the tongue cannot be elevated, and protrusion is effected to a slight degree only. Characteristic furrows or wrinkles develop upon the dorsum. Galvanism applied to the neck seems to do some good.

Acromegaly with great enlargement of the tongue has been observed, and in two recently reported instances the organ was so increased in size as to be of serious inconvenience in the mouth.

Myxœdema may be attended with enlargement of the tongue, which is described as being broad, flat, and square, and nearly filling the mouth.

MACROGLOSSIA.—This usually congenital form of enlargement has been shown to be a lymphangioma of the tongue. Nota[4] thus classifies the methods of operation usually employed for its cure:

A, Simple scarification. B, Compression, direct or indirect. C, Incision in V-shape. D, Amputation. E, Ignipuncture. F, Electrolysis and galvanocautery.

The lingual arteries may be tied upon both sides as recommended by Demarquay, and practised successfully by Nota in one case, or the protruding portion may be divided with scissors and each half removed separately with the écraseur, as in a case reported in the *China Med. Miss. Journ.*, June, 1892. Brück[41] has written an interesting paper on the subject.

Clonic spasm is a rare affection observed by Erb, Berger, Remak, Wendt, and Seppilli.[5] The tongue may be protruded against the will, pushed forward against the dental arch, or show involuntary muscular contractions on one or both sides. Clonic spasm is seen in hysteria and in the epileptic seizure. Bromide of potassium, electricity, etc., are recommended. The condition may be looked upon as a neurosis of the hypoglossus.

Chorea-like movements, limited to the tongue, have been reported[6] as occurring in hemiplegia to the extent of interfering with speech. The movements grow less as the paralysis improves.

Tonic spasm is also seen in hysteria, and in other cases where the cause is unknown, probably from reflex irritation.

Glossitis superficialis was described by Möller[7] in 1851, and again more recently by Michelson.[8] The process is somewhat chronic and difficult to cure. It is a rare disease and usually occurs in women. Irregular red spots and hyperæmic, enlarged papillæ, with loss of epithelium, appear for the most part upon the sides and tip of the tongue, and may occasion pain of a burning character, which is intensified by eating and speaking, and often affects the patient's disposition so as to cause moroseness or hysteria. There is no pathological secretion and no ulceration. Regarding the etiology, digestive disturbances appear to have been present in the cases reported.

Joseph[9] observed an instance which had begun two and a half years before, after eating a dish prepared with an abundance of mustard.

Hahn[10] reports one which began near carious teeth, but did not disappear when these were extracted.

The diagnosis might be confounded with neuralgia from the occasional sharp character of the pain. Molènes reports three cases under the title, "*glossite épithéliale en paires*," all in arthritic subjects and associated with dyspepsia.

Treatment is unsatisfactory. More can be accomplished by attention to the digestion than by local measures. Joseph secured the best results with fifty per cent. lactic-acid solution, rubbed well into each patch separately. Hahn secured temporary relief with ten per cent. menthol solution.

The writer has treated one case of this nature which, in addition to the intensely red and painful patches, enlarged papillæ, etc., presented a yellowish-white pseudo-membrane, which dipped down into the numerous deep fissures of a naturally fissured tongue, and also occurred upon the mucous membrane of the cheeks, in a young lady. The disease had appeared after eating much candy, the digestion being at the same time somewhat faulty. Chromic acid, nitrate of silver, and various mouth-washes gave but temporary relief, and the extremely annoying condition has persisted for three years and has been seen by a number of physicians here in New York. The patient is somewhat hysterical. Another case likewise associated with dyspeptic attacks, recurred at intervals for several years.

Glossodynia exfoliatu of Kaposi is thought by Joseph to be identical with the foregoing. Both may have a long course and show hysterical and hypochondriacal symptoms.

HEMIGLOSSITIS.—Up to 1885, Güterbock had been able to find but twenty instances of hemiglossitis in medical literature, including his own observations. Undoubtedly many one-sided inflammations of the tongue are due to herpes, though phlegmonous inflammatory states end-

ing in abscess formation are not unknown. In the herpetic form the territory of the trigeminus or, according to de Mussy, that of the chorda tympani, is invaded.[11]

Abscess, aside from the origin above hinted at, may be occasioned, Bamberger says, by the action of cold. Spontaneous cure after rupture is the rule, but the volume of the tongue may remain much increased in exceptional instances. If seen early, the inflammation may be reduced by the free use of ice and emollient washes.

Ulceration of the tongue may develop upon a pre- or co-existing tumor, or upon the surface of an otherwise healthy organ. Of the former variety is especially to be mentioned the ulcer of epithelioma, which is to be distinguished from those due to syphilis of the tongue and those resulting from the irritation of faulty teeth. In cancer the ulcer is in relief, resting upon a markedly indurated base, is irregular, red, bleeds readily, has ragged edges, is covered with an ichorous secretion, and occasions often severe lancinating pains and otalgia.

In chancre, the ulcer is likewise attended with an indurated base, although this at times may be very slight. The ulcer may penetrate deeply, but it occasions little or no pain or inconvenience. The borders are not perpendicular, but incline gently inward to the base. The ulcer in gumma is hollowed out, has perpendicular, or as though incised borders, sometimes suggesting that a piece had been removed with a cutaneous punch. The base is yellowish with a sloughy uneven adherent eschar-like substance. Resolution is hastened by treatment, which is not the case in cancer. The ulcer which develops secondarily upon a syphilitic sclerous glossitis or a sclero-gummous condition of the organ may be of the nature of a simple ulcer, which depends upon the mechanical conditions present and does not assume the characteristic form of gummy ulcer. Ulcers not associated with neoplasms are much more frequent than those just discussed. They may be due to mechanical and traumatic causes, to the presence of micro-organisms, to eruptive lesions such as are seen in skin diseases, including syphilis, to the breaking down of patches of leucoplasia, and to the excessive use of mercury. Ulceration produced by the constant friction against a sharp or even blunted irregularity of a tooth is a common form of the traumatic variety. Le Pileur [12] reports instances in which tongue ulcers could not be cured until the slight projections of otherwise healthy teeth against which the lesions impinged were covered with a protective apparatus made of gutta-percha. Bugnot [13] reports a similar case in which futile attempts were made for three months to heal two small ulcerations at the tip of the tongue in a nine-year-old boy, which at first sight looked like aphthous ulcers, but which occasioned such intense hyperæsthesia as to prevent sound sleep and cause much discomfort in eating. The first night after a protecting cap was placed over the lower lateral incisors, which were somewhat out of line with the other teeth, the child slept well and the ulcers disappeared without further treatment.

The *herpetic ulcer* is at first quite superficial, small, often in the form of miliary erosions, rather than ulcers, which by confluence form an irregular ulcerating surface. They follow the rupture of small vesicles. Superficial round ulcers often thickly dot the tongue in varicella, likewise from the rupture of vesicular lesions. Larger ulcers result in the same manner from rupture of full-size vesicles or bullæ in zoster, pemphigus, or hydroa. In lupus the ulcer is much the same as that of tubercle presently to be considered.

The chief *syphilitic ulcer* is the mucous patch, so common as to be an almost invariable lesion of secondary syphilis. In size it is usually somewhat larger than a lentil, for the most part round or oval, hollowed out and with a grayish-yellow base as a rule, but, as Fournier [14] says, there is nothing special in the configuration, color, or character of the border by which the mucous patch of the tongue can be always diagnosticated. Ulcerated fissures may occur in secondary and tertiary syphilis. Vertical striæ or a form of fissured mucous patch may occupy the borders of the tongue. For all of these lesions probably the most useful local application is chromic acid. I have employed it for several years in from twenty-five to seventy-five per cent. solution. It is superior to nitrate of silver for all ulcerative lesions and especially for mucous patches.

Ulcerations taking place on patches of leucoplakia, either starting from fissured lesions in the plaque, or following the detachment of a portion of its area, will have their nature indicated by the original condition, which may or may not be syphilitic.

Mercurial ulcerations have a grayish-white, sometimes diphtheroid appearance, and are accompanied by a generalized stomatitis. The breath is offensive and there is salivation. The lesions occupy the lateral borders of the tongue, which are usually indented by pressure of the teeth. Gangrene may supervene. I have recently found benefit from the local use of bichloride mouth-washes, which might lend some weight to the septic theory of mercurial stomatitis.

Tuberculous ulcer assumes constantly greater importance, and the question of its existence as a primary condition renders it the more interesting. Tubercular deposit in the glands may add to the already strong simulation of epithelioma for certain cases, and the depth of infiltration beneath the ulcer makes it necessary to remove much tissue when operation is resorted to in an attempt at radical cure. This ulcer has been observed in childhood and its nature confirmed by bacteriological examination. Dr. Robinson presented two cases at the New York Dermatological Society.[15]

In one the lesion had first appeared on the point of the tongue three years before, and although it was removed, together with the whole tip of the organ, the wound had never healed.

The second case, also in a man, was regarded as an instance of primary tuberculous ulcer, which had developed near the point of the tongue nine months previously as a hard grayish lesion, the size of a pin-head, and slightly painful to the touch. Subsequently a similar growth appeared on the opposite side, and there extended until an oval-shaped ulcer, three-quarters of an inch in length, occupied the apex. At the present time this ulcer presents the following appearance: the base is reddish, like the floor of a granulating wound and irregular, with reddish points, having grayish-yellow material between; the margin is irregular and elevated, and the edges are perpendicular, and beyond it the tongue tissue is apparently normal. Bacilli have been found in a few sections. Now, after nine months of good health, evidences of pulmonary implication are beginning to manifest themselves. One of the surest evidences that a chronic ulcer of the tongue, which is not influenced by any ordinary treatment, is really tuberculous, is the appearance, upon the surface, of the minute yellow points which Trélat, in 1870, demonstrated to be tubercles in course of development. The presence of these, together with microscopical sections of a small excised portion, and bacteriological cultures made from scrapings of the surface, furnish the only positive proof of the real nature of these ulcers. The importance of early and radical operation in primary tuberculous ulcer, so as to prevent systemic infection, need not be dwelt upon. Weir reports recurrence in five out of seven operations regarded as thorough.

In the *ulcer of lupus* there is much less pain, or it is entirely absent, and the process is much slower of evolution. Primary lupus has been observed by Leloir [16] and Clarke,[17] the former author confirming an instance by inoculation.

Lichen planus is occasionally observed in association with this disease upon the cutaneous surface, and I have seen several such cases, which have of late years been presented at the New York Dermatological Society.

Exfoliatio areata linguæ is a condition seen mostly in children, but also occasionally in the adult, whose nature is not yet wholly understood, but which is looked upon by many as a deformity rather than a disease, and is considered by some to be a physiological condition. The writer has repeatedly noted its presence in several children of the same family, starting at or shortly after birth, and

persisting for many years. While almost impossible to correct by treatment it disappears at times spontaneously. The dorsum of the tongue is covered with various-sized rounded smooth areas, from which the filiform papillæ have been shed. At the margin of the patch is almost constantly present a broad white or yellowish ring, and the color of the patch is usually of a brighter red nearest the ring. These patches increase at the periphery and wander from one portion of the organ to another, even exteuding upon the under surface where no papillæ exist, giving the *lingua geographica* appearance. It seems improper to call it a *glossite exfoliatrice marginée*, for there is no subjective symptom or evidence of inflammatory action. While no micro-organism has been demonstrated as the cause, it has the features of a parasitic affection. Unna compares it to alopecia areata, and places it among the tropho-neuroses. I have observed the condition about twenty times in some two thousand consecutive examinations of children and adults, finding it, however, in only four instances in the latter, one being in a patient with lupus of the face. Fortunately, treatment is rarely demanded, and it is of little avail.

Leucokeratoses include all white patches of the tongue due to epithelial change—keratosis, dyskeratosis, and hyperkeratosis—whether the result of syphilis, arthritism, the abuse of tobacco, alcohol, faulty teeth, or other cause. The chief importance of the condition is the great tendency it shows toward degeneration into epithelioma. It should therefore be treated and cured if possible before any sign of papillomatous change takes place, and as soon as such change is noticed operation should be resorted to. If there is a syphilitic history a thorough course of treatment should be instituted.

Leloir[18] applied to the histology of leucoplakia Ranvier's theories in regard to eleidine and showed that we must distinguish two periods in the process:

1. That in which the mucous membrane is, so to speak, transformed into skin or hyperkeratinized (a thick granular layer forming with abundance of eleidine).

2. Partial exfoliation of the plaque and consecutive inflammation with formation of fissures, exulcerations, and ulcerations—dekeratinization, characterized by the disappearance of the granular layer and of the eleidine.

Schwimmer, who first described the histological lesions of leucoplakia, advises[19] as local treatment salicylic acid, ten to fifteen grammes dissolved in fifty grammes each of alcohol and distilled water, while he has obtained no good results from lactic acid. In advanced cases, with thickening of the mucous membrane, the curette has given good results. At the same meeting De Watraszewski said he had obtained the best results from a five and subsequently a ten per cent. solution of bichromate of potash, securing after its application a soft, supple, and hyperæmic cicatrix, which, however, showed tendency to ulcerate when irritated. Leucoplakia has been observed in association with lichen planus, lupus, keratosis follicularis,[25] vitiligo,[20] and other skin diseases, but the connection is not clear.

Nigrities linguæ is a hyperkeratosis of the filiform papillæ, and especially of the horny epithelium, and was first described by Rayer in 1835. The black discoloration which gave to the condition the name of "black tongue" was long considered due to the presence of parasitic growths, but Brosin found the organisms to be a poorly developed form of *oïdium albicans*, to which he attributes little or no importance. The prevailing opinion now held is that the *lingua nigra* depends upon the development of some form of pigment whose nature is still unknown. Leviseur,[57] who reports a case, says it is probably the same pigment which Unna has shown produces the black color in comedones and ichthyosis histrix, and he still sees no reason why a fungus growth should not act very much in the same manner as a chemical preparation. I have observed as a chronic condition the lengthening and epithelial increase of the papillæ upon the dorsum, so that they would lie like a thick growth of hair, pointing outward, and I have seen such growths accidentally blackened by iron and other drugs, but have never yet met with a blackened condition which I could regard as of essential nature.

Primary erysipelas of the tongue has been reported by a number of observers, but while some[21] maintain that the organ does not become tumefied, others[22] describe the swelling to be of such a size as to prevent the mouth's being closed, with pain[23] attending every movement of the organ. Though this condition is rarely observed, there would seem to be no good reason why the streptococcus should not effect an entrance through a lingual ulcer or fissure, and implicate the tongue in an erysipelatous inflammation before making its presence known upon the skin surface, as it usually does in these cases within a short time.

Strawberry tongue is not confined to scarlatina, but is seen quite frequently in epidemic influenza, and in a mild degree of development in parotitis and some other diseases. The peculiar appearance is occasioned by swelling of the filiform and fungiform papillæ whose epithelial covering has been shed. Neumann[24] gives three stages in the strawberry tongue:

1. Swelling of the mucous membrane and cloudiness of the epithelium.

2. Desquamation.

3. Regeneration of the epithelium.

Strawberry tongue appears to be present in about eighty per cent. of scarlet-fever cases, appearing on the fourth day and lasting four days or more.

In the tongue of dyspepsia the red fungiform papillæ slope toward the tip, while in scarlet fever they are round and erect.

Varicella is almost constantly attended with lesions upon the tongue, according to my personal experience during the past few years, but as they tend to heal as promptly as those upon the skin they have little importance. The vesicle is never to be seen, but a small, round ulcer with yellow base takes its place.

Psilosis is the term employed by Thin[26] to describe a disease of the tropics attended with intestinal disorders, in which the tongue is the seat of an eruption at first almost herpetic in nature, and subsequently leaving separate areas or the whole surface bare of epithelium. Sinuous longitudinal clefts are present, and the whole organ is tender and can be protruded only with difficulty. The fissures soon heal, the patches become pale, and the surface becomes glazed. Superficial ulcers at times appear. The condition might be mistaken for syphilis, were it not for the above characteristic changes which take place.

Zoster of the tongue is reported by Fournier,[27] but the instance given is not very convincing.

Xeroderma pigmentosum. Lesions of this nature upon the tip of a child's tongue have been observed in one instance by Keating.

Urticaria.—A case is reported by Laveran[28] in which a plaque of urticaria upon the tongue aided in the diagnosis of urticaria of the throat, in a man who for three years had been subject to frequent outbreaks upon the skin. Occasionally urticaria is the cause of great swelling of the tongue, but lesions on the skin render the diagnosis clear.

Eczema of the tongue probably has no existence, but Besnier[29] thinks certain desquamations with well-defined margin have some analogy with seborrhœal eczema or eczema marginatum. It is probably the same condition described above as *exfoliatio areata*. He advises the following ointment to be applied several times daily: Cocaine, five centigrammes; balsam of Peru, boric acid, each one gramme, and vaseline, forty grammes.

Impetiginous stomatitis, in which the tongue, along with the buccal surface of the cheeks and lips, is covered with a tenacious exudation, and at times fissured, has been described by Sevestre and Gaston.[30] It occurs in debilitated infants with gastro-intestinal diseases, measles, pertussis, and impetigo. The staphylococcus aureus was found in eight cases.

Stomatitis epidemica, with œdema of the tongue, vesicular eruption, and ulceration of tongue and lips, and at times necrosis of portions of the organ from the excessive

swelling, has been reported by Siegel.[31] The disease seems to have a certain identity with the foot-and-mouth disease of domestic house animals, and at the same time it presents a certain resemblance to epidemic aphthæ in children and to epidemic scorbutus.

Dermoid tumor, of a probably unique kind, is reported by Backer.[32] The cyst protruded several inches out of the mouth, pressing down the tissues of the chin, and contained forty ounces of soft sebaceous matter. If possible, such tumors should be removed with the cyst-wall intact to obviate an inflammation of neighboring tissues, which may be severe.

Schmitt[48] describes a sublingual dermoid which was mistaken for a ranula.

Sublingual fibroma is a disease of childhood, often encountered in Southern Italy, and, since the writings of Riga in 1872, it has been known by this author's name. It is at first a small pearl-colored, painless growth upon the frænum. Fede[33] found hypertrophy and hyperplasia, especially of the papillary layer of the mucous membrane at the base of the frænum, resulting from irritation of the first two lower incisors. Riga, however, reported cases which had been observed before the eruption of these teeth. It may exulcerate and become necrotic, especially where there is concomitant systemic disease. Here the general condition must be improved while antiseptics and caustics are applied, or the ulcerating growth must be cut out with scissors.

Lipoma is not very common. Rydygier[34] reports one as large as a plum, which gave pseudo-fluctuation and was easily removed by incising the mucous membrane and shelling out the growth. This author states that Krausnick could find only fourteen instances in literature.

Kirchoff[34a] reports one as large as an egg. Two cases of congenital lipoma are to be found in the literature of the subject. Zander[49] saw an encapsulated lipoma fibrosum in a boy of three years, which had existed from birth. It protruded from the mouth and was covered with mucous membrane.

Papilloma in a child of two and a half years is reported by Coverton ;[40] it was operated upon by electrolysis and the galvano-cautery. In about three thousand consecutive tongue examinations I have seen papilloma four times, but only once of sufficient size to give annoyance and require operation. The condition is, however, comparatively common, owing to the papillary nature of the tongue and the facility with which the papillæ enlarge under irritation.

Fibroma is occasionally congenital, but otherwise not very common, judging from Williams's statistics, which show only three instances in eight hundred and eighty tongue neoplasms. Vincent saw one attached by a pedicle which gave the infant the appearance of having two tongues.

Osteoma and *enchondroma*[42] are rare, and are looked upon as degeneration changes in fibroid growths.

Angioma furnished about one per cent. of tongue neoplasms treated in the London hospitals during the past twenty years. Fischer[43] relates an instance of mixed tumor — *angioma cavernosum* and *fibroma* — for which thermo-cautery and electrolysis are advocated as the proper means of cure.

Lymphangioma cavernosum, as a congenital deformity, is illustrated in a case reported by Barker,[44] in which the greater part of the tongue was removed by operation. The condition had been aggravated by repeated attacks of acute and subacute glossitis. Examination of the excised tissue confirmed the opinion expressed under "Macroglossia," that the latter is usually due to lymphangiectasis.

Myxoma was seen in one instance in Williams's 880 collected cases.

Sarcoma of the tongue exists in medical literature to no greater extent than does lipoma. Targett[35] operated on a round-celled sarcoma which had existed for a year in a patient of sixty-one years, and Scheier[36] removed one from a patient of twenty-eight. The situation is almost invariably deep, and the floor of the mouth is most apt to be invaded. They seldom extend above the surface and ulceration is extremely rare, while concomitant glandular swelling appears late, if at all. Recurrence took place five weeks after operation in Scheier's case, but this is not to be expected if the whole growth can be removed. It is not probable that, for these cases, the view holds good that all sarcomas in muscular tissue are of syphilitic origin ; still in any given case, so long as the diagnosis is uncertain, a sufficiently thorough antisyphilitic course should be instituted. Further differentiation must be made from chronic abscess and from actinomycosis.

Actinomycosis now and then occurs primarily in the tongue ; an instance of which has recently been given by Doyen and Reussel,[37] the disease developing as a deep phlegmon at the base of the tongue, with woody hardness of the whole supra-hyoid region. Maydl[38] relates an interesting instance of probable infection from the fingers, in the person of a veterinary cattle inspector, who was in the habit of moistening the finger tips on the tongue in turning over his paper. Some time after the examination of infected cattle, the tongue began to swell, pus formed, and on examination was found to contain the characteristic yellow granules of actinomycosis. The abscess cavity was scraped out and recovery took place. The tongue is often affected in animals, and numerous nodular growths form in its substance, from the size of a pea to ten times this size. Infection usually takes place by way of the mouth, and in countries where the disease is prevalent it would not be surprising to find the human tongue more often involved than the number of instances so far reported would indicate.

It is presumable that the fungus on which the disease depends exists outside the body, on such vegetable growths as cattle feed upon, and this would account for the freedom enjoyed by carnivorous animals. Miller[64] has collected 75 instances of actinomycosis in man, which, added to the 38 previously found by Israel, make a total of 113 cases in the human subject.

Recurrent herpes of a chronic nature, differing somewhat from that described by Fournier, is recorded by Flatau[39] as affecting the lips, gums, buccal surface of the cheeks, and exceptionally the palatine vault as well as the tongue. Distinct vesicles are to be seen upon the borders of the latter, especially just back of the lingual **V**. Etiologically, the condition of the teeth, excesses of tobacco and alcohol, and in this particular case systemic depression from typhoid, must be taken into account. It is regarded as an affection of the trigeminus, but whether central or peripheric is obscure.

Hypertrophy of the follicular glands far back upon the dorsum near the papillæ vallatæ and the sinus epiglotticus, attended with some inflammation and causing the sensation of a foreign body in the throat, painful deglutition, irritative cough, dyspnœa, asthmatic symptoms, and fatigue of voice, is a condition mentioned by Schech[45] and other authors.[46, 47] The follicles are inflamed, red and swollen, and may be felt with the finger or observed with the laryngoscopic mirror lying over the epiglottis and glosso-epiglottic fossæ.

The prognosis is favorable. Treatment consists in applications of nitrate of silver, tincture of iodine, or the following :

℞.	Iodii puri	0.1–0.3
	Kali iodati	1.0–2.0
	Glycerini	20.

Syphilis may cause an acute or chronic hypertrophy in this region, as indicated by Labit,[58] in which case mercury internally must be added to the above local application.

Hypertrophy of the lingual tonsil, as the preceding condition is at times called, is an adult affection, and may reach such a degree as to suggest a new-growth or polypus. The adenoid vegetations may be removed with a snare or linear écraseur, sharp spoon, or caustics, just as similar growths in the naso-pharynx are treated. Scrofulosis, catarrhs, syphilis, and leucæmia are suggested as possible etiological factors. In differential diagnosis it must be remembered that primary carcinoma very rarely,

and much less often sarcoma, occurs so far back on the organ. Indirect examination with the aid of a mirror is necessary for a satisfactory view of the region.

Hypertrophy of the papillæ.—The filiform papillæ occasionally undergo hypertrophic change, and stand out over the dorsum like little porcupine quills. They are, however, pliable, and unless kept erect by the action of the teeth, lie flat upon the surface in the direction of the tip. Such papillæ, when covered with epithelial deposits and débris, and possibly when occupied by the fungus which Dessois [50] described under the name glossophyton, constitute the condition known as "black tongue" or *nigritius linguæ*. Ten per cent. salicylic solution in alcohol is recommended as a local wash, or a solution of bichloride of mercury, chlorate of potash, borax, or alum may be tried.

Neuralgia of the tongue is a most distressing affection, and one difficult to eradicate without operation. Fortunately it is not common. I have observed one instance of it in a lady with arthritis deformans. The paroxysms are of short duration but of frequent repetition, and the attacks may come on at intervals of a few months. The pain is usually located along one border of the organ.

Papilloma of the tongue is an occasional cause of neuralgia, but more often the lingual nerve is affected. Daily scraping of the tongue has been accused of favoring its development. A rheumatic or other diathesis may be found as a predisposing cause.

Dubreuil [51] reports a case in which he performed resection of the lingual nerve in a woman forty-five years of age, whose neuralgia had lasted for four years. She had had syphilis. The lingual nerve can be reached in three ways: 1, The intra-buccal method; 2, by an incision beneath the lower border of the jaw; 3, by trephining the ramus, or the transmaxillary method. The latter (resorted to by Linhort) was the method chosen in the above case: the nerve was divided with the thermo-cautery, and the neuralgia was cured, but the inferior dental nerve was injured in the operation—an accident to be guarded against—and the right side of the lower lip rendered insensible in consequence. Wounding of Stenon's canal or the facial artery must also be avoided.

Mycoses of the tongue remain to be spoken of. There is the *mycosis leptothricia*, which affects also the fauces, tonsils, and mucous membrane of the mouth, and forms on the tongue a fibrinous network of the leptothrix starting out from the region of the circumvallate papillæ and follicular glands, and forming a dark-colored or grayish-black membrane. Threads and tufts of the fungous growth extend over the mucous surface of the cheeks. There is scarcely any fever or systemic disturbance, and this serves to distinguish the condition from diphtheria deposits, which it may simulate. Adults have usually been the ones affected. The diagnosis is most readily established by the microscope. Treatment is best carried out by means of sublimate wash in strength of 1-200. *Mycosis sarcinica* is rare, and is distinguished by the characteristic grouping and quadrangular form.

Mycosis tonsillaris et lingualis benigna was described by Fränkel,[52] in which the follicular glands at the base of the tongue were grayish-white and swollen, without subjective symptoms.

Stomatitis mycosa or thrush, considered now by some to be due to saccharomyces albicans, is seen mostly in infants, but may also be observed in the course of a serious illness and in extreme age. While the tongue is not usually alone affected, it may be, and in all cases is largely implicated, and the first patches are usually seen upon the tip. They are small, discrete spots of grayish-white color surrounded by a very faint and narrow ring of hyperæmia. They can be brushed away mechanically, disclosing a superficial loss of tissue. Much may be done to prevent the disease in infants by proper attention to matters of cleanliness, care in washing out the mouth, and in cleansing the natural or artificial nipple before the child takes its nourishment, as well as after feeding. As treatment, boracic acid, chlorate of potash, or soda solutions may be used. Forchheimer [53] considers soda the best.

Gonorrhœal stomatitis, implicating the tongue in a state of erosion or exudation of a grayish-yellow color, is among the possibilities. Dohrn recently reported such an instance in an infant eight days old. Here the back of the tongue was chiefly affected.

Stomatitis aphthosa has recently been studied by Ollivier,[55] whose observations give support to the view originally suggested by Jagar, in 1765, that the milk of animals suffering from what is called aphthous fever is capable of producing the disease in those drinking it. The connection between aphtha and foot-and-mouth disease of cattle is strongly maintained by many European observers. Fränkel has demonstrated the presence of staphylococcus pyogenes citreus and the staphylococcus of Rosenbach, neither of which in all probability has any etiological importance. Since aphthous ulcers are attended with constitutional disturbance, the theory of a general infection seems quite tenable. The primary lesion upon the tongue is granted by many to be a vesicle which, however, is rarely if ever observed, the vesicular wall having collapsed or been rubbed off before the case is seen. Forchheimer believes that various processes, and not the foot-and-mouth disease alone (which is rare in this country), may act to produce a material which, affecting the nerve-tissues of the human body, produces the herpetic process.

As a wash the following is recommended:

℞ Iodii sulphat..... ʒ j.
Aquæ..... ʒ j.

Ageusia and *parageusia* are derangements of the special sense of taste, which is lost for such substances as sugar, salt, acids, etc., in the first, and perverted in the second. Ageusia of an incomplete character is seen in some facial paralyses and hysteria. It may also result from injury of the trigeminus or glosso-pharyngeal. Both conditions may arise from irritation of the nerves of taste, and be a symptom in catarrhal diseases.

Treatment.—Antiseptic and stimulating mouth-washes and electricity. If the cause can be found and removed, the taste will speedily return.

Glossitis, besides the forms already mentioned, may occur under a variety of conditions and present different clinical features. Without entering into descriptions, we will enumerate some of those which have been described: *Acute hæmorrhagic*, with extravasation into the connective tissue of the organ, and supposed to be due to alcoholic excesses. *Dissecting*, in which the whole dorsum is cut up into furrows and clefts, permitting food particles to be retained, fungous growths to form, and epithelial débris to be deposited, until the conditions favor inflammatory reaction and ulceration. (For the cure of this condition, antiseptic or detergent sprays and douches directed into the depths of the furrows, are more efficacious than attempts to wash the mouth in the usual way. Helmkampff [56] recommends the following to be applied four or five times daily with a brush: borax, 5.00; glycerine, 25.00.) *Erectile*, with stiff hard tongue, due to hypertrophy. *Mucous*, in which the mucous coating is slightly affected. *Papillary*, with inflammation of some or all the papillæ. *Parenchymatous*, implicating the whole substance of the tongue in hard exudative inflammation, followed at times by suppuration. *Septic*, due to infection. *Sclerous*, with cellular infiltration, and offering a superficial and a deep variety, the first having superficial indurated plaques devoid of papillæ, and of a deep-red blue; the second showing a mammillated and lobulated dorsum with the mucous membrane smooth and red, though often fissured and ulcerated.

Periglossitis sublingualis has been described as a rare condition of inflammatory œdema in the cellular tissue beneath the tongue, causing pain and difficulty in speaking and eating. The causes are unknown. Treatment consists in the application of leeches beneath the jaw.

Syphilis.—All forms of syphilis are prone to mani-

fest themselves upon the tongue, but much confusion still exists, and many questions are still unsettled, concerning the exact part played by alcohol, tobacco, and other irritants in tongue lesions in syphilitics. In conditions of sclerosis and keratosis of the organ it is often difficult to say just what are specific manifestations and what changes are due to adjuvant causes. The lingual ulcer of primary syphilis usually occupies the tip or margin near the tip of the organ, and rarely the under-surface. The base of the ulcer is apt to be considerably indurated, while the level of the sore is above that of the surrounding surface. The lesion is smaller as a rule than that upon the lip or the tonsil, while it may involve nearly the whole tip, and, in my experience, is much less frequently seen than chancre of either of the last-named situations. The subhyoid as well as the submaxillary glands are found enlarged and indurated.

Diagnosis from tuberculous ulcer, which commonly occupies the same situations, depends upon the chancre's comparative freedom from pain and its greater induration, or the characteristic cardboard-like hardness of the base. Again, the chancre is apt to be hollowed out, bowl- or crater-shaped, with sides gently sloping to the centre, while the tuberculous ulcer has irregular borders and base, and the latter shows granulations which make it uneven, while here and there at the periphery are little yellow points somewhat suggesting miliary abscesses. In doubtful cases cultures made from scrapings of the ulcer's base will render the diagnosis certain by showing the presence of the bacillus tuberculosis. From chancroid it is recognized by its red or rosy color, while the latter has a yellow base.

Treatment, by internal administration or inunction of mercury and a bichloride mouth-wash, can be instituted as soon as the diagnosis is established or has been made positive by the appearance of eruptive signs. No little confusion has arisen from the indiscriminate use of terms in describing syphilitic tongue lesions, but, if it is borne in mind that the moist papule or tubercle, the mucous patch or plaque, condylomata lata and certain opaline plaques, are for all practical purposes identical lesions, corresponding, if not coinciding, with papular or tubercular eruptions upon the cutaneous surface, and modified by the conditions of the ground on which they grow, and influenced by the moisture, heat, presence of micro-organisms, and various sources of irritation to which they are subjected in the cavity of the mouth, so as to appear under various types, the apparent differences will be readily understood. The papular type of the mucous plaque is less common than the erosive, but in one form or another this lesion is the most frequent sign of syphilis, in the period immediately following the initial sore, and in the early periods of inherited syphilis. It comes early, recurs at frequent intervals, and may become persistent and obstinate, especially along the borders of the tongue which come into contact with the teeth, and especially in those who use and abuse tobacco.

The opaline appearance of some plaques is explained by the presence of the young cells with which the serum escaping from the hyperæmic patch is charged ; and the pseudo-membrane which covers some patches is said to be the result of an excess of fibrin in this same serous exudate. Brisk friction will remove the whitened cells and membranous coating, but the latter will be quickly reproduced. These lesions of the tongue are highly contagious, and together with those of the lips and other parts of the buccal membrane, prove a fruitful source of contagion in non-venereal syphilis, making it possible for the disease to be acquired in innocence and to be possessed often for a long time in ignorance. Occasionally mercury appears to act as an irritant upon recurrent and persistent opaline plaques of the tongue, and it is not until iodide of potassium is substituted that they disappear and remain away. Several small plaques may coalesce and form an area of irregular outline upon the dorsum, sometimes almost covering its entire surface. This is seen especially in hereditary syphilis, where the mucous plaque is the most important sign of the disease, and the most to be dreaded by the wet nurse.

An analogous condition is found in the smooth, dry plaque, which Fournier has so happily termed *glossite tonsurante*, occupying any portion of the dorsum as a single or multiple lesion, and appearing along with the early mucous patches or quite late. The appearances are similar to those of the bald patches of alopecia areata seen upon the scalp, being quite smooth from loss of the filiform papillæ over a given area, while all around the papillæ retain their natural length and appearance. The color of these bald spots is bluish-gray, and this is not appreciably altered by the application of nitrate of silver, which, however, stains the surrounding papillæ and increases the contrast. Chromic acid colors the patch slightly in comparison with the surrounding tissue, but appears to materially hasten a return to the normal condition. Very similar tertiary plaques exist, though their existence is often overlooked until a resulting fissure or series of fissures has taken place in the area which has been the seat of diffuse hyperplasia. When a number of patches lie close together or have become confluent, and the interstitial connective tissue is in a state of hyperplasia producing an *interstitial glossitis*, and the resulting fissures divide the tongue tissues, possibly in various directions, the condition has been called *glossitis dissecans*. These forms are seen in late syphilis more especially, and at times seem to be only connected in an indirect way with the disease itself, and are not to be looked upon as wholly due to the specific poison, any more than are certain cases of *sclerous glossitis* or leucoplasia in those who have had syphilis. There is, however, a deep form of sclerous inflammation of the tongue which is of undoubted specific origin, produces no pain or discomfort, and is succeeded by fissuring or cleavage. Fournier finds that multiplication of the plaques and condensation by fibro-plastic deposit may take place. Organization is followed by contraction, which results in strangulation of the tissues and consequent sclerosis. In his superficial variety there are rounded indurations in the derma which appear as firm, smooth, cherry-red areas, either distinct or confluent, and tending to develop erosion, ulceration, or fissures. In his second or deep variety, swellings on the dorsum are succeeded by atrophy. The lobulated surface here presented has been compared to the surface of the liver in cirrhosis. It is considered almost pathognomonic of syphilis. The mucous membrane is smooth and of a wine-colored hue. As in the first form, furrows and fissures result from contraction of organized tissue, and may leave the tongue greatly disfigured unless treatment is prompt. Iodide is indicated in large dose, especially when gummata coexist, as is not unusual. If contraction has taken place, little can be done. It is possible, however, for papillary growths to spring up in clefts and fissures, and in a measure help to obliterate them, and such growths can be induced and stimulated, as I have convinced myself in one case, by packing the fissure with powdered aristol. This powder is also efficacious in ulcerating forms, but is difficult to keep upon the surface, and not greatly superior to chromic acid. If the case has not already received a thorough course of mercury, and does not show signs of rapid improvement under increasing doses of iodide, these inunctions are greatly to be preferred to mercury by the mouth.

Leucoplasia may exist independently of syphilis or the previous use of mercury, though both these factors enter largely into the etiology of many cases ; while in those of undoubted syphilitic base the element of tobacco and alcoholic irritation is almost constantly present.

Thus, mixed forms are probably much oftener observed than leucomas having a single cause. The syphilitic form is apt to be yellowish-white and of rather a dull hue as compared with the silvery or bluish whiteness of the non-specific kind. The latter may occasionally be found stained with the juice of tobacco. Then, too, the former is said to be often divided into little squares by crossed fissures, while the latter is more or less irregularly furrowed with superficial lines. The syphilitic form is much more readily influenced by treatment and can be cured, while recovery is rare in that due to other causes.

To be successful, local and constitutional treatment must be combined, and tobacco must be withdrawn.

The diagnosis from mucous plaque is generally an easy matter, since the latter is of much more rapid development, is usually multiple, dead-white, and not so translucent as beginning leucoplakia. Syphilitic scars may simulate the condition, but they are usually depressed, occupy the margins rather than the dorsum, and never change their location or spread.

Fissures are prone to occur in leucoplakia, causing pain in patches otherwise free from discomfort. Denuded patches and ulceration may follow the exfoliation of portions of the thickened epithelium, either from traumatisms or from spontaneous shedding of dead tissue. Since leucoma, whether in a syphilitic subject or in one who is free from the taint, is so apt to be the starting-point of carcinomatous change, the question of treatment assumes a double importance.

Treatment.—While it is possible for certain superficial, soft, pliable, bluish-white leucomas to disappear spontaneously or under local and constitutional treatment, the thicker and older plaques rarely if ever do so. There are those who maintain that every leucoplakia should be cured, if possible, even by surgical means if necessary, because of the danger from tongue cancer. While I am not prepared to admit that the resulting cicatrix and deformity, which may prove an object of irritation and be subject to many of the same dangers as was the original patch, is greatly to be preferred to a plaque which gives no trouble, still I am strongly of the opinion that all such tongues should be regularly inspected by a physician, and a radical operation undertaken at the first evidence of approaching danger. Perrin regards the best line of treatment in any case to be the total destruction of the white patch with the thermo-cautery or the galvano-cautery, and such a course seems to me much to be preferred to any attempt to remove the plaques by acids or other caustic applications.

Gumma or node is important not only in differential diagnosis from cancer, but also by reason of the fact that it may at times be the sole evidence of a specific taint, which, unless recognized and treated, may cause considerable loss of tissue.

Again, the node must be distinguished from that of tuberculosis, which is small, prominent, single, sometimes yellowish, and almost always ulcerated when observed. Deep-seated gumma may simulate a foreign body embedded in the tissues, and conversely, a tooth in the tongue has been taken for a gumma, and in the same way confusion may be caused by fatty and fibrous tumors, which, however, are quite rare. The former are apt to be lobulated, and the latter are harder and more circumscribed.

The characteristic of the gumma is that it is not sharply defined from the surrounding parts, and is often multiple, while both benign and malignant tumors are single. In doubtful cases always test by treatment before operating.

Prognosis is very favorable, and the earlier the diagnosis is made before softening the better. Phagedenic gumma is rare.

Treatment by large doses of iodide of potassium almost invariably brings about speedy resolution and cure.

Tuberous elevations located between the furrows and fissures of those tongues (in old syphilitics) which have been the seat of interstitial fibrous inflammation, and are due to the constricting effect of bands of tissue throwing the intervening tongue substance up into little mounds, must not be mistaken for gummatous formations, although to the touch they are often quite firm, and may materially soften under anti-syphilitic treatment.

Papillomatous, fungous, vegetating, or cauliflower-like growths, sometimes with ulceration at the summit, may occur, as the result of syphilis, upon the region of the tongue lying between the papillæ maximæ and the epiglottic fold. They may be scraped off with the curette and the base cauterized.

Lingual tonsil hypertrophy is found in hereditary syphilis; but it is also observed in the so-called strumous cases, and concomitant lesions or other evidence of syphilis may be necessary to distinguish it. A laryngoscope is required to show plainly the region. There are no positive symptoms by which specific hypertrophy can be distinguished from non-specific. Both give the sensation of a foreign body in the throat, affect the voice, cause fatigue in speaking, and occasion spasmodic cough. Iodine makes a good local application.

Diffuse sclerous glossitis, with much enlargement and hardening of the tongue, is rare. The surface which is free from papillæ is smooth, with red and white patches scattered over the dorsum. An instance of superficial sclerous glossitis, in which the organ appeared contracted or atrophic, and the smooth denuded dorsum was of a faint bluish tinge, was recently observed in a patient of mine who had contracted syphilis twenty-five years ago.

Disfiguring cicatrices upon the dorsum, as well as along the margins, are found upon the tongues of those who may have had no active signs of the disease for many years. They result from fissures, ulcers, and ulcerating gummata, and are permanent, excepting in so far as the possibility of their again breaking down is concerned, in which case new scars result. They present star-shaped, linear, or curvilinear, whitish, slightly raised or depressed striæ, or they may occur as more or less rounded patches.

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TRANSPORTATION OF THE DISABLED ON LAND.

At the time of the publication of the article on this subject in Vol. VII. of the HANDBOOK, the principles of the carriage of the disabled were firmly fixed and no change has since been made in them. But through the labors of the medical officers of the army, the details have been revised and improved until, at the present time, a practically permanent system may be said to have been determined upon. Chief among those whose work has contributed to this result are Colonel Woodhull, Majors Smart, Heizmann, Havard, and Hoff, Captains Brechmin, Strong, Dietz, and others. The present article is an abstract of the methods now used with certain additions and modifications made chiefly by one of the officers best qualified by experience and observation to select the most serviceable; in many instances, the exact words of the manual are employed; and the writer wishes to state distinctly that he is not presenting his own work, but that of his colleagues in the medical department.

The litter has been modified somewhat, and now consists of a canvas bed, six feet long and twenty-two inches wide, attached laterally to two poles, seven and a half feet long, held apart by a jointed brace at either end of the bed, as in the Halstead litter described in the HANDBOOK, Vol. VII., p. 224. The projecting ends of the poles form handles, nine inches long on either end. The litter rests on four fixed, looped-shaped, strap-iron legs, four inches high and an inch and three-quarters wide. On the left front and rear handles, a half-round iron ring is fixed, four and a half inches from the end; between this and the canvas plays the movable ring of the sling. A cross strap with ring and snap is permanently fastened to the bottom of each pole, near the handles, the free (ring) end passing through a staple under the opposite pole. When the litter is open, the straps lie transversely under the canvas, but when it is closed, they are passed around it through the free loops of the slings, and fastened to the snaps, thus securely closing the litter.

On either end of the litter is attached a sling, made of woollen webbing, two and a half inches wide, with a leather-lined loop at one end and at the other a leather strap with buckle, the strap passing through a steel swivel, itself attached to the movable ring on the handle.

The officers of the Hospital Corps detachment are the medical officers on duty with it. The non-commissioned officers are the hospital stewards and acting hospital stewards attached. Officers and non-commissioned officers of the same grade rank according to date of commission or warrant.

In the latter part of 1891 members of the Hospital Corps, who had previously been required to enlist in the line and serve one year there before entering the Hospital Corps, were permitted to be enlisted directly. In order to give these men the military training which had previously been given in the line companies, companies of instruction were organized at certain central military stations, where recruits are given a course of training in military and professional subjects.

Applicants for admission to the Hospital Corps are required to be over eighteen and under thirty years of age, and qualified to pass the physical examination as described by Colonel Greenleaf (HANDBOOK, Vol. II., p. 738, and SUPPLEMENT, p. 650) for all recruits, with the exception of refractive errors of vision. Marriage and excessive addiction to stimulants are positive disqualifications. The pay of privates of the Hospital Corps was increased in 1892 to an average of twenty-one dollars a month, with allowances consisting of clothing, lodging, board, and medical attendance, worth at a low estimate forty dollars a month more, making the position worth over seven hundred dollars a year.

An important feature of the training of the Hospital Corps, together with the company bearers (HANDBOOK, Vol. VII., p. 224), consists of instruction in carrying the disabled. In drilling in these manœuvres the detachment is formed in single rank, privates of the Hospital Corps on the right, company bearers on the left, each class graduated in size, the tallest man on the right. Civilian classes, in rehearsing these methods, should be formed in single rank, according to height, from right to left.

The medical officer commanding stands two paces in front of the centre of the detachment, with junior medical officers, arranged according to rank from right to left, two paces in the rear. The non-commissioned officers are arranged, the senior two paces in rear of the second file from the right, the second on the right of the rank acting as the right guide, the third on the left of the rank as left guide, and the remainder at equidistant points on a line with the senior non-commissioned officer, ranking from right to left.

At the command *Fall in*, the men take their positions in line, each with his left arm akimbo, so as to preserve a certain distance from his neighbor, dropping the hand when the interval is obtained. After each man has responded "Here" to the roll-call, the senior non-commissioned officer commands *Count Fours*, which is executed in the usual manner (HANDBOOK, Vol. VII., p. 225). He then commands, *Count Squads*, at which the Nos. 1 of each squad, beginning at the right, call out the number of the squad in turn. He then reports the formation of the detachment to the senior medical officer, and takes his post.

The junior medical officers having taken their posts, the senior commands, *Right* (or *left*) *Dress*, at which all the men, with left arm akimbo, turn the head and eyes to the right (or left) and dress upon the guide. At *Front*, they turn the head and eyes to the front, and drop the left hand.

The detachment may be sized before counting fours, the senior non-commissioned officer arranging the men from right to left. The relative positions thus once obtained, the men habitually take them thereafter.

MARCHINGS.—The men are drilled in marching to accustom them to uniform movements. These marchings are performed as directed in the Infantry Drill-Regulations, except that the formation is in single rank.

To march in line the command is, *Forward, Guide right* or (*left*), *March*, changing the step by *Guide left* (or *right*), and correcting losses of step by, *Step*.

To march backward: *Backward, Guide right* (or *left*), *March*.

To march to the rear: *To the rear, March, Guide right* (or *left*).

To side step: *Right* (or *left*), *step, March*.

To change direction obliquely, *Right* (or *left*) *Oblique, March*, the original direction being assumed at *Forward, March*.

To move rapidly: *Forward, Guide right* (or *left*), *Double Time, March*.

To pass from quick to double time: *Double Time, March*.

To pass from double to quick time, *Quick Time, March*.

Turnings are performed as follows: To turn and halt, *Detachment Right* (or *left*), *March, Front*.

To turn and advance, *Right* (or *left*), *Turn, March, Forward, March, Guide Right* (or *left*).

To march by the flank in column of files, *Right* (or *left*), *Face, Forward, March,* if at a halt; if marching, *By the Right* (or *left*) *flank, March.*

To change direction in column of files, *Column Right* (or *left*), or *Column half Right* (or *left*), *March*; if at a halt, the command, *Forward*, precedes these.

Being in line to march by the flank, the command is: *Fours Right* (or *left*), *March.*

To form column of twos or files, from fours, the commands are: *Right* (or *left*), *by twos* (or *files*), *March.*

To form column of fours from twos or files, the command is: *Form fours, Left* (or *right*), *Oblique, March.*

To change direction in column of fours, the command is the same as in column of files. Being in line, to form column of fours and change direction, the command is: *Fours Right* (or *left*), *Column Right* (or *left*), or *Column half Right* (or *left*), *March.*

Being in line to march in column of fours to the front, the command is: *Right* (or *left*), *Forward, Fours Right* (or *left*), *March.*

To change the file closers from one flank of a column of fours to the other, the command is: *File Closers on the Right* (or *left*) *flank, March.*

To oblique in column of fours, *Right* (or *left*), *Oblique, March.*

To march to the rear in column of fours, *Fours Right* (or *left*) *about, March.*

Line may be formed from column of fours by, 1, *Fours Right* (or *left*); 2, *March*; 3, *Guide Right* (or *left*), or, 3, *Detachment*; 4, *Halt.* Or line may be formed by *On Right* (or *left*) *into line, March, Detachment Halt, Front*; or *Right* (or *left*) *front into line, March, Detachment Halt, Front.*

In line, to march to the rear the command is: *Fours right* (or *left*) *about, March, Detachment, Halt,* or *Guide Right* (or *left*); or *To the rear, March, Guide Right* (or *left*). If at a halt the command may be: *Detachment About, Face, Forward, Guide Right* (or *left*), *March.*

On long marches the men are relieved from the necessity of keeping in step and in silence, by the command, *Route step, March,* the regular step being resumed at *Detachment, Attention.* In cases where silence is desired the men may be permitted to march as in route step but silently by the command: *At Ease, March.*

When at a halt, the men are rested by one of four commands: *Fall Out, Rest, At Ease,* and *Parade Rest.* At *Fall out*, they may leave the ranks, not going away, but remaining in the vicinity to resume their places at *Fall in.* At *Rest* they keep one heel in place, but are not required to preserve silence or immobility. At *At Ease* they need keep but one heel in place, but are required to be silent. At *Parade Rest*, the right foot is carried straight to the rear, the left knee slightly bent, the hands clasped in front, and silence and immobility maintained. Attention is resumed from the last three positions by *Detachment, Attention.*

The detachment having halted in line, the senior medical officer commands the senior non-commissioned officer, *Dismiss the Detachment,* whereupon the junior medical officers fall out, and the senior non-commissioned officer salutes, steps in front of the detachment, and commands: *Dismissed.*

INSPECTION.—The detachment being formed, the senior medical officer commands: *Open Ranks, March, Front*; which is executed in the usual way. As the inspector approaches, the senior medical officer faces about, commands: *Inspection Arms,* and facing to the front salutes him.

At *inspection,* each man armed with a knife grasps and slightly raises the scabbard with the left hand and seizes the grip with the right hand, thumb to the rear and against the guard; at *arms,* he draws the knife quickly, raising the arm to its full extent at an angle of about forty-five degrees, the knife in a line with the arm, which he then drops naturally extended by the side, the back of the blade to the front and the point down. The junior medical officers, and non-commissioned officers draw and carry sword.

When inspected, the senior medical officer returns sword, and accompanies the inspector, the junior medical officers facing about, and standing at ease when the inspector passes to the rank.

Commencing at the right, the sword or knife, accoutrements, and dress of each soldier are successively and minutely inspected, each man, as the inspector approaches him, brings his sword or knife vertically to the front, raises the hand as high as the neck and six inches from it, guard at the height of the chin, edge to the left, the thumb on the back of the grip; after a slight pause he turns the wrist outward to show the other side of the blade, and, as the inspector passes on resumes the original position; after the inspector has passed, he returns knife or sword without command.

To *return knife,* the scabbard is grasped by the left hand, the right hand quickly raised as high as the neck and six inches in front of it, the point of the knife is then dropped and the blade sheathed.

After all have been inspected, the senior medical officer commands: *Inspection pouches,* at which the pouches are shifted under the right arm to the front, the flap opened and held up by the left hand, the non-commissioned officers hold up their dressing packets, pouches and packets being returned as the inspector passes.

If the detachment is equipped with knapsacks, they are inspected in the same manner as with infantry.

At the completion of the inspection, the senior medical officer *closes ranks* in the usual way.

When the detachment is to be mustered, the inspection is followed before closing ranks, by the command *Draw, Knife, Attention to Muster.* As the names are called, each man answers "Here" and returns sword or knife, or, if unarmed, steps forward one pace.

LITTER-DRILL.—Each "four" is a litter squad, which is marched by the same commands as a set of four, substituting "litter" for "four." No. 1 commands the squad, in his absence No. 4, and if Nos. 1 and 4 are both absent, No. 3 commands. In the absence of No. 2 or 3, their duties fall to No. 4 or 1, respectively. The squads are to be so arranged as to place a man of intelligence as No. 1, and to pair Nos. 1 and 4, and 2 and 3 in size as nearly as possible.

To obtain the litter the instructor commands,* *Procure Litter, March,* at which each No. 3 steps one pace to the front, faces in the direction of the litters, and proceeds thither by the shortest route, takes one, places it in the position of "shoulder litter," and resumes his place, first stepping through the interval one yard to the rear and facing about.

To shoulder litter, the command is *Shoulder, Litter;* the litter is lifted and laid over the right shoulder canvas down, at a slope of about forty-five degrees, being supported by the right arm, the right hand grasping the left pole.

At the command, *Order, Litter,* the litter is brought to a vertical position and dropped to the ground, being retained in position by the right hand and arm.

When not in use, litters are well disposed in stacks consisting of three litters, to which two more may be added. At the command *Stack, Litters,* each No. 3 brings his litter from the shoulder to a vertical position and steps one pace to the front; No. 3 of the first squad stands fast and the other Nos. 3 close in upon him and face to the front. Then Nos. 3 of the first and third squads advance two paces, and facing each other, lock the upper handles of their litters together; No. 3 of the second squad then locks his handles in and all lower the stack to the ground, spreading it below sufficient to make it stand firmly. The other litters are then laid on and all resume their posts. To remove the litters, at the command *Take, Litters,* the Nos. 3 close in as before, then advance to the stack opposite their respective litters, take their litter, and return to their posts.

* It has been suggested to make this command *Procure Litter, Right* (or *left*) *Face, March,* facing the bearers in the direction of the litters.

In the foregoing remarks, the litter has been managed by No. 3, alone. In those which follow, the entire squad is engaged.

At the command *Carry, Litter*, No. 3 brings his litter from the shoulder to a vertical position, and drops the upper handles forward until the litter is horizontal, with the canvas to the left; No. 2 steps forward and catches the front handles with his left hand, and Nos. 1 and 4 advance to the middle of the litter on the right and left, respectively. Nos. 2 and 3 hold the litter between the hand and the hip, grasping the lower handles.

At *Ground, Litter*, Nos. 2 and 3 stoop and lower the litter to the ground, with the canvas up. The carry is resumed by stooping and picking it up at *Carry, Litter*.

With the litter at the carry, the shoulder is resumed at the command, *Shoulder, Litter*, when No. 3 brings the litter to a perpendicular and then on to the shoulder, the other bearers stepping back into the same line with him.

At the command *Open, Litter*, with the litter at a carry, it is unstrapped, opened, and placed upon the ground, Nos. 2 and 3 standing between the front and rear handles, respectively.

At the command *Fold, Litter*, Nos. 2 and 3 step around to the right and left of the handles, respectively, stoop and raise it by the right handles; they then fold the braces and support the closed litter at the carry. At *Close, Litter*, No. 4 supports the folded litter at the centre with the canvas up; Nos. 2 and 3, assisted by No. 1, double the canvas smoothly on the top of the poles, release the free loop of the slings, which they place lengthwise along the poles, and secure all by the cross straps at each end, passed about the whole.

At the command *Form, Rank*, the bearers step into the same rank.

Posts at the litter may be assumed at any time at the command *At Litter, Posts.*

Posts are changed, Nos. 1 and 3, and 2 and 4, exchanging at the command *Change Posts, March.*

The litter being at the open with or without a patient upon it, is lifted at the command, *Prepare to Lift, Lift.* At *prepare to lift*, Nos. 2 and 3 stoop, place the slings over their shoulders with the loops upon the handles, and grasp both handles; and at *Lift* they rise erect.

The litter squad with the lifted litter march with a short sliding step of about twenty inches, and, while Nos. 1, 2 and 4 step off with the left foot, No. 3 steps off with the right, forming the "break step."

To lower the litter, loaded or unloaded, the command is *Lower, Litter*, at which Nos. 2 and 3 gently lower the litter to the ground and relieve themselves of the slings. In lifting and lowering the litter the rear bearer watches the front bearer and moves simultaneously with him.

To return the litter, the command is,* *Return Litter, March*, at which each No. 3 steps one pace to the front and faces in the direction of the place designated for the litter, proceeds thither by the shortest route, deposits it, and returns to his place in line.

While usually the interval between litter squads is sufficient, it may be increased by the commands, *To two* (or more) *paces, extend, March*, and the regulation intervals resumed by *Litters Close, March.*

A line of litters is marched like a line of fours, substituting "Litter" for "Fours" in the commands. To turn and halt, the command is, *Detachment, Right* (or *left*), *March, Front;* to turn and advance, being in line, (*Detachment, Right* (or *left*), *Turn, March;* in line of litters to form column of litters and halt, *Squads Right* (or *left*), *March;* in line, to march in column of litters to the front, *Right* (or *left*), *Forward, Litters Right* (or *left*), *March;* to march to the rear, *Litters About, March*, whereupon the litters are faced about, the squad moving as if the centre were mounted on a pivot; if the litter is closed or folded the squads may be marched to the rear by, *To the Rear, March;* each man facing about, the two bearers passing the litter handles from one hand to the other.

A section consists of two litter squads in line. Column of sections may be formed from line by the command, *Sections Right* (or *left*), *March, Front;* or *Sections Right* (or *left*), *Turn, March, Forward, March, Guide Right* (or *left*).

The advantage of this formation is that it permits the shortening of the column at the carry without increasing its front, by the commands, *Sections Close, March*, when the sections close up to one pace and the litters oblique toward one another, until close against the inner free bearers, the outer free bearers meanwhile closing in on their respective sides. The normal formation is resumed by the command, *Sections Extend, March.*

Single column is formed from column or sections, at the command, *Right* (or *left*) *by Litter, March*, performed in the same manner as *Right by file.*

Column of sections is formed from single column at the command *Form Sections, Left* (or *right*) *Oblique, March.*

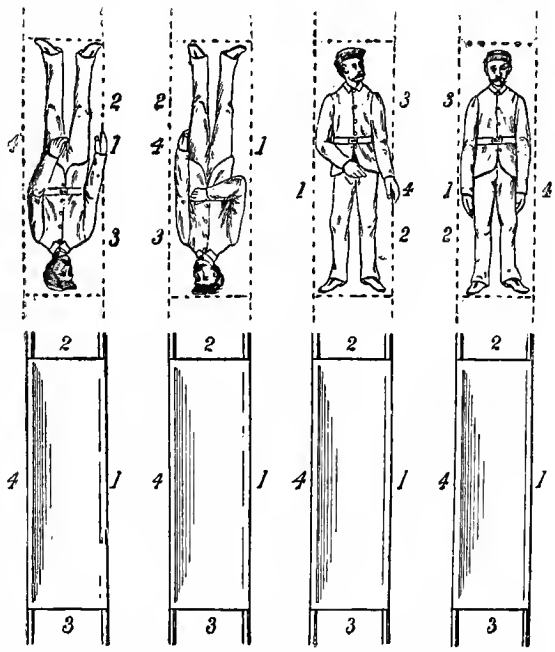

FIG. 641.—Relations in the Positions of "At Patient Posts, Right and Left."

LOADING THE LITTER.—With the litter at the carry, at the command, *Take Post to Load, March*, the squad approaches the patient and Nos. 1 and 4, in double time, take posts at his right and left side, respectively. The litter is opened and lowered as nearly as possible one pace from the patient's head, and in a line with his body. If this is impracticable, it may be placed in any convenient position.

Or, at the command, *Search for wounded, March*, each squad proceeds independently under command of No. 1. On discovering a patient, Nos. 1 and 4 proceed to him in double time, as indicated before, Nos. 2 and 3 joining them after placing the litter.

At the command, *At patient, Right* (or *left*), *Posts*, Nos. 2 and 3 take posts respectively, according to whether the command is "right" or "left," at the patient's right or left ankle and right or left shoulder; Nos. 1 and 4 invariably take posts respectively at the patient's right or left hip.

When Nos. 1 and 4 have reached their posts on either side of the patient, they search for the cause of his disability, removing his arms, accoutrements, and such portions of his clothing as may be necessary; they apply such first-aid treatment as may be required, Nos. 2 and 3 also assisting when they have arrived. In drilling, a

* The command, *Return Litter, Right* (or *Left*) *Face, March*, has been suggested as a substitute for this.

diagnosis tag is attached to the man who represents the patient, indicating the character of his disability, or the location and description of the injury, and the bearers pursue the line of conduct suggested by the disability.

The patient being ready for the litter, at the command, *Prepare to lift*, all the bearers kneel on the knee nearest the patient's feet, the right if on his right, the left if on his left, No. 2 passing both forearms under the patient's legs, Nos. 1 and 4 passing their arms under his loins and thighs, and No. 3 passing one arm under his shoulders and his other under his neck to the farther shoulder, supporting his head. In case of a fracture or other injury, the bearer nearest to it supports and looks after it. Then, at *Lift*, all collectively raise the patient slowly and gently to the knees of the three bearers, who

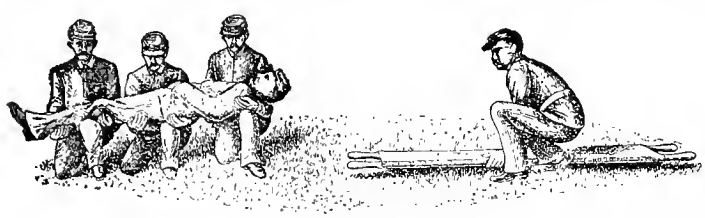

Fig. 642.—Lifting the Patient.

are in line; then the odd bearer, No. 1 or 4, arises and passing by the shortest route to the litter, grasps it by the middle, one pole in each hand, and returning, places it in front of the bearers and against their ankles.

Then at *Lower, Patient*, he stoops and assists the other bearers, who gently and carefully deposit the patient on the litter and resume their positions at litter posts.

If for any reason it is impossible to place the litter in this position, at the command, *Rise*, the bearers arise and move slowly to the litter, where they gently deposit the patient.

Passing Obstacles.—A breach should be made in a fence or wall for the passage of the litter if there be no gate or other opening, but if it becomes necessary to surmount the obstacle, at the command, *Obstacle*, Nos. 1 and 4 grasp the litter poles at the centre on either side; at *March*, No. 2 slips the litter sling from his shoulder, and, climbing over, receives the litter as it is passed over; Nos. 1 and 4 now climb over, and again seizing the litter poles, pass it over, No. 3 slipping off his sling and following. All then resume their positions and proceed.

The passage of a narrow cut or ditch is similarly effected, Nos. 1 and 4 bestriding or descending into the ditch to support and assist in crossing the litter. A wide cut or ditch may require the litter to be halted and lowered, with the handles near the edge before proceeding as before.

When it is desirable that four bearers support the litter, at the command, *By fours, Carry, Litter*, No. 1 steps back to the right, rear handle, and No. 4 forward to the left, front handle, which are relinquished by Nos. 2 and 3. The litter may be lifted or lowered in the same way by prefixing, *By four*, to the ordinary command.

Carrying the Loaded Litter up an Ascent.—The litter is faced about at the foot, and at the command, *Prepare for ascent*, Nos. 1 and 4 face inward and support the litter by grasping the poles, No. 3 adjusts his slings and grasps his handles, No. 4 steps to the near rear handle, which he grasps with both hands, while No. 2 grasps the other; No. 1 accompanies the litter as before, falling to the rear if necessary; at the command, *March*, the litter is carried up, Nos. 2 and 4 keeping their end at the height necessary to maintain the litter at a level. With but three bearers, the litter will have to be lowered before the first command. If the patient is to be carried but a short distance the original position need not be resumed until the destination is reached.

Carrying the Loaded Litter down a Descent.—Without facing the litter about at the command, *Prepare for descent*, No. 4 co-operates with No. 2 as above, but in front.

Loading with Reduced Numbers.—As previously stated, in the absence of No. 2 or 3, his place is taken by No. 4 or 1, respectively. With three bearers, the patient is lifted on the knees of two while the third places the litter; or, when the patient is to be carried to the litter, he may be carried on a two-handed seat, as described hereafter, his legs supported by the third bearer. If there are but two bearers they simply carry the patient on the two-handed seat; or, in case of fractured lower extremities it is recommended that the two bearers kneel on the injured side, raise the patient on their knees, and grasp him firmly in a comfortable position, No. 2 supporting both lower extremities, the body being supported by No. 3, around whose neck the patient clasps his hands, and they arise.

Unloading the Litter.—With the bearers at patient-posts, at the command, *Prepare to Lift*, they kneel and adjust their hands; at *Lift*, they lift him to their knees. The litter being removed at *Lower, Patient*, they gently lay him on the ground. With but two bearers the patient is removed with a two-handed seat; or, in case of fractured lower extremity, by two on a side, as in loading.

Transferring from Litter to Bed, or Litter.—With four or three bearers the litter is placed at the foot of the bed, and as nearly as possible in a line with it. After taking the patient on their knees the bearers rise and side-step gently to the bedside and lower him; or, placing the litter at the side of the bed as close as possible, the three bearers on the side away from the bed take the patient on their knees, and rising, step forward to the bedside, and with the help of the odd bearer gently lower him upon it.

The patient is removed from litter to litter by lifting the patient on to the knees, replacing the litter by the new one, and lowering him on to it.

Improvising Litters.—Litters may be extemporized from many objects, a subject that has already been fully discussed in the Handbook, Vol. VII., p. 232; but the usual military improvisation is by means of rifles and blankets.

Each squad being provided with two rifles and bayonets, carried by Nos. 3 and 4 at the "carry," and a blanket carried by No. 2, they are brought into position at the commands, *Squads, Right by Twos, March, Halt. Squads to three paces interval, Right* (or *left*), *Step, March, Halt.* The squads having thus obtained their proper positions, at *Prepare, Blanket-Litter*, Nos. 1 and 2 face about, No. 2 brings forth the blanket, which is unrolled and spread upon the ground; Nos. 3 and 4, pulling the ramrods out twelve inches—if there are no bayonets—lay the rifles under the edges of the blanket, muzzles to the front and somewhat converging, hammers in, and all the bearers roll the rifles tightly in the blanket, equally on both sides, until the space between them measures twenty inches, hammers down, and rise. At the commands, *By four*, the bearers take positions external to each rifle, facing one another, Nos. 3 and 4 opposite the butts, and Nos. 1 and 2 opposite the muzzles; at *Prepare to Lift*, they stoop and grasp the rifles firmly with both hands, and at *Lift*, slowly rise with the litter. To take this litter apart, at *Break, Blanket-Litter*, the blanket-litter being lowered, the bearers stoop and unroll the blankets on either side, return the ramrods, Nos. 1 and 2 roll the blanket and return it to its place, and face to the front, Nos. 3 and 4 bring their rifles to an order. The line is then reformed at *Form fours, Left Oblique, March.*

The blanket-litter may also be formed by rolling half of the blanket lengthwise into a cylinder, which is placed along the back of the patient, who has been turned carefully on his side. The patient is then turned over on to the blanket and the cylinder unrolled on the other side. The rifles (with bayonets fixed, if at hand) are then laid on the ground under the side edges of the blankets, muzzles to the front and somewhat converging, butts to the

head of the patient, and are rolled tightly in the blanket, equally from each side, until the body of the patient is reached, when they are turned hammers down.

REMOVING THE DISABLED WITHOUT LITTERS.—*For One Bearer.*—Four positions are taught. To bring the patient to any of these, he is first brought to the preliminary position :

FIG. 643.—Standing Astride.

Preliminary Position.—The bearer, turning patient face down, steps astride his body, facing his head, and with hands in armpits lifts him to his knees, then, clasping hands over abdomen, lifts him to his feet and places patient's left arm around his (bearer's) neck, patient's left

FIG. 644.—Preliminary Position.

side resting against his body, and supports him with his right arm around his waist.

To Lift the Patient in the Arms.—The bearer, with his right arm behind the patient's back, passes his left under the thighs and lifts him into position.

To Place the Patient Astride the Back.—The bearer shifts himself to the front of the patient, back to him, stoops, and grasping his thighs, brings him well up on the back. As the patient must help himself by clasping his arms around the bearer's neck, this method is impracticable with the unconscious.

To Place the Patient across the Back.—The bearer with his left hand seizes the right wrist of the patient, and draws the arm over his head and down upon his left shoulder, then shifting himself in front, stoops and clasps the right thigh, with his right arm passed between the thighs, his right hand seizing the patient's right wrist; lastly, with his left hand he grasps the patient's left and steadies it against his side, when he rises.

FIG. 645.—Astride of Back.

FIG. 646.—Across Shoulders.

To Place the Patient across the Shoulder.—The bearer faces patient, stoops, places his right shoulder against the abdomen, and clasps the right thigh with the right arm passed between his legs; he then grasps the patient's right hand with his left and draws the right arm down upon his left shoulder until the wrist is seized with his own right hand; lastly, he, with his left hand, grasps the patient's left and steadies it against his side, when he rises.

To Lower the Patient.—In lowering from these positions the motions are reversed.

Should a patient be wounded in such a manner as to require the motions to be conducted from his right instead of his left side, the change is simply one of hands.

For Two Bearers.—The two- and four-handed seats are formed at the command, *Form Two-* (or *Four-*) *Handed Seats, Prepare to Lift, Lift.* At the first command the two bearers take position facing each other on the right and left sides of the patient, near his hips; at the second they raise him to a sitting posture and pass their hands under him, forming the seat, passing their inner hands and arms about his neck in the two-handed seat, and rise.

Carriage by the Extremities is performed at the command, *Prepare to Lift, Lift.*

FIG. 647.—By the Extremities.

A rifle seat may be formed by running a rifle across the shoulders and through the sleeves of an overcoat, buttoned, and with buttons down, and rolling another rifle tightly into the tails, both pieces being held hammers down.

A stronger seat is formed by using the gunslings as

follows: Two men, with the slings of their rifles equally loosened as for carrying on the back, face each other with their pieces at a "present;" No. 1 seizes the sling of No. 2's rifle with the right hand, lifts his own rifle with the left hand, and passes the butt through the sling

FIG. 648.—By the Rifle Seat.

from left to right, straightening his sling as soon as his hammer has cleared the sling; No. 2 grasps the sling of No. 1's rifle with the right hand, and depressing the muzzle of his own piece, passes it through the sling he holds, from left to right, straightening the piece as the sling is cleared. The pieces now being at the original present, the butts are lowered to the ground, the left hand of each man being brought to the muzzle of his piece. No. 2 grasps the muzzle, No. 1 stoops and secures the butts. A seat 20 inches wide and 2 feet long is thus formed, on which the patient sits with his back against the rear bearer, his legs hanging over outside, and the hollow of his knees resting on the barrels.

PLACING A PATIENT ON HORSEBACK.—The help required to mount a patient depends upon the site and nature of his injuries; in many cases he is able to materially help himself. If he be entirely helpless, five men are needed to mount him, one to hold the horse, the others as bearers. If necessary the horse is blindfolded.

To load from the near side, the bearers take posts at patient's left, lift the patient and carry him to the horse, to which his body is made parallel, his head toward the tail. No. 1 takes post on the off side of the horse, ready to grasp the right leg of the patient when it is brought within his reach. Being close to the side of the horse, at the command *Mount*, the patient is carefully raised and carried over the horse until his seat reaches the saddle, when he is raised into position.

If necessary to mount him from the off-side, the bearers take posts at patient's right. The same general plan is used in mounting with reduced numbers. To dismount the patient, the process is reversed at the command, *At Patient Right* (or *left*), *Posts, Prepare to Dismount, Dismount.*

To make a mounted patient comfortable, a comrade may be mounted behind to steady him and guide the horse; or a lean-back may be provided of a blanket roll, a pillow or a bag of leaves, hay, or grass; or one may be made of a sapling bent into an arch over the cantle of the saddle—its ends securely fastened—or of some other framework, to which the patient is bound.

THE TRAVOIS.—The travois is practically a litter drawn by one animal, the rear handles dragging on the ground. It is the ordinary Indian conveyance for baggage and the sick. The travois requires but one animal and two men, one to lead the animal, and one to watch the patient and be ready to lift the rear poles when passing over obstacles, crossing streams, or going up hill.

A regulation travois consists of two jointed side-poles 17 feet long, when extended, connected by two-cross-bars, the front of which is somewhat larger than the rear, and placed six feet apart; from the cross-bars a regulation litter is suspended by straps provided for the purpose. This folds into a package nine feet long, which may be carried on the brackets of the ambulance.

A travois may be improvised by cutting poles about 15 feet long and 2 inches in diameter at the small end. These poles are laid parallel to each other, small ends to the front, 2½ feet apart; the large ends about 3 feet apart, and one of them projecting about 8 or 10 inches beyond the other. The poles are connected by a cross-bar about 8 feet from the front ends of the poles, and another about 2½ feet from the rear ends, each notched at its ends and securely lashed by its notches to the poles. Between the cross-pieces the litter bed, 6½ feet long, is filled in with canvas, blankets, etc., securely fastened to the poles and crossbars, or with rope, lariat, rawhide strips, etc., stretching obliquely from pole to pole in many turns, crossing each other to form the basis for a light mattress or improvised bed; or a litter may be made fast between the two poles to answer the same purpose. The front ends of the poles are then securely fastened to the saddle of the animal.

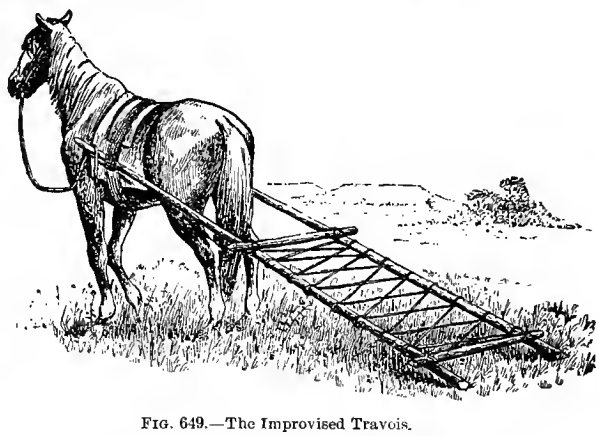

FIG. 649.—The Improvised Travois.

THE TWO-HORSE LITTER.—This is a litter with long handles used as shafts for carriage by two horses, or mules, one in front, the other behind the litter. On a good trail it is preferable to the travois, as the patient lies in the horizontal position, and, in case of fractured limbs, they can easily be secured against disturbance. The great disadvantage of this litter is that it requires two animals and three men for the carriage of each patient, one to attend the disabled man, and the others to watch over and guide the movements of the animals. The litter may be improvised in the same manner as the travois, only the poles should be 16½ feet long, and the cross-bars forming the ends of the litter-bed should be fastened 5 feet from the front and rear ends of the poles. The ends are made fast to the saddles by notches, into which the fastening ropes are securely tied.

THE AMBULANCE.—The regulation ambulance is a four-wheeled vehicle, drawn by two horses. It measures 7½ by 4 feet inside and accommodates eight men sitting, or two recumbent on litters, or four sitting and one recumbent. Its four seats can be hung, when not in use, two on each side, as cushions. The medical and surgical chests are stored in a box under the driver's seat, and there are two water-tanks under the body; outside are two brackets on each side to hold the litters.

AMBULANCE DRILL.—The litters are said to be *packed* when they are closed and put in place. The seats are

said to be *prepared* when they are horizontal, resting on the legs, and *packed* when they are hung on the sides.

Being in line at *At Ambulance, Posts*, the squad executes right by file and marches by files to the ambulance, No. 1 taking post on the left, No. 2 in the centre, No. 3 on the right of the rear of the ambulance and close to it, and No. 4 on the right of No. 3. This is the invariable position at ambulance posts, and it may be taken at that command from any position whatever.

To Prepare Seats.—With the seats packed and the squad at ambulance posts, at the command *Prepare Seats*, Nos. 1 and 3 raise the curtain if necessary, and open the tail gate, Nos. 2 and 3 enter the ambulance, No. 2 facing the front and No. 3 the rear seat of their respective sides. Each man seizes the lower edge of the seat, about six inches from the ends, with both hands and lifts it carefully to free the hooks from the upper slots, and then slips them into the lower slots; he raises the legs and adjusts them firmly in place. Then he prepares the opposite seat in like manner, and each bearer resumes at ambulance posts.

To Pack Seats.—With the seats prepared and the squad at ambulance posts, at the commands, *Pack, Seats*, Nos. 1 and 3 raise the curtain, if necessary, and lower the tail gate, Nos. 2 and 3 enter the ambulance, No. 2 facing the front and No. 3 the rear seat of their respective sides, each man releases the legs, seizes the edge of the seat with both hands, unhooks the seat and hangs it from the upper slots. After packing the opposite seat the men resume at ambulance posts.

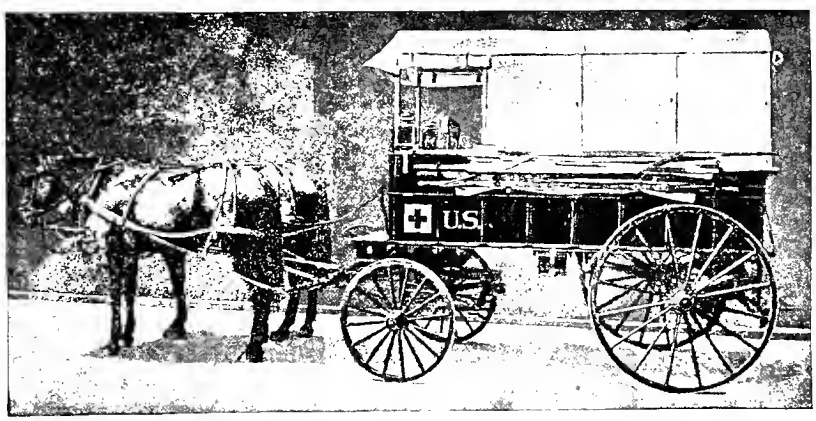

Fig. 650.—Ambulance of the U. S. Army. Pattern of 1892.

To pack or prepare seats on one side only, leaving the other side for recumbent or sitting patients, the command is, *Prepare* (or *Pack*) *Seats, Right* (or *left*).

To Load the Ambulance.—With the litter lifted, at the command *Take Posts to Load Ambulance, March*, the squad proceeds to the ambulance, executing an about on its arrival so as to bring the patient's head toward the ambulance, and a yard to the rear of it, and lower the litter.

At *Prepare to Load*, after securing the slings, Nos. 1 and 3 take posts at the patient's right and left shoulder, respectively, No. 2 facing about, and all stoop, No. 2 grasping his handles, and Nos. 1 and 3 the poles on their sides, while No. 4 opens the tail gate and sees that the ambulance is properly prepared. At *Load*, the bearers gently lift the litter to the level of the floor of the ambulance and advance to it, taking care to keep the litter horizontal; the legs are placed on the floor by Nos. 1 and 3, and the litter pushed in by No. 2, assisted by the others. This leaves Nos. 1, 2, and 3 at ambulance posts, Nos. 1 and 3 close the tail gate, No. 4 places the arms and accoutrements of the patient under the litter and takes his post.

To Unload the Ambulance.—With the squad at ambulance posts, at the command, *Prepare to Unload*, Nos. 1 and 3 raise the curtain and open the tail gate, while No. 2 grasps the handles of the litter. At *Unload*, No. 2 draws out the litter, assisted by Nos. 1 and 3, who facing inward, support the poles until the inner handles are reached. The litter, carefully kept horizontal, is lowered with the head a yard behind the ambulance, No. 4 closes the tail gate, and all take posts at litter.

To Load with Two Bearers.—The bearers seize the poles on either side and pass the litter into the ambulance. To unload, each one seizing a handle, they draw the litter out, grasping it on the sides as near the middle as possible and lower it.

The right side of the ambulance, unless otherwise directed, is invariably loaded and unloaded first.

If desired to load feet first, the command take posts to load is preceded by, *By Fet*, Nos. 1 and 4, and 3 and 2, exchanging functions.

An important part of the Hospital Corps drill is concerned with the pitching and striking of the tents composing the Field Hospital. This is done according to a uniform method and in concert.

They are also taught to pack and load pack-mules with the medical and surgical chests. *James E. Pilcher.*

TRICHLORACETIC ACID. This is one of three chloracetic acids produced by the substitution of chlorine for hydrogen atoms. In trichloracetic acid three atoms of hydrogen of acetic acid are replaced by three of chlorine. Its chemical formula is $C_2Cl_3O(OH)$. It may be prepared by introducing a small quantity of acetic acid into a bottle containing chlorine gas and exposing it to the sun's rays for several hours. It is a colorless crystalline salt, deliquescent and freely soluble in water, alcohol, and ether; it has a faint odor and a sharp caustic taste.

This acid is now used as a very convenient and delicate test for albumin in the urine. Its application is very simple, a crystal is to be dropped into the urine, where it rapidly dissolves and produces a cloudiness if albumin is present. A saturated solution may also be used, a few drops being allowed to fall upon the surface of the urine: at the point of contact a cloudiness is at once observed.

This test was proposed by Boymond (*Répert. de Pharm.*, October, 1889), and has been endorsed by numerous observers during the past few years. (*Johns Hopkins Hosp. Bullet.*, February, 1890.) (*Lancet*, March 21, 1891.) The reaction is very prompt and does not require to be confirmed by heat, as peptones are not acted upon. The only danger to be guarded against is the presence of an excessive amount of urates, which will cause a similar cloudiness. This, however, is very slow in appearing and may be overcome by diluting the urine with water.

The chloracetic acid has also been recommended as an escharotic to replace chromic acid. The advantage of this cauterization is that the effects are very localized and do not extend into the surrounding soft tissue. It has been used with success in the treatment of venereal warts, papillomata, and other cutaneous growths. It is used pure, a crystal being placed upon the part, which produces its effect at once. A dry, white, adherent scab forms, which detaches itself after a few days without causing any reaction whatever, and leaving a raw surface which rapidly cicatrizes. A single application may be sufficient for small growths, while for larger ones it may be necessary to repeat the application several times. These are not very painful, and may be rendered painless by the use of cocaine. Nævi are also reported to have been cured by three or four applications, the cicatrix remaining being

very superficial and hardly noticeable. It has also been used successfully in the treatment of chronic inflammations and hypertrophied conditions of the mucous membrane of the nose and throat. It is employed as an escharotic or as an astringent application. For the latter purpose a solution is prepared by dissolving the acid in an equal quantity of glycerine and adding a small amount of iodine and iodide of potassium. In chronic gonorrhœa it has been used by applying it directly to the source of the trouble by the aid of an endoscope.

Beaumont Small.

TRIONAL AND TETRONAL. These two hypnotic compounds have now been before the profession for two or three years, but are very rarely employed, as they have not proved to be superior to sulphonal, which they were introduced to replace. They are closely allied to sulphonal, being formed by substituting ethyl groups for those of methyl. In sulphonal there are two ethyl and two methyl groups; in trional an additional ethyl group replaces a methyl group; and in tetronal the two methyl groups are replaced by two of ethyl. The following formulæ explain the differences in their construction: Sulphonal, $(CH_3)_2\ C\ (So_2C_2H_5)_2$; trional, $C_2H_5CH_3C\ (So_2C_2H_5)_2$; tetronal, $(C_2H_5)_2\ C(So_2C_2H_5)_2$.

These two drugs are the result of a series of experiments for the purpose of determining upon which of the radicles the therapeutic action of the several sulphones depended (*British Medical Journal*, January 11, 1890). The sulphur-containing radicles were generally supposed to be the active element, but it was found that these had little influence, while the various compounds were more or less active, according as they contained a greater or smaller number of the ethyl groups. Sulphonal with two ethyl groups possessed a certain hypnotic action; when the number was increased its therapeutic power became greater, and when fewer groups were introduced it became correspondingly less. To the compounds containing three and four groups, respectively, the names tri- and tetronal were given, the title indicating the number of groups present. They both form in lustrous, tabular crystals; soluble in alcohol, but only slightly so in water—trional to the extent of one part in three hundred and twenty; tetronal, one in four hundred and fifty; the former melting at 76° C., the latter at 85° C. The taste of both is bitter, somewhat resembling camphor.

Clinical experience has shown that the relative activity of the two compounds to sulphonal and to one another, is not what was to be expected from the early theoretical and experimental reports. Both have been found to possess valuable hypnotic properties, but not superior to sulphonal; the strength, also, is not materially increased, as the quantity required is almost as great as that of sulphonal. They, however, often prove serviceable when sulphonal has been given without producing any effect. The one advantage that is evident, is a greater freedom from any undesirable after-affects or toxic action. Compared with one another it appears that the trional is really more active than tetronal, though the difference is not very great. They both have a valuable sedative as well as hypnotic action, and have proved of service in the treatment of the insane. The dose of each ranges from fifteen to sixty grains, and their best effects are obtained when administered in an abundance of hot water, about half an hour before sleep is desired. They have no analgesic action, and do not exercise any effect when the sleeplessness is due to pain. *Beaumont Small.*

TUBERCULIN AND TUBERCULOCIDIN. When Robert Koch announced, in an address before the International Medical Congress in Berlin, in August, 1890, that he had discovered a substance which conferred on animals experimented with an immunity from inoculation with the tubercle bacillus, and which arrested tuberculous disease, a degree of enthusiasm was aroused in the medical profession such as perhaps had never been witnessed before. Although the announcement was premature, the sterling character of Koch, and his brilliant scientific work, led the profession to the belief that the discovery would be even more far-reaching in its therapeutic value than the modest statements of the author claimed.

When Harvey demonstrated the circulation of the blood, his teachings were vigorously opposed by most of the older men of the time; and when Jenner's observations and experiments led him to advocate universal vaccination as the only means of eradicating that dreaded scourge—small-pox—he found his views largely opposed both by the profession and by the public. Quite different was the reception of Koch's recent discovery. Scientific medical men throughout the world were not only willing but anxious to fully test the therapeutic value of this new remedy.

That the hope entertained by Koch, as well as by the whole civilized world, has not been fulfilled, is a disappointment shared alike by all; for we must admit that we have no remedy for the malady which annually carries off a larger number of our population than any other disease—consumption.

Koch is, however, continuing his investigations, and it seems reasonable to hope that his efforts may yet meet with success. If this result is to be realized, however, it must be attained through patient research, and not by thoughtless acceptation, or hasty rejection. Koch's first publication appeared in the *Deutsche medicinische Wochenschrift*, November 14, 1890, and was published on the following day in the *British Medical Journal*, and in the *Medical News*.

Definition.—Tuberculin is a concentrated glycerine-extract of tubercle bacilli. It was at first called *Koch's fluid*, and later *Koch's lymph*. It is now known almost entirely by the name *tuberculin*, although the term *paratloid* is also sometimes applied.

History.—The discovery of tuberculin was entirely synthetical. Koch had observed that after injecting healthy guinea-pigs with tubercle bacilli, hardening and ulceration followed at the point of inoculation; the ulcer remaining unhealed up to the time of the death of the animal. If at the time of inoculation the animal was suffering from tuberculous disease, the changes were altogether local. At the seat of injection the epidermis became necrotic and was finally thrown off, leaving a rapidly healing ulcer.

If, however, instead of being fully active the cultures of bacilli were weakened in various ways, as by exposure to cold, heat, or to various chemicals, and then suspended in water and injected, the result was quite different. In healthy guinea-pigs the only effect was local suppuration, whereas tuberculous animals were killed by injections of even small doses in from six to forty-eight hours.

If the solution was further diluted and injected at intervals of from one to two days, a notable improvement in the condition of the animal took place, leading ultimately to its recovery. It was found that tubercle bacilli so injected did not spread, and it therefore seemed certain that the effect observed was due to soluble substances that had been taken into the circulation. These results were so uniformly observed in animals, that Koch was led to use the remedy in tuberculous individuals.

Preparation.—An infusion of veal is prepared in the ordinary way, and made weakly alkaline; to this is added one per cent. of peptone, and four and a half per cent. of glycerine. The best culture vessel is the flat-bottomed Ehrlenmeyer flask, in which is placed from thirty to fifty cubic centimetres of this fluid. The latter is inoculated with a small scale of the seed culture-material, which is allowed to float on the surface, and then incubated at 38° C.

The colonies of bacilli gradually form thick, white crusts, which at the end of six or eight weeks slowly settle to the bottom of the vessel. The cultures used for extraction must be fully ripe—from six to eight weeks old; they must be absolutely pure, to insure which, each vessel should be examined microscopically. The fluid culture medium extracts a considerable portion of the activity of the cultures. The pure cultures so prepared are evaporated in a suitable vessel over a

water-bath to one-tenth their original volume; they are then kept for an hour at a temperature of about 100° C. in order to kill the tubercle bacilli, which are then removed by filtering the fluid through a clay or silica filter. The fluid so prepared contains from forty to fifty per cent. of glycerine, which preserves it from decomposition, so that the remedy remains active for a long time.

A purified tuberculin has been prepared by Koch by precipitating the original fluid with sixty per cent. alcohol. Solutions of this precipitate in fifty per cent. glycerine are entirely stable. This preparation is forty or fifty times as strong as the crude tuberculin, but in practice it did not appear to present any advantages over the latter.

Test.—Before being sent out tuberculin is injected into tuberculous guinea-pigs. It has been found that 0.5 gramme kills with certainty. This requirement is therefore fulfilled before the remedy is put on the market.

Physical Properties.—The remedy is a brownish, transparent liquid, with a slightly saline taste, a specific gravity of 1.150, and a faint odor suggesting that of extract of beef. It does not tend to undergo decomposition. For use the fluid must be more or less diluted, and when so prepared putrefactive changes occur with the development of bacterial growths, unless special measures be employed. To render the diluted fluid stable it must be sterilized by heat and preserved under a cotton-wool stopper, or, more conveniently, prepared with a one-half per cent. solution of carbolic acid. It is probable that the strength of the drug is weakened by the action of heat or of carbolic acid, and therefore freshly prepared solutions should always be employed.

Chemistry.—The fluid is always alkaline in reaction. Chemically it seems allied to the albumoses, from which, however, as well as from toxalbumins, it differs in two important particulars: first, in withstanding high temperatures without losing its properties; and, second, in passing easily and quickly through the dialyzer. The active principle, which perhaps is present in but a fraction of one per cent., can be precipitated from the impure extract by absolute alcohol, not in a pure state, however, but associated with insoluble extractive substances. According to Koch, the active principle is neither an alkaloid nor a ptomaïne, but is allied to the albuminoids (*Deut. med. Woch.*, 1891), and gives the following albuminoid reactions: The biuret reaction, Adamkiewicz's reaction (glacial acetic acid and concentrated sulphuric acid); Millon's reagent causes a white precipitate which changes to a reddish color on being heated. The active principle is isolated with great difficulty, as it rapidly undergoes chemical change.

Tuberculin is completely precipitated by phosphotungstic acid, acetate of iron, and ammonium sulphate. With sixty per cent. alcohol, it gives a flaky white precipitate. An aqueous solution of picric acid causes a flaky precipitate which redissolves on the addition of heat, and again separates on cooling; nitric acid gives a precipitate which increases in density on standing, and when heated the solution turns yellow, becoming brownish-red on the addition of sodium hydrate. Acetate of lead causes a cloudiness, but no precipitate. Crookshank (Klinische Jahrbuch, 1891) gives the following reactions: alcohol in excess, a turbidity; phosphotungstic acid, a white precipitate; potassic bismuthic iodide, a slight orange precipitate; potassic ferricyanide, after standing a few minutes, gives the Prussian-blue test on the addition of ferric chloride; iodine in iodide of potassium, after standing, an amorphous precipitate; phosphomolybdic acid, a yellow precipitate; a blue color on the addition of ammonia, which disappears on boiling.

The researches of Dr. William Hunter (*Brit. Med. Jour.*, vol. ii., 1891) indicate the following as the chief constituents of tuberculin, named in the order of their importance and the relative amounts present: 1. Albumoses, chiefly proto-albumose and deutero-albumose along with heteroalbumose, and occasionally a trace of dysalbumose. 2. Alkaloidal substances, two of which can be obtained in the form of the platinum compound of their hydrochlorate salts. 3. Extractives; small in quantity and of unrecognized nature. 4. Mucin. 5. Inorganic salts. 6. Glycerine and coloring matter.

The following substances appear from these observations to be absent, namely: serum albumen, globulin, and peptones.

Brieger and Proskauer (*Deut. med. Woch.*, 1891) obtained from 16.65 to 20.46 per cent. of ash, consisting almost entirely of phosphate of potassium and magnesium. These observers give as the average composition of three samples examined, carbon, 47.61 per cent.; oxygen, 7.62 per cent.; nitrogen, 14.54 per cent.; and sulphur, 1.15 per cent.

Physiological Action.—Introduced into the stomach the remedy produces no effect whatever; it is therefore necessary to administer it subcutaneously. Man is much more sensitive to the drug than the guinea-pig, in proportion to the relative weights. In a healthy guinea-pig the injection of two cubic centimetres of the undiluted liquid was without visible effect. In a healthy adult person, 0.25 cubic centimetre administered in the same manner, was sufficient to produce a marked reaction.

Koch injected into his own arm 0.25 cubic centimetre of the remedy, and describes the symptoms which resulted as follows: From three to four hours after injection there was a drawing sensation in the extremities, weakness, inclination to cough, and difficulty in breathing, which rapidly increased. In the fifth hour there appeared an unusually severe chill lasting an hour; this was accompanied with nausea, vomiting, and a rise of temperature to 39.6° C. (103.3° F.). In about twelve hours all these symptoms decreased, the temperature became lower, and on the following day was again normal. Heaviness and debility lasted for some days, and the seat of injection remained somewhat painful and reddened during this time.

The minimum dose that will produce any effect in a healthy man, as demonstrated by numerous experiments, is about 0.01 cubic centimetre, which is equal to one cubic centimetre of the one per cent. solution. The usual effects of this dose are slight pains in the members and a transient debility. Occasionally the temperature rises to 38° C. (100.4° F.). The same effects are noted after administering the remedy to individuals suffering from diseases other than those of a tuberculous nature.

Geissler (*Wratsch*, No. 21, 1891) has injected healthy rabbits with tuberculin, killing them after ten injections, and comparing at the same time the condition of the various organs of the tuberculinized with that of the same organs in healthy animals. His studies show in the tuberculinized animals the following changes: In the liver, evidences of hyperæmia and localized patches of parenchymatous degeneration. The heart-muscle showed cloudy swelling, with hyperæmia and granular degeneration of the muscle-fibres. The changes in the kidneys corresponded with those seen in the heart. The spleen was markedly hyperæmic.

Action on Tuberculous Individuals.—If, however, 0.01 cubic centimetre is administered to a person suffering from a tuberculous affection a marked general, as well as a local, reaction follows. There is usually a chill, the temperature rises to 39°, 40°, or even 41° C. (105.8° F.); at the same time pain is experienced in the extremities, there is a desire to cough, a feeling of great debility, and frequently nausea and vomiting. Sometimes a slight icterus is to be noted. In rare cases a measle-like exanthem has been observed on the neck and breast, and still more rarely a scarlatiniform eruption has followed the administration of the remedy.

The reaction begins as a rule four to five hours after injection, and lasts from twelve to fifteen hours. Exceptionally it commences later and then runs a milder course. The patients are surprisingly little affected by the attack, and as soon as it is over are relatively well, usually as well as before the injection. Some express themselves as feeling better than before.

The local reaction can be best observed in those patients presenting external tuberculous affections. In the case of lupus, for example, the changes that take place are so characteristic, and show in so remarkable a manner the

specific effect of the drug, that a description of these in this affection will render a repetition in other tuberculous troubles unnecessary. Some hours after the injection has been made the lupus points become reddish and begin to swell, usually before the beginning of the chill. During the fever the swelling and discoloration increase and may finally reach a high degree, so that the lupus tissue in places assumes a brown-red color and becomes necrotic. Frequently the swollen brown-red patches have a whitish border, nearly a centimetre broad, which again is surrounded by a broad, highly reddened halo. As the fever declines the swelling begins slowly to decrease, so that in two or three days it may have disappeared, the lupus patches having become covered with crusts from the oozing and drying of serum. After two or three weeks these scabs fall off, leaving in favorable cases a smooth red scar beneath. The healthy skin is unaffected, but lupus points that were before invisible become apparent after the administration of the remedy. Less striking reactions, but none the less characteristic to the eye and touch, take place in cases of tuberculosis of the glands, bones, and joints.

The remedy acts upon the living tuberculous tissues in the body, but does not affect the bacilli. On dead tissue, such as caseous masses and carious bones, as well as upon tissue which has already been destroyed by the remedy, it has no effect.

It is possible, and in fact necessary, rapidly to increase the dose of the remedy, as the patient fails to react to the smaller quantities, so that in a few weeks many times the original dose may be given. This is explained by Koch by supposing that after each injection a certain amount of tuberculous tissue has been destroyed, whereby less remains to be acted upon.

Botkin (*Deut. med. Woch.*, 1891) has studied the blood after injections of tuberculin in tuberculous individuals, and has arrived at the following conclusions: (1) After tuberculin injections an acute leucocytosis is observed, in which all forms of white blood-corpuscles participate. (2) The day after the reaction the number of the leucocytes in the blood falls rapidly, and probably the greater number of the same are destroyed. This may be inferred principally from the increase in the number of blood plaques. This appearance coincides in time with the very frequently observed maximal decline in temperature after the tuberculin injections; in this respect being analogous to the blood crisis of many acute infectious diseases which are accompanied by fever. (3) The tuberculin reaction in the blood can also happen in the cases in which the temperature does not rise. (4) The increase in the eosinophil cells in the blood can not only happen in chronic diseases of the skin, but also in acute, quickly disappearing exanthemeta which appear as complications in many of our therapeutic interferences.

In analyzing the effect produced by tuberculin, Hunter concludes (*British Medical Journal*) that tuberculin owes its activity, not to one principle, but to at least three, and probably more different substances; that the fever produced by tuberculin is absolutely unessential to its remedial action. The same holds true, he believes, with regard to the inflammation produced by it. Inflammation is not absolutely necessary for the manifestation of its therapeutic effect. It is in some cases, however, beneficial, and helps under certain circumstances the action of the curative agent. Its remedial and inflammatory actions are connected with the presence of certain of its albumoses, while its fever-producing elements are chiefly associated with substances of non-albuminous nature.

Amann (*Centralbl. f. Bakteriologie und Parasitenk.*, 1891) found in examining a large number of patients that the quantity of expectoration and the number of bacilli were increased after reaction had occurred. He also confirmed the observations of others, that the bacilli appeared broken and took the stain but poorly.

The expectoration is usually increased at first, and is sometimes blood-tinged. In the favorable cases it gradually becomes mucous and later disappears; with the change from the purulent to the mucous condition the bacilli diminish in number and finally are absent.

Hoppe-Seyler (Virchow's *Archiv*, Bd. 128, Heft 1), writing on the effect of tuberculin on the formation of the coloring matter of the bile, states that after injections of tuberculin, polycholia is developed, manifesting itself by an icterus and an increased secretion of urobilin. The icterus is due to the destructive effect of the tuberculin upon the coloring matter of the blood, while the increased secretion of the urobilin to all appearances results only when the organism reacts after the injections, and is in direct proportion to the degree of the reaction.

Therapeutic Uses.—It was originally expected by Koch that tuberculin would be invaluable in uncertain cases, as a means of diagnosticating between tuberculosis and other affections which simulate it; but much more important was supposed to be its curative power in all forms of tuberculous diseases. It was believed also that with his remedy it would be possible to determine accurately when all tuberculous tissue in the body had been destroyed.

With regard to its use for diagnostic purposes, although its action is positive in the large majority of cases, it is asserted by competent observers that in rare cases of undoubted tuberculous disease, reaction does not occur. Eber (*Centralb. f. Bacteriolog. und Parasit.*, 9 and 10, 1892) has collected the results of injections of tuberculin in 247 cattle for diagnostic purposes. In 134 animals, the characteristic reaction occurred, and in 113 the result of the injection was negative. Of the 134 showing reaction, 115, or 85.82 per cent., proved to be tuberculous after killing, and 19, or 14.18 per cent., non-tuberculous. Of the 113 in which no reaction occurred, 101, or 89.38 per cent., were found after killing to be free from tuberculosis, while 12, or 10.62 per cent., were tuberculous. In a total of 247 cattle inoculated with tuberculin for diagnostic purposes, the evidence thus gained was confirmed by post-mortem examination in 216 cases, or 87.45 per cent. In 31 animals, or 12.55 per cent., the results of the inoculations led to conclusions which were at variance with the post-mortem findings.

The supposed curative effect of tuberculin has been much more disappointing. During the early weeks of the use of the remedy, cures of all forms of tuberculous affections were being reported by observers; but, unfortunately, prolonged observation of these cases has shown the beneficial results to have been apparent rather than real. The temporary improvement which occurs in the course of all forms of tuberculosis, particularly of the pulmonary variety, under any form of treatment, is a matter of common observation, and was in the cases of those receiving the tuberculin treatment but a repetition of the experience with hosts of quasi-remedies. Koch realized this to be true early in his experiments, for he says, "In many cases I have been convinced that the care which the patient received had considerable influence on the curative effect." One very serious obstacle to the treatment of internal tuberculosis by this method is the problem of the removal of the necrotic tuberculous tissue supposed to be thrown off as a result of the injection.

The practical fact remains, however, that an exceedingly small proportion of the cases subjected to the treatment have been improved; some have rapidly grown worse. Further disadvantages lie in the fact that the remedy is uncertain in its action, sometimes producing marked local and constitutional disturbance, and at other times having slight or no effect. Owing to the rapid dissemination which occurs in tuberculous affections at times, under any treatment, or without treatment at all, it is rather difficult to say on post-mortem evidence that an acute eruption of tubercles has been due to the tuberculin administered. In spite of this, however, Virchow, than whom none can speak with more authority, has noted fresh submiliary tubercles, particularly on the serous membranes, so frequently in autopsies on patients dying in the course of Koch's treatment, that the question of the causal relation of the tuberculin has forced itself upon him.

To speak briefly of the use of this remedy as a means

of determining when a tuberculous process has been brought to an end, I need but refer to the preceding paragraphs. To repeat, the reaction is uncertain, it does not cure in the vast majority of cases, so that its use for this purpose is rarely called for, and even if a tuberculous patient had progressed favorably under another treatment this test-injection might cause a rapid metastasis.

ADMINISTRATION.—Tuberculin is sent out in stoppered bottles, each containing 5 c.c. Its very great activity renders it necessary to dilute the fluid before administering it.

The diluting fluid is prepared as follows: A pint of distilled water is placed in a flask and boiled five minutes; forty-four grains of carbolic acid are then added and the liquid boiled one minute; cork and remove the flask from the fire. When cold, add to the solution, if necessary, enough boiled distilled water to make the whole measure one pint.

Having sterilized the necessary apparatus, the dilutions are made by attaching a pipette of 1 c.c. capacity to an ordinary half-ounce syringe by means of rubber tubing. With this, 0.5 c.c. of tuberculin is delivered into a 10 c.c. measure. The pipette is rinsed in the diluting fluid, the rinsings added to the lymph, and enough diluting fluid to make 5 c.c. Place in a sterile stoppered bottle, which may be labelled "Solution No. 1," or ten per cent. solution; 1 c.c. of this equals 0.1 c.c. of tuberculin, or 0.1 c.c. equals 0.01 c.c. of the lymph. Similarly, 0.5 c.c. of this mixture may be added to the diluting fluid, making as before 5 c.c.; label this "Solution No. 2," or one per cent. solution. One c.c. of this equals 0.01 c.c. of the pure lymph, or 0.1 c.c. equals 0.001 c.c. of the undiluted fluid. Again, 0.5 c.c. of the second solution is taken, and enough of the diluting fluid added to make 5 c.c. This is to be marked "Solution No. 3," or $\frac{1}{10}$ per cent. solution. One c.c. equals 0.001 c.c. of the original fluid, or 0.1 c.c. equals 0.0001 c.c. of tuberculin.

Distilled water, which has been boiled and allowed to cool, may be used instead of the one-half per cent. carbolic solution, provided the fluid is to be used at once; otherwise it is necessary to use the carbolic mixture, or to sterilize the solution by heat—in which latter case it will not remain stable long, but must be sterilized from day to day. This process tends to affect the strength of the tubercreulin, and therefore is not so desirable as the use of carbolic acid.

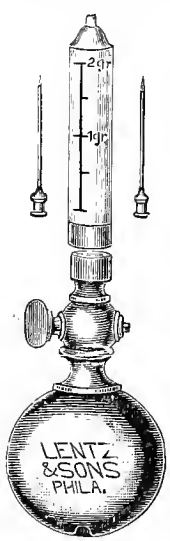

FIG. 651. — Koch's Modification of Pravaz's Syringe.

As the remedy has no effect when given by the stomach, it must be administered hypodermatically. Koch originally advised the back as the most suitable place for the injections, because by experience he had found the selection of this position to give less pain and inconvenience than other locations, and this recommendation has been almost universally adopted by those who have used the tuberculin. Between the shoulder-blades is a convenient point, or below them, in the region of the latissimus dorsi, on the side opposite to that on which the patient is in the habit of lying. The injections are preferably made with Koch's modification of Pravaz's syringe. It consists of a rubber ball, which is provided with a stop-cock, and which is adapted accurately to a graduated glass cylinder: to the opposite end of the latter the needle is adjusted.

The special advantages of this syringe are its simplicity and the ease with which it can be sterilized. To keep the syringe aseptic it should be cleansed before and after use. The glass cylinder may be rinsed in corrosive sublimate solution 1 to 2,000, or in carbolic solution 1 to 20, and finally in absolute alcohol. Needles should be cleansed and kept in 1 to 20 carbolic solution. Before using they should be rinsed in absolute alcohol. The skin of the patient at the point of injection, and the hands of the operator, should be well washed with soap and warm water, then with carbolic solution 1 to 40, and finally with absolute alcohol. By observing these precautions and by using a sterile fluid, but little if any inconvenience should result from the injection. In over one thousand inoculations, Koch did not have a single abscess.

After administering the remedy, the patient should be carefully watched, and the second dose withheld until all evidence of the previous reaction has subsided. After the injection, Koch advised that the patient go to bed; but unless the reaction is severe this does not seem essential.

DOSE.—In cases of lupus and the various forms of surgical tuberculosis, the initial dose should not exceed 0.01 c.c. of the original fluid (1 c.c. of the one per cent. solution). This amount may be more or less rapidly increased according to the severity of the reaction that follows.

In cases of pulmonary tuberculosis, the action of the remedy is much more pronounced. The maximum dose for the first administration should not exceed 0.001 or 0.002 c.c. These doses may be repeated daily if the previous reaction has subsided, and increased by 0.001 c.c. as the constitutional effects become slight. These small doses are particularly necessary if the patient is weak. In children, the commencing dose should be very small, 0.0001 to 0.0005 c.c., to be increased by 0.0001 c.c. according to the effect produced.

DANGERS.—It is of course impossible to say, in any case of acute dissemination of the tubercles, whether a given post-mortem appearance occurred in the natural course of the disease, or whether it was precipitated by the tuberculin. As before pointed out, however, Virchow has seen so frequently extensive fresh submiliary deposits, particularly on the serous membranes, in patients that have been under the treatment for some weeks, that it may very properly be questioned whether the remedy did not bear a causal relation to the metastasis. This view does not seem unreasonable when it is remembered, as pointed out by Koch, that the bacilli are not affected by the tuberculin, and in the separation of the necrotic area new avenues may be opened for the entrance of the bacilli into the circulation.

Cases of pulmonary hæmorrhage have been reported after injections in patients with tuberculosis of the lung. This may be brought about either by the intense congestion during the period of reaction, or later from the separation of the necrotic area involving the blood-vessel. The danger in tuberculous ulceration of the bowel is even greater. Here, likewise, hæmorrhage may result from the opening of a blood-vessel when the slough separates; or perforation with septic peritonitis may occur from the same cause. Meningitis has followed in the course of the treatment in a few instances, but as it occurs under all circumstances it is impossible to do more than hint at this possible sequel. Theoretically, the remedy would also be dangerous in cases of tuberculosis of the urinary organs, on account of the congestion and swelling which ensues, thereby causing obstruction or suppression. Facial palsy has been reported after the use of the remedy, and probably indicated tuberculous disease of the middle ear.

Too much attention cannot be paid to the diet of patients undergoing this treatment, particularly in the advanced cases, in order to avoid if possible perforation of ulcers in the bowel.

Jolly has reported three cases in which mental disturbance has followed the use of the lymph. In the first patient the injections had been administered for two weeks. There was considerable constitutional reaction, with high fever and delirium, which was followed by a psychosis lasting two weeks. This is the so-called fever psychosis. Following the administration of the remedy to a feeble-minded person in whom there was but mild febrile reaction, melancholia and hypochondriasis developed. In the third case delirium accompanied the fever and disappeared with the latter.

Post-mortem Changes.—Virchow has described the following post-mortem appearances in the lungs of patients suffering from pulmonary tuberculosis, who had been treated with tuberculin. The most distinctive alteration corresponds to the condition called caseous pneumonia; pleurisy, simple and tuberculous, frequently hæmorrhagic, and often bilateral, is met with. "Injection" pneumonia somewhat resembles catarrhal pneumonia, but the infiltration in the former is watery and turbid rather than gelatinous, as in the true catarrhal affection. He suggests for this coudition the name "turbid pneumonia."

Dr. Crooke found in the lung of a patient who had died in the course of Koch's treatment for pulmonary tuberculosis, after the third injection of 0.003 c.c., that there was surrounding the caseous foci an intense inflammatory zone of leucocytic infiltration, both into the alveoli and into the walls. In another case, in which death had followed the fourth injection, there were to be observed unmistakable evidences of coagulation necrosis.

Tuberculocidin or Alexin.—On account of certain disadvantages possessed by tuberculin, various observers have endeavored to isolate the remedial constituents of the remedy and to eliminate the uudesirable substances. Of the many modifications which have been subjected to experimentation, the only one that seems to deserve notice is tuberculocidin, which was first described by Dr. E. Klebs, of Zurich (*Deutsche medicinische Wochenschrift*, No. 45, 1891). It is prepared from the crude lymph by precipitating with one of the alkaloid reagents, as platinum chloride. The precipitate contains the noxious constituents, while the albumoses remain in solution. If so desired, they may be obtained in a pure state by precipitation with alcohol. Tuberculin yields about two and a half per cent. of tuberculocidin. As in the case of Koch's remedy, the tuberculocidin is tested on tubercular animals before being put upon the market, so that a certain standard is always maintained. According to Klebs, in non-tubercular animals his remedy causes no disturbance in the temperature nor depression of the heart. It is claimed that tuberculocidin is the secretion of the tubercle bacilli. This offers a possible explanation of the statement made by certain observers, that a few doses of TC (as Koch abbreviates tuberculocidin) cause the decomposition of the tubercle bacilli. The temperature reaction after injection of TC, as a rule, is very slight and lasts but a short time. Under the continued use of the drug the fever is said to disappear entirely, and it is even claimed that it possesses antipyretic properties.

It is advised to discontinue the use of the drug at intervals, since its uninterrupted administration might give rise to malaise and loss of weight. Tuberculocidin is said to render animals temporarily immune to tuberculosis. Klebs believes that the remedy is retained in the body, and that it acts directly on the bacilli as soon as they are introduced by inoculation. He has shown by experiments on animals, that fully developed tubercles are entirely rednced under the actiou of TC. As a result of his observations he concludes that two grammes of TC per thousand grammes of body-weight may be given in the course of three or four days without harm. It was found that injections of 0.1 gramme per five hundred grammes of body-weight, given successively for twenty-five days, was sufficient to cure animals which had previously been inoculated with tuberculous material, even after six weeks had elapsed since the inoculation. From this it is estimated that the amount per diem necessary to cure tuberculosis in man would be 1 to 1.2 c.c. for a person weighing fifty to sixty kilos. This dose may be increased to 2 c.c. daily with entire safety. Of 33 cases of tuberculosis submitted to this treatment by Klebs, 8 are reported as cured, and 21 improved; of 42 additional cases treated by others, 6 are reported cured, and 24 improved. There were two deaths during this treatment. Of the remaining cases, in some there was no change and in others a general improvement is recorded. It is stated that necrosis of the tissues and propagation of tubercle bacilli never occur during the treatment with TC. As a rule, it is not necessary that the patients should be confined to bed during the administration of the remedy.

In administering TC the hypodermic syringe of Overlach is recommended, observing the same antiseptic precautions as described under tuberculin. A series of injections is to be considered quite successful if the temperature remains between 36° and 37° C., without regard to decrease of the cough and of the amount of expectoration. Greater diurnal fluctuations of temperature indicate the necessity for an early repetition of the injection. Rises in temperature which cannot be accounted for otherwise, show that the morbid process is not quite suppressed. In his latest communication Klebs states that a rise in temperature is an indication for increasing the dose, and that the remedy does not cause fever, as was at first supposed.

The use of tuberculin and its modifications has been almost totally abandoned, as already stated. Isolated observers are still experimenting with the remedy here and there, but no constant results have been obtained that would warrant its general use. At the present time it would seem that the employment of this drug should be restricted to properly appointed hospitals, and under the direction of competent observers only.

Perhaps the greatest misfortune which has occurred in the history of this discovery is the enthusiasm which Koch's first announcement aroused. It can safely be said that the only motive which actuated the discoverer was to learn the true value of the remedy. The process of reasoning and the line of experimentation which resulted in the production of tuberculin is unparalleled in the history of medicine, so that if it is finally found to be without value, the discovery in this manner of a remedy which has so marked an affinity for tuberculous tissue, must ever remain a triumph to the author.

The following, taken from a letter written by Professor Guiteras (*University Medical Magazine*, vol. iii., 1891, p. 372), expresses a just appreciation of Koch's work:

"It was very evident that only one thing could produce the remarkable effects of this lymph, and that is the tubercle bacillus itself. To think of anything else producing such results, we would have been forced to build, upon new principles, an entirely new pathology.

"The statement made by Professor Koch is a model of simplicity and clearness. The directness of his line of investigation, from the first suggestive fact to the final conclusion, is an unsurpassed attainment of mental discipline. The triumph of the author is complete. He has discovered new facts, he has studied them thoroughly, and he now announces them with becoming modesty. If we remove from this discovery all possibility of success as a therapeutic agent, if we take away the wide-spread interest it has awakened, it still remains unequalled by any other discovery in the history of medicine. For Professor Robert Koch has given us the first clear insight into the functional pathology of the approaching epoch." *Alfred C. Wood.*

TUBERCULOSIS OF THE PERITONEUM, DIAGNOSIS AND TREATMENT OF. Among the intra-abdominal conditions that render a determination of their character doubtful or difficult, none equal tubercular lesions of the peritoneum or its contents. The cyst or papilloma, the fibroid or sarcoma, may turn out, under an exploratory operation, tuberculosis pure and simple, to the confusion of the most expert diagnostician. Of seventy recorded cases of laparotomy in tubercular disease of the peritoneum, or of the abdominal organs, forty of them were discovered as errors of diagnosis upon the operating-table, and nearly all were reported by distinguished men. This doubt and confusion attending tuberculosis of the peritoneum, from the surgeon's standpoint, will always give it intense interest independently of questions of pathology and treatment. Sick states that among 2,500 post-mortem sections made at the new General Hospital of Hamburg, but forty-six cases of tuberculosis of the peritoneum were noticed. This is a striking illustration of the infrequency of the disease, and why it may so unexpectedly reveal itself upon the operating-table to the confusion of the most expert diagnostician.

Our interest and knowledge concerning tuberculosis of this region is contemporaneous with the development of abdominal surgery. Previous to that a diagnosis was a post-mortem affair, except as the disease was found associated with advanced lesions of the lungs or other parts. It is doubtful if a diagnosis of tuberculosis can be made simply as a pathological condition; the diagnosis must be based upon the status of the lesion. The clinical features are thus constantly changing, each advancing phase, and each part of the abdominal contents successively invaded, modifying or offering a new group of symptoms. A case that at first presents itself as one of free ascites unassociated with any appreciable abdominal growth, may, on another examination a few months later, offer all of the physical signs of ovarian cyst; or while the fluid accumulation may remain free, irregular and nodular growths, giving what seem to be unmistakable signs of malignant tumors, may startle and confuse us at a later examination. An intelligent study of tubercular peritonitis, with a view to its diagnosis, calls for a division of the subject. Such a division would naturally fall into the following order: (*a*) Free ascites; (*b*) encysted ascites; (*c*) tuberculosis of the pelvic organs; and (*d*) tuberculosis of the abdominal organs.

(*a*) *Free Ascites.*—It may, in our present knowledge of the subject, be undertaking to prove too much, to claim that in a given case of free ascites we may be able to recognize it as the effusive stage of a peritonitis due to tuberculosis; but without asserting too much, it is a subject well worth looking into. In the first place, in such a condition have we really a peritonitis, as understood in the idiopathic sense of the word? No one claims that tuberculosis of the lungs is a pneumonia, although in some of its periods of development it offers symptoms closely related to that disease. If we examine the life-history of the bacillus, we shall see that inflammation is not the agency by which it works out the circle of its life and propagation. The tubercle is a stage of development only—the chrysalis, as it were, of a colony of bacilli lying dormant until ready to swarm forth and invade new territory. We know also that frequent instances occur in which this chrysalis never matures, and the bacillus remains dormant and at last becomes buried in a mass of plastic or fibrous exudate. The first means a destruction of adjacent tissue, the second a latent case. We know from clinical observation something about the manner in which this destruction is effected. In lung tuberculosis we do not observe the matured tubercle in the sputa, but the liberated bacillus. Histologically, it has been shown that liberation consists in a breaking down of the containing capsule, or in other words, of the tubercle itself. This process in the peritoneal cavity does not always lead to effusion, even when general, and when local, as in the inner genitals of women, great masses may form without a suspicion of an inflammatory process.

Effusion may begin without abdominal tenderness and without a febrile condition, and with the nutrition unaffected. Here is a condition that, if unexplained in some other way, ought to create a suspicion of tuberculosis. Another matter which has been quite generally overlooked, is the history of the habitual environment of the patient. The bacillus does not originate *de novo* in the peritoneal cavity, it migrates from without, or from some other part. Thus at the Woman's Hospital, a year ago, I removed the tubes by laparotomy for tuberculosis in the case of a woman who had lived with a husband affected with tubercular consumption, and who died within a few weeks after her return home. It is easy to get an explanation of the manner of infection here. This unfolds another fact worthy of attention. In our hypothetical case of free ascites, is the subject a woman? Now, pelvic invasion is common in women, rarely, if ever, met with in men. The reason is clear. Woman offers an open road to the migration of the bacillus through her genital track direct to the peritoneum. It is as open and direct as that of the bronchi to the lungs. This is why the history of the woman and her environment will throw light upon the diagnosis. My own experience of this disease does not embrace a very large number of cases, but it offers a group extremely valuable in this relation. In every case the woman gave a history of tuberculosis in her own family, or had lived and cohabited with a tubercular subject.

We frequently observe free ascites associated with pelvic tumors both large and small, but the gynecologist having established that fact, would not be justified in accepting it as a sufficient explanation. But if an evident salpingitis existed associated with a pelvic exudate and uterine fixation, it would be difficult to assign any reason other than tuberculosis for the ascites. Another condition, that ought to throw suspicion on the ascitic accumulation, would be its association with chronic adenitis of the cervical glands or indolent abscess of the part. This condition is called scrofula, but it is as much a tuberculosis as the abdominal scrofula of the old writers. A subnormal temperature that may exist for weeks or months at a time, has been found attending tuberculosis of the peritoneum. This is an important fact, and was not generally known until Dr. William Osler called attention to it in his exhaustive monograph. Pigmentation of the skin, especially of the face, has been repeatedly observed, simulating that of Addison's disease. Osler believes that the symptom may be present when the tubercles are confined to the peritoneum. Extreme tympanites is very often found, as one would reasonably expect from the impairment of the muscular tone of the intestines.

We must exclude diseases which may be attended with fluid accumulations within the peritoneum. The usual urinary examination would not exclude an implication of the kidneys, as the adrenals may be involved in the general invasion of the abdominal organs. The face is free from effusion, as are also the lower extremities. Effusion due to cardiac disease and to cirrhosis and cancer of the liver, would have to be eliminated from the problem, and if the patient had been under observation from an early period of the disease an effusion from such a source could be differentiated, but in the later stage this would be difficult. The peculiar character of the effusion would point to disease of the liver, which organ ought to receive the most careful scrutiny. We have to look to the lungs as organs which will give the strongest confirmation to the diagnosis of tuberculosis of the peritoneum, It is not known what proportion of cases show the coexistence of the two diseases at the early stage we are considering; but it is comparatively frequent, and if the diagnostic features already mentioned are present, the disease might safely be pronounced tuberculosis. In a study of the encysted form, as we shall presently see, coincident lung affection forms a most important guide to a knowledge of the peritoneal condition.

Lastly, the bacillus may be found in the effused fluid, and, when present, is a positive indication to the nature of the disease. But it is not always found. In a case of my own, in which an exploratory laparotomy was made, the fluid was carefully examined for bacilli, by an experienced microscopist, with negative results; the operation, however, revealed large masses, apparently having their origin in the tubes, rising out of the pelvis and extensively involving the omentum and intestines, the peritoneum throughout being covered with dark-colored tubercles of different sizes. The fluid was dark-brown, and in it were floating numerous flakes of lymph. I thought the failure to detect the bacillus in fluid of this character, with such extensive masses of the disease, must have been an error of observation, and I again had a more careful examination made, but with the same results. The bacillus has usually been sought for in the tubercle itself, and found in that situation. This method of diagnosis would imply at least an exploratory incision. Such an examination of the tubercles ought always to be made, for, as Spaeth has pointed out, there are numerous cases in which the suspected nodules have the appearance of tubercles, but which prove to be nodular forms of chronic peritonitis or lymphomatous masses. This observation has since been confirmed by several

observers. It is thus seen that our difficulties of diagnosis do not diminish even after an exploratory incision. This method of examination is too dangerous to undertake lightly in advanced stages of the disease. The case to which I have just referred terminated fatally on the third day, and I believe other surgeons have had a like experience. These advanced cases of general tubercular degeneration of the abdominal organs react in very much the same manner as do malignant cases after exploratory operations.

In a recent article by Dr. Edebohls, mention is made of "plaque-like, localized thickenings of the deeper portions of the abdominal parietes, perceptible to gentle touch." This condition was observed in the flat abdomen. It is a valuable sign if it can be detected, which I doubt; I have not noticed it in any case of my own. It is well worth bearing in mind. In cases without effusion Osler's observation, that the "association of a tubal tumor with an ill-defined, anomalous mass in the abdominal cavity," ought never to be lost sight of while endeavoring to make a diagnosis.

(*b*) *Encysted Ascites.*—In the diagnosis of encysted tubercular ascites, I cannot do better than to briefly review what I said some time ago upon this question in my paper, "Laparotomy as a Cure for Tuberculosis of the Peritoneum," which was published in the *American Journal of Obstetrics*, September, 1887. The patient was twenty-eight years old, married, and had one child, a year old. She had noticed a gradually advancing enlargement for two months. She was losing flesh and menstruation was very scanty. Fluctuation was marked but diffuse, extending in an evident wave over the abdomen when the patient was upon her back. In this position the abdomen was flat with bulging upon either flank, and with protrusion of the umbilicus. In this position, also, the area of percussion dulness corresponded to the extent of lateral fulness, while the umbilical region was clear—an evident intestinal note—down nearly to the pubes. On changing her position to the side, the upper flank became clear on percussion, while the region of dulness was transferred to the lower side on a line nearly to the level of the umbilicus and parallel to the body axis. On reversing the position, the regions of dulness and clearness changed sides. The examination of the pelvic organs gave negative results. The uterus approximated the normal in size and position; the organ was freely movable and was not affected by abdominal manipulation, except by the percussion wave which could be felt in the vaginal cul-de-sac. The region of the liver was free from tenderness and gave a normal outline on percussion. The temperature was normal, the appetite fair, there was no cough. She complained of indigestion and a tendency to looseness of the bowels with flatulency. The urine was stated by the patient to be normal in amount. The specific gravity was 1.019, acid and free from albumin. There was no œdema of the feet or eyelids. There was but one diagnosis to be made here, that of ascites; but there was no evident cause of the effusion. She was placed upon tonics and diuretics, and sent home. She was seen at intervals of two or three months. There was no change other than a slow increase of the ascites and loss of weight. In the following spring she had a troublesome cough which lasted five or six weeks, but abated under the use of simple remedies.

Nothing further was seen of the patient until late in the fall of the same year. A complete change was then observed in the condition of the abdomen. The outline had lost the character of a free fluid effusion, the flatness of the abdomen and the bulging of the flanks had disappeared, and the abdomen had become prominent and rounded. The area of percussion dulness had changed from the loins to the central region. By deep palpation in the right iliac space an irregular, hardened mass could be detected, and an induration of apparently the same character could be felt near the right hypochondriac region, having a right and left direction. The wave of fluctuation was limited to the line of dulness at the epigastrium and at the flanks. The uterus seemed free from any connection with the abdominal masses, and was in a fairly normal position. The umbilicus was still protuberant. There was no cough or hectic, and the temperature was about normal; she had wasted considerably, the face was pinched, and the expression such as is seen with ovarian cystoma, not like that observed in malignant disease of the pelvic or abdominal organs. The urine was free from albumin. The aspirator brought away about a quart of straw-colored fluid. Laparotomy showed how all this remarkable change came about. The peritoneum was of extraordinary thickness, the intestines lying behind the effusion were highly injected and matted together. The stomach and the transverse colon were united with the peritoneum and enclosed the effusion. All the parts were beset by thousands of tubercles, some white, some yellow, and of various sizes. The irregular masses were composed of the adherent and thickened organs. I was fortunate in being able to observe the case throughout its course, and in the light of a laparotomy to be able to trace each step in the development. One might hunt in vain to find a parallel case due to causes other than tuberculosis, or one in which the successive stages in the evolution of the case were brought out in such clear relief. Here we had the heart, lungs, liver, and kidneys in a normal condition and without any history of previous peritonitis, but associated with an abundant free effusion into the peritoneal cavity. On examination of the pelvis, the organs there were found to be healthy, without tenderness, nodes, or tumors. All ordinary and usual causes of ascites were therefore eliminated in this case. Speaking with a due regard for the anomalism of disease, we had only peritonitis left to explain the phenomena; but the absence of any of the necessary symptoms of this disease showed that it could be of no ordinary form, while the freedom of the lungs from any indication of tuberculosis simply rendered uncertain what, with this indication, would have been a fairly clear case of the abdominal form of the disease. Nothing was added to this history for months except meteorism and a pulmonary irritation which was self-limited, and a gradual wasting of the body. Then, on examination, a state of affairs presented itself which could reasonably characterize but one thing—the free ascites had become encysted without a cyst to enclose the contents. In the whole range of pelvic and abdominal disease, under the conditions named, I know of none that offers this peculiar anomaly except tuberculosis of the peritoneum. This disease has two leading traits: one is plastic exudation, and the second is effusion. The first is always present, the second is absent in many cases, but when it characterizes a case it is the initial symptom, and is sure to become incarcerated by the adherent organs. Our case further demonstrates that miliary tuberculosis of the peritoneum may antedate the development of tubercular nodes and tumors upon the ovaries and tubes, and that it persists to nearly a fatal stage without these parts becoming secondarily involved.

(*c*) *Tuberculosis of the Pelvic Organs.*—We may have pelvic tubercular disease without ascites. A case of a young girl, seventeen years of age, upon whom my colleague in the Woman's and Children's Hospital, Dr. A. B. Breese, made a laparotomy, offers a very interesting proof of this. The pelvis was occupied by distinct but not sharply defined masses in the situation of the broad ligament. The girl was extremely delicate, with advancing emaciation and anæmia. Menstruation had never been regularly established. The outlook was so very unpromising that I concurred with Dr. Breese in the necessity for laparotomy. The tubes and ovaries were mingled in indistinguishable, highly vascular masses, which were enucleated with difficulty and at the expense of a copious hæmorrhage; but a very unusual feature of the case was a rounded fleshy mass, nearly an inch in diameter, which just above the pubes stretched across the pelvis from side to side. It was adherent at both ends, very vascular, and made up of extremely friable tissue that a ligature would cut. A careful examination showed that it was composed of the lower border of the omentum. The operator now did a thing which he has never had cause to regret, but which my laparotomy friends,

who clean anything and everything out of the female pelvis with such praiseworthy industry, would surely condemn—he let it alone. The patient made a rapid recovery, and now, two years after, is a strong, hearty girl. An examination showed that it was a case of tubercular degeneration of the parts. There was also a consumptive taint in the family. What became of our omental tumor? We simply know that it never afterward gave any trouble.

There are several diseases that may be confounded with tubercular peritonitis when the onset is sudden. For example, it has been confounded with hernia. Such a case has been reported by Thomann in which an operation was actually made. Typhoid fever has been repeatedly confounded with it; but usually the mistake is made of regarding it as a simple acute peritonitis. It is in these acute cases that a moderate amount of ascites may be met with that rapidly assumes the encysted form; or it may present this feature from the beginning, owing to the extensive adhesions that are formed between the peritoneum and the abdominal organs previous to the effusion. Very extensive accumulations are not common. Biat, quoted by Osler, states that in eighty-one cases, thirteen only were attended by extensive ascites. A moderate ascites may thus be assigned some value in differential diagnosis. This encysted form does not always present symmetrical or uniform outlines. In a case of which I saw the post-mortem, the omentum formed a flattened tumor, which confined the fluid to one side, giving a very distorted appearance to the abdominal outline. In life the fingers could be inserted under the edge of the advancing growth, which began above and to the left, and progressed obliquely downward and to the right. It was diagnosticated as an omental tumor, but tuberculosis was not thought of until at the post-mortem. According to Fagge, an obscured intestinal note may be obtained by firm percussion over the mass, especially when overlying a distended colon.

Osler divides these sacculated exudations into three abdominal zones. In the upper, which includes the liver, stomach, and spleen, confined accumulations of fluid are common, which may belong to the gall-bladder, stomach, or spleen. In the middle zone, from the transverse meso-colon to the false ribs, and which includes the omentum and intestines, sacculation is much more common. Ovarian tumor, if an error is made, is the usual diagnosis. The ovarian growth may generally be traced from the pelvis upward, while the fluid exudate of tubercular peritonitis begins in the middle zone. As already stated, these exudations of tuberculosis may not be in the middle line, but confined to one side or to a limited area in the centre. In these cases it would not be easy to confound them with ovarian tumor. Diagnosis becomes still more difficult when the coils of intestines are thickened and adherent, giving most distinctly the sensation of solid tumors. In tuberculosis these are more frequently situated in the cæcal region. In the lower zone the disease may be confined to the parietal peritoneum, which has formed adhesions to coils of intestines, and thus confines the fluid to the pelvic cavity. In such a case, the solid or nodular enclosing wall here and there may possibly give an obscured intestinal percussion note, which would serve to give a hint of its origin. The pelvis, however, offers conditions for tubercular disease radically different from those observed in the abdominal cavity proper. In the first place, tuberculosis of the tubes and ovaries is generally the primary condition, or at least sufficiently common to account for the excess in frequency of tubercular peritonitis in women over men. It is the initial lesion, the point at which the invading bacillus halts, and from which it invades remoter regions. As already referred to in speaking of free ascites, if encysted ascites follows disease of the tubes we have a right to suspect a tubercular origin. If nodes or distinct masses are observed in the abdomen, following upon trouble referable to the region of the pelvis, without the usual history of acute salpingitis or pelvic peritonitis, tuberculosis will naturally first suggest itself as an explanation.

There are intercurrent conditions that may afford some aid in determining the character of the abdominal disease. Dr. Howard, in his paper in the Gynecological Society's Transactions for 1885, states that a number of observers have noticed a red blush on the surface of the central portion of the abdomen. This is probably a late sign in advanced tuberculosis of the peritoneum. Effusions in the pleura attending abdominal tumors have been very generally regarded as signs of malignancy. Mr. Tait positively expressed that opinion, and has only recently met with a case in which this rule was at fault. It has, however, been repeatedly noticed as attending tubercular peritonitis, and has been usually found to be coincident with the effusion stage of the peritonitis; associated, however, so far as I am familiar with the reported cases, with an extension of the tubercular disease to the lungs. It is well to note, then, the marked difference between the pleural effusion of malignant abdominal disease (unassociated with lung complication) and tubercular peritonitis associated with disease of the lungs. Further, the implication of the lungs without effusion has even a greater value as defining the abdominal disease, as it is more frequently met with—so often, in fact, in advanced stages of abdominal tuberculosis, that its absence would tend to throw doubt upon that theory of the condition. An adenitis of the supra-clavicular glands has been observed in the disease. I have seen this complication but once, and others may also have noticed the same, but it is not referred to in the literature of the subject. But as these glands very early become involved in many forms of abdominal tumors, this symptom could not be given any independent value in the diagnosis, its real place being but one in a group of differential signs. A pigmentation of the skin, especially of the face, has been given special importance to by De Mussy as significant of tuberculosis of the peritoneum. Osler, who makes the reference, states that Sir William Jenner, in a lecture, pointed out that this skin discoloration, as marked as in Addison's disease, attended a case of abdominal tuberculosis. In a case of like character, reported by Boulland, the supra-renal capsules were involved.

The treatment of tubercular peritonitis has in recent years received marked attention. This is due to the cures which have followed laparotomy. That such is the case may be now considered a matter of accumulated experience. Many abdominal surgeons have now independently observed that cases of tuberculosis of the peritoneum and of the abdominal viscera appear to undergo a remarkable amendment, or apparent cure, directly after the performance of laparotomy. This has been observed so frequently as to justify the opinion that it is a possible sequence. Why there should be an arrest of progressive tubercular development after laparotomy, it is difficult to say. We know too little about the tubercular process, to begin with, to predicate upon it any well-defined explanation; and, in the next place, there is a total lack of precision in the method. I said, as long ago as 1887, that there was no instance known of a laparotomy having been performed for tuberculosis; we simply learned the favorable results of the operation, mainly as the outcome of errors of diagnosis, as Hegar says. From what I have observed of its literature since that date, I have no reason to change my opinion. These cases are to-day more frequently revealed as a surprise upon the operating-table than as a condition clearly recognized at the bedside.

Concerning laparotomy itself there prevails the same confusion. At the first meeting of the German Gynecological Society, in 1886, and to which meeting we are mainly indebted for the general attention given to this interesting matter, the subject came up in an irregular way during the discussion of a paper by Elischer on the use of iodoform in the toilet of severe laparotomies. Dr. Frommel headed the diversion from the main topic of the paper, by stating that he had used the drug in two cases of tubercular peritonitis, and in another case of ovarian tumor with ascites and small papillæ all over the peritoneum. Hirschberg had cured peritonitis with tubercular nodules by corrosive sublimate; hence iodoform

was unnecessary. Dr. Meinert agreed with the last speaker so far as iodoform was concerned, but threw doubt upon the sublimate, as a like result may be obtained by incision and tapping. Dr. Olshausen had seen it cured by incision, but also stated, what we all know, that it may get well of itself, or remain stationary for years. Dr. Saexinger gave curative value to laparotomy, while Dr. Battlehner had seen the same results follow tapping. Hegar, in an exhaustive monograph, confined mainly to genital tuberculosis in women, published in the same year, gave the matter its definite place in literature. He reports two cases that were either cured or rendered stationary by laparotomy, and another case of apparent arrest in which nothing was done. Sir Spencer Wells, in 1862, was one of the first to whom this experience came, or at least he was the first to place his experience upon record. König reports a case of seeming cure, after the use of iodoform in the toilet of the peritoneum. Neuman reported two cases. Poten gave the report of a case operated upon by Hartwig, of Hanover, and which seems to be, from the description, identical with my own. Lindfors records a case of like character. Mundé has had three cases. Kelly reports upon four, each operation gaining but temporary success. Homans reports four cases, one being followed by apparent cure. Gardner, of Montreal, reported by Osler, has had two cures; Wilson, of Baltimore, one in which the patient lived for six months after the operation; Dudley, of Chicago, one case with death in four years. Osler has collected four cases from Spaeth. One died after operation; one in three months from acute phthisis; the third by an advance of the disease; and a fourth was in a fair way to die from the same cause. Shoemaker reports a case of recovery; Schmidt also a complete recovery, and one case followed by death five months later. Imlach reports five cases all apparently cured. Goodell reports four cases, with cures so far as he knows. In addition to the above collected by Osler, we have to add the seventy-one analyzed by Maurange, which completes the record up to 1889. This is a total of ninety-seven cases. Of these nine proved fatal after operation, fourteen died from generalization of the disease, twenty-nine recovered, sixteen survived six months, twenty-seven were alive at the expiration of a year, one four years, and one—my own case—six years afterward.

König has brought the statistics down to 1890 by the tabulation of 131 cases, being an addition of 34 new cases. Of these 89 were cured, and 23 greatly improved. Among those classified as cured, 30 gave sign of a renewal of the disease several years afterward.

Why laparotomy or drainage of the abdominal cavity should cause retrograde changes, if I may use that term, in the tubercular masses, has had some light recently thrown upon it by a case reported by Osler. Laparotomy was made upon a young woman for a doubtful tumor. It proved to be one of a tubercular nature, with effusion. She recovered with greatly improved health, and resumed her occupation. About six months later she was readmitted with pneumonia and died. The autopsy showed the changes that had occurred in the tubercles after operation. There was general pigmentation of the tubercular nodules. The "surface surrounding them was thickened and puckered as though from slight cicatricial formation. Microscopical examination showed that the tubercles in the peritoneum were composed of numbers of submiliary nodules, very fibrous, containing few cells in a firm tissue. In the middle of the masses, giant cells with several nuclei and fatty granules. No caseation in the nodules. Tubercle bacilli very abundant." In a very remarkable manner this appearance corresponds with the condition noticed in the post-mortem room. Dr. Henry P. Loomis, in a very able paper on the arrest or cure of phthisis, based upon the reports of 1,146 examinations made at the dead-house of Bellevue Hospital, gives us this valuable piece of evidence:

"There was a group of cases in which the pleura gave the same cicatricial puckering over masses enclosed in dense bands of new connective tissue. Another group, in which the lungs showed extensive fibrous tissue changes, the same character of pigmentation and the same giant-cell formation mingled with tubercles. It appears reasonable from the coincidences noted here that laparotomy merely places the surfaces in a condition favorable to spontaneous cure. Another condition has been noted as following laparotomy, namely, the formation of hard calcareous masses about a tubercle, in which state it remains indefinitely without change. Thus three conditions attending the so-called spontaneous cure may be noted: Thickening and contracting of the peritoneal surfaces, fibrous encapsulation, and calcareous formation."

It may be useful to review briefly the forms of tuberculosis of the peritoneum in which laparotomy may be expected to give favorable results. Kaulich, in an elaborate study of the disease, divides it into three groups. The first we may term the acute form, which advances by a series of attacks with pyrexia and intervening lulls, until the entire abdomen has been involved, without effusion, but with retraction of the abdominal walls. There is no record of the surgical treatment of this group, nor would it naturally fall under the observation of the laparotomist. The second group is characterized by an insidious invasion without pyrexia, but with ascites as a leading and early trait. In this class also we get the apparent spontaneous cures, for Kaulich's third group is composed of the second, which affords the phenomenon of decrease of effusion with general improvement. If cases belonging to this second group can be brought under treatment before the secondary lung invasion, and the disease thus be attacked midway in its advance from the genitalia to the respiratory organs, we have an ideally typical case for laparotomy. There can be little doubt that the removal of the effusion is the essential point. Distention by the accumulation, aside from the irritating qualities of its constituents, may act in a two-fold way to intensify the morbid process—mechanically, by pressure, and by affording a medium for the distribution of the bacillus. Braxton Hicks has given a very clear exposition of the intra-abdominal conditions associated with this state of tension, from which the inference is logical that the evacuation of the fluid is an effectual curative measure. Muret, quoted by White, states the fact that all the methods attended with success in the treatment of ascites have tended to produce a diminution of the intra-abdominal tension. Among these measures he includes the use of purgatives. Dr. J. W. White, in a unique paper on the "Supposed Curative Effect of Operations per se," has thrown much light upon this special subject while treating of this interesting matter generally. Analogous cases, quoted from widely different sources, prove the remedial effect of simply evacuating the fluid. If this be true, we see why tapping, or purgatives, equally with other methods, act as a cure; and if true, drainage through a large opening and a thorough toilet of the cavity must be the better way. There is another reason why laparotomy is better than drainage, which is forcibly stated by Tait. He says that a marked physiological alteration is induced by opening the abdominal cavity, indicated by a most distressing thirst, whichlasts for days—a symptom with which every laparotomist is familiar, and which is never observed of a like degree after any other operation. It can be readily seen how such a rapid diversion of fluids from the direction of the peritoneum must greatly modify the nutrition of the tubercles. In this way caseation, which may be regarded as an evolution of the tubercle to completion, is arrested. The irritated peritoneum is given a rest, and there is then established a process that belongs *per se* to tuberculosis, namely, a thickening and induration of the surfaces—the erection of a fibrous envelope about the tubercles, and a substitution of calcareous masses, which are indefinitely unalterable, in the place of the latter.

Helmrich, in a thesis, states that 65 communications are to be found in literature of the employment of Koch's tuberculin in the treatment of tuberculosis of the peritoneum. In one case of a girl of sixteen years, at the Gynecological Clinic at Basil, sixteen injections of 0.005 of tuberculin were made in the period of three

months. She died in about a year with pulmonary complications. In another case the remedy was employed after a laparotomy had been performed by Fehling. In a period of one month and a half twelve injections were made. The patient became healthy and able to work. The author concludes that from our present experience other means, such as medication, diet, and laparotomy, must be resorted to in connection with the treatment in order to get results from this agent, but that nevertheless it calls for a more extended experience.

While the changes which follow the employment of tuberculin are the same as those noticed in cases of spontaneous cure, changes still more striking have been observed after laparotomy. The tubercular nodules have entirely disappeared. Cases of this character have been reported by Hirschberg, Kuemmel, and Ahlfeld. And, lastly, it has been suggested that the cure due to tapping or laparotomy is the result of removing the ptomaïnes which may be present in the ascites, thus relieving the constitutional symptoms and permitting a renewal of nutrition. The conclusion is warranted that laparotomy and drainage constitute a method of treatment of tubercular peritonitis that is now placed upon a sound basis of experience in all cases of general tuberculosis of the peritoneum attended with ascites. We may, however, reach further results with surgical treatment in cases other than those thus defined. Nodular masses may develop on the tubes and ovaries and consolidate within the folds of the broad ligaments into fixed and irregular tumors, or the tubes and broad ligaments may form elongated, round, or uneven masses, but without the even and circumscribed tumor of a pyosalpinx. Another form of pelvic infection is that where the broad ligaments, ovaries, and tubes are consolidated into one mass in connection with a wide extension of miliary tubercular peritonitis. Here Hegar, except in cases in which other and vital organs are involved, would advise salpingotomy. The uterus must be dealt with separately per vaginam with the curette, or by means of caustics and iodoform, although Hegar treated one extra-peritoneally. The treatment by laparotomy offers some special difficulties not met with in pyosalpinx. The extirpation of the tubes is difficult, owing to vascular and close adhesions, and oftentimes to the doubtful safety afforded by ligatures in the friable tissues. The tubes are involved in the posterior folds of the broad ligaments, and Hegar cautions against breaking through to reach them, as it might possibly result in irrepressible hæmorrhage. Of course, such extensive breaking down of vascular adhesions requires drainage in the after-treatment. It is doubtful if, in such cases, salpingotomy will meet with general favor. Hegar's results are none too favorable to warrant such severe measures in search of a problematical cure. He had one direct death; the third case, as well as the fourth and fifth, rapidly developed secondary lung infection. I believe that in cases which present such extensive breaking down of adhesions a more conservative operation would give better results; that laparotomy, a thorough washing of the pelvic cavity with drainage, leaving the mass otherwise undisturbed, would, in the light of our present experience concerning the curative effect of laparotomy *per se*, possibly result in cure or arrest of the disease. The case of Dr. Breese, already mentioned, demonstrates the fact that the removal of all the tubercular masses in sight is not necessary in order to reach a cure.

A few words in conclusion as to how far our judgment ought to be modified by the likelihood of spontaneous cure. The statistical data upon this point are very meagre. There are no carefully recorded observations in the *post-mortem* room that correspond with those made by Loomis upon the lungs and published in the *Medical Record*. The post-mortem evidences of spontaneous cure after tuberculosis of the peritoneum would mainly resemble those described by him, namely, pigmentation and fibrosis. There is a very general agreement concerning the group of cases in which a natural cure may be expected as a possibility, and this is also the form of the disease in which laparotomy has given so-called curative results. The second group of Kaulich is defined by an insidious invasion without pyrexia, and with ascites as a leading and early trait. The third group of this author is simply the second exhibiting the phenomenon of spontaneous amendment in active operation. Another condition essential to this termination is that the lesion be confined to the peritoneum, without an active tendency to involve the lungs or pleura.

The lungs appear to be the region in which the life-history of the bacillus attains its perfect fulfilment. Here it multiplies with the greatest activity, and as a result produces its most destructive effects upon life and tissue. In other parts its course is more prolonged and its spread hampered by the resistance of normal tissue. In the latter the tendency to incapsulation and innocuous latency is, as a natural result, greater. This tendency may be assumed naturally to be intensified in proportion to the inherent disposition of the surrounding healthy tissues to limit the extension of the disease. In the lungs, in a general way, we may say that this normal environment favors rather than retards the extension of the invasion. If we refer again to the researches of Loomis we have the logical inference before us that the ratio which he observed of spontaneous cicatrization in the lungs, may be assumed to be true of the peritoneum plus the enhanced tendency of the latter part to limit the extension of the disease. Tuberculosis being a disease of exhaustion with pyrexia, the probability of spontaneous cure must largely depend upon the extent of invasion. It is well-known that the extension of the disease from the peritoneum to the lungs is almost inevitably fatal.

In the present state of our knowledge on this subject I may state that we have reasonable grounds to expect a spontaneous cure in the second group of Kaulich, namely, where the disease is characterized by an insidious invasion, slow and even advance, without, or with only occasional pyrexia, and with ascites as an early and a leading trait; when the disease shows no tendency to involve the lungs or pleura and the subject is a woman at or past middle life.

Osler has well expressed the conditions of spontaneous cure, and as it is not wholly in accord with the above expressed conclusions of my own, it is proper to give space to an author so well worthy of respect. "There is," he says, "no inherent improbability why tuberculosis of the peritoneum should not undergo involution as tubercles do elsewhere. Anatomically the peritoneal growth bears in its evolution a close analogy to the pulmonary, and this is further borne out by the retrograde changes through which it passes. Just as the aggregations of miliary nodules in the lung may undergo the changes which we speak of as healing, becoming hard and fibroid, so in the peritoneum the tubercle tends in many cases to become sclerotic and passes into a condition in which it is practically harmless. The beneficial result is more likely to be seen in cases in which, from the outset, the process is subacute and not associated with much exudation; but there are cases on record in which recovery has followed even after extensive effusion." Concerning the concluding clause in the last sentence, it may be said that effusion is a safeguard against damage to the viscera through adhesions, by keeping them separated. Adhesions may greatly favor the spread of the disease, and also, by the resulting impaired function of matted intestines, interfere with that degree of nutrition which forms so important an element in the self-limitation of the disease. Without effusion the disease assumes the form of the first group of Kaulich, in which there is retraction of the abdominal walls due to adhesions, and which of themselves are active factors in the fatal result. In cases in which laparotomy has been performed, ascites was the surgical motive for the operation, whether the diagnosis was an error or not; and in these cases, and for this very reason, surgery has given its best results. There is no record of laparotomy having been made upon the retracted abdomen for tuberculosis; so unfortunately from these data the opposite contention cannot be maintained.

The word cure is used only in the sense of a limitation of the invasion and a metamorphosis of the tuberculous

groups into new-formed products by incapsulation, calcification, with pigmentation. Caseous degeneration of the tuberculous nodules, while it has been observed to afford a more or less prolonged period of latency, can hardly be regarded as anything more than a condition favoring fibrosis, calcification, or incapsulation, and, contrary to some authors, in no way a condition possessing any power of its own to favor a spontaneous cure.

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Ely Van de Warker.

TUBERCULOSIS, SURGICAL. MODERN METHODS OF TREATMENT.—The treatment of tuberculous affections forms a large part of the surgeon's work. Until recently these conditions have been considered as a manifestation of scrofula, or of a strumous diathesis, and in their treatment the custom of applying local remedies, with or without rest, and the administration of general tonics was universal. These measures failing, as they commonly did, extensive operations became necessary to eradicate the disease. With the rapid development of modern surgery there has been a tendency to operate early in these cases and consequently spare the patient such radical measures. The best illustration of this is seen in the case of tuberculous inflammation of the knee-joint. Until a very recent period no operation short of excision was performed for the relief of this condition, and amputation was often resorted to. The most favorable result, therefore, was recovery with a short limb and with bony anchylosis at the seat of excision. Now, surgeons operating early, are able to attack the disease by opening the joint and removing the affected areas, either with the knife or curette, thus substituting arthrectomy for the more grave operation of excision or amputation. After arthrectomy in a favorable case the patient recovers with a good range of motion in the joint, and if anchylosis does occur there is at least no shortening of the limb. Since the pathology of tubercle is now understood, and its curability in certain cases has been demonstrated, there has been a tendency to attack the disease still earlier.

Recently, local tuberculous affections have been treated by the injection of a large variety of substances by different surgeons, in the hope that the disease could thus be arrested. An attempt is thus made to cure these troubles without operation, and also to successfully treat those cases that are not accessible to surgical interference. The literature of the subject is already voluminous, the reports of many of the observers show a very fair degree of success attending this treatment and certainly warrant a more extended trial. The different substances used have been largely those supposed to be destructive to the tubercle bacillus. The most important of these are arsenious acid, balsam of Peru, camphorated naphthol, carbolic acid, creasote, iodine, iodoform, zinc chloride, and tuberculin. At the present time we may dismiss all but the three last mentioned. These have been subjected to extended trials, while the others have been more or less completely abandoned after the initial observations. It is not probable that any of these methods will supplant surgical measures to any great extent, but it is probable that the best results will follow a well directed combination of the two. Of all the drugs employed so far, iodoform pre-eminently takes the first place.

IODOFORM.—The question of the germicidal action of iodoform has been the subject of much discussion. Mosetig von Moorhof, Bruns, Verneuil, and others attribute a positive anti-tubercular effect to iodoform. König believes that tuberculosis cannot develop in rapidly organizing and contracting scar-tissue. Brodnitz states that the results of the operative treatment of bone and joint tuberculosis have considerably improved since the introduction of the use of iodoform. Billroth speaks highly of iodoform as an anti-tuberculous material. He says, in summing up his experience, "The results have surpassed my boldest expectations." Von Bergmann likewise commends the injections of iodoform-glycerine in local tuberculosis, and confirms the opinion expressed by König in which early resections were condemned. Küster speaks highly of this treatment, and it is also commended by Koch (Dorpat). Verneuil believes iodoform is a specific against the tubercle bacillus. Von Büngner says: "No one can now deny that iodoform has an anti-tuberculous effect, and many cases of the disease are thus cured."

The exact mode of action in these cases is still uncertain, but the weight of evidence seems to rest with those who hold that iodoform does not possess any positive germicidal action; it is probable, however, that its decomposition-products are somewhat active in this regard. In spite of this fact surgeons have for many years placed much confidence in the beneficial effect of iodoform in tuberculous and other specific processes. It was probably this knowledge that led Billroth and Mikulicz in 1881 to employ injections of iodoform in surgical tuberculous affections. Since this time the method has been extensively employed by German and French surgeons, but particularly by the former. The beneficial effect of these injections is variously explained by different authors as dependent upon a bacillicidal influence and upon a stimulating effect upon the surrounding healthy tissues by which the diseased process is limited and eventually absorbed. Conservative writers are inclined to attach some importance to each of these theories. The particular combination of iodoform and its preparation for use is a matter of the greatest importance. Iodoform-ether, which has been largely employed in France by Verneuil, is objectionable for the reasons that it is irritating, it is much more liable to cause iodoform poisoning, and the results are not so good as where other combinations are used. Opinion is divided between the mixtures made with olive oil and with glycerine. Of the two the latter is perhaps more generally preferred. In either case the strength is the same, ten per cent. of iodoform. The greatest care is requisite in the sterilization of the mixture, as the presence of iodoform does not insure against miero-organisms. The term "emulsion," which was originally applied to the combination with gum arabic, and retained for the mixtures made with oil and with glycerine, is still largely used, but the physical condition which exists in the combination with the two latter vehicles is much more correctly expressed by the word "mixture."

Stubenrauch has referred to reactions of a threatening character following injections of iodoform, such as great swelling, severe pain, iodoform exanthemata, etc. Garré believes these untoward effects to have been due to the use of a mixture which was not sterile. He states, that in hundreds of injections in the Tübingen clinic he had never observed such results.

Iodoform intoxication is reported to have followed the injections in a few instances, but this will be a most exceptional occurrence if the iodoform-oil or iodoform-glycerine mixtures are used. As much as a fluid ounce, or two, may with safety be employed.

De Vos recommends the following method for the sterilization of iodoform-oil: Into clean, black glass bottles of proper size ten grammes of iodoform are placed and the bottles filled with a solution of corrosive sublimate, 1 to 1,000, well shaken and allowed to stand four days. The sublimate solution is then decanted and the iodoform repeatedly washed with freshly distilled or boiled water. To this aseptic iodoform is now added ninety grammes of olive oil, previously boiled ten minutes and cooled to 30° C. and the mixture repeatedly shaken. Brodnitz recommends the sterilization of iodoform-glycerine as adopted by Levy. Into common medicine-bottles of twenty grammes capacity are placed two grammes of iodoform and eighteen grammes of glycerine; corks are tightly inserted and tied. The bottles are then immersed in salt water and subjected to a temperature of 110° C. for from two to three hours. By means of tongs the bottles are removed from the hot-water bath and the necks quickly dipped in melted paraffine to seal the corks and prevent the entrance of air. Before use the bottles are washed with sublimate solution and the contents are poured into small dishes which have also been so sterilized. In this way a fresh bottle can be used for each operation. To prevent decomposition the bottle should be kept from exposure to light. A brown-red coloration of the glycerine indicates the liberation of iodine; when the mixture has assumed this condition it should be rejected. Böhni prefers a solution of iodoform to a mixture, and therefore uses oil of sweet almonds as a vehicle. This oil will dissolve as much as five per cent. of iodoform. Personally, I prefer a mixture containing ten per cent. of iodoform with seventy-five per cent. of glycerine, and twenty-five per cent. of water. This preparation, being less viscid than if pure glycerine is used, is more convenient to manipulate in the syringe, it penetrates the ramifications of sinuses and joints, or other cavities, better, and I believe causes less local reaction.

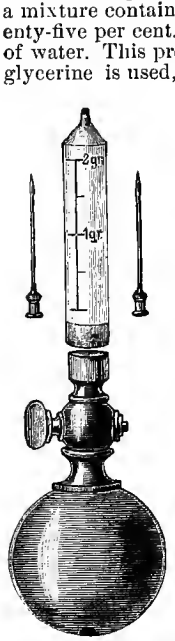

FIG. 652. — Pravaz's Syringe (Koch's) Suitable for Parenchymatous Injections in Tuberculous Diseases.

The iodoform for this purpose should be in an impalpable powder rather than in the coarse particles in which condition it is so often met with. When made by the usual process it has a crystalline character, which is altered by powdering, but almost always a number of coarse particles are to be found in the powder. That made by electrolysis is entirely free from this objection and is therefore to be recommended. A very satisfactory product is made by E. Schering, of Berlin, Germany.

Application.—The method of using the different combinations referred to is the same. Undoubtedly the best results will be obtained by the most careful application of modern aseptic principles in making these injections. To secure this end, in addition to the careful preparation of the mixture as described above, the syringe, the skin of the patient, the hands of the surgeon, and all utensils coming directly in contact with the fluid should be thoroughly cleansed. Parenchymatous injections are most conveniently made with the Pravaz syringe. In injecting large cavities a syringe of proper size, with a nozzle to fit the cannula used in aspirating, should be employed. The injections are to be repeated every eight days to two or three weeks, according to the degree of reaction resulting. The application of this treatment may be best detailed under the following special localizations of the disease:

TUBERCULOUS LYMPH-GLANDS.—If they have not yet broken down, injections into and about the affected glands should be practised about every eighth day. A single puncture through the skin should be made, but by partially withdrawing the needle five to ten drops of the mixture may be inserted at several points. If softening has already occurred a quantity of the mixture should be deposited in the degenerated area, and injections about the circumference of the disease also made. If the vitality of the skin overlying the abscess is impaired, the needle should be entered through healthy skin at some contiguous point. It is well always to draw the skin to one side before making the puncture, so that on withdrawing the needle the tract becomes subcutaneous. When the glands have become the seat of a mixed infection, suppuration will not be prevented by the use of the injection, and they should be subjected to one of the usual surgical procedures—incision, excision, or erasion—after which the iodoform mixture may be used as a dressing and for parenchymatous injection, in the surrounding infiltrated area. This treatment has not been used extensively enough as yet in glandular tuberculosis to determine its exact value, but it does not seem likely to supplant, but rather to be an adjunct to, other surgical measures. If the glands are in a position in which removal is possible, the treatment will be much shortened by resorting to this measure.

SINUSES.—A number of instances have been reported in which tuberculous tracts have closed under the influence of the iodoform treatment. It is necessary to inject the mixture in the walls of the sinus, and the cavities may be filled with gauze saturated with the same substance.

COLD ABSCESSES. — Continental surgeons have employed iodoform in cold abscesses very extensively in recent years. Billroth proceeds as follows: Under aseptic precautions the abscess is evacuated, the cavity thoroughly flushed with a solution of corrosive sublimate, 1 to 3,000, the iodoform mixture introduced, and the wound closed with sutures. When necessary this is repeated in four or six weeks; the majority of cases requiring the second, third, or even more treatments. It is reported that fifty per cent. of the cases were thus cured.

Bruns reports one hundred cases of cold abscess connected with the vertebral column and sternum, subjected to the iodoform treatment, with eighty cures. Brodnitz reports twenty cases of cold abscess treated by this method. Of these nine were definitely cured; eight had fistulæ remaining; and three had not been heard from. Of the cured cases, three were treated by puncture and injection; four by packing after incision; one with incision and primary suture; and one by incision with secondary suture. Recent medical literature has contained many reports from representative surgeons similar to those just given. The conclusion seems justifiable, therefore, that in iodoform we have a valuable addition to our resources in the management of tuberculous abscesses.

The method of its use has been already indicated. The strictest asepsis is imperative. This having been attended to, the abscess may be aspirated and the iodoform mixture injected, or the fluid may be evacuated by incision, followed by primary suture and the introduction of the remedy, or the cavity may be packed with iodoform gauze and secondary sutures employed. The particular method adopted must be left to the special indications of the case and the preference of the surgeon. In those cases in which incision is employed, the walls of the cavity should be gently curetted or roughly brushed over with a sponge, in order to remove as much as possible of the unhealthy membrane. If the abscess is aspirated the cavity should be irrigated with a three per cent. solution of boric acid, or a 1 to 4,000 corrosive sublimate solution, before the injection is made. The puncture should be sealed with iodoform collodion. In favorable cases, although the collection re-accumulates, it is smaller in quantity, and by repeating the treatment every three to six weeks a cure may be looked for in a fair proportion of cases.

BONE AND JOINT TUBERCULOSIS.—The remarks that

have just been made apply with equal force to bone tuberculosis. The iodoform not only has a beneficial effect upon the accompanying abscess-wall, but it is said also to have a curative influence upon the bone lesion.

Tuberculosis of joints has furnished a large field for the use of the iodoform treatment. The mode of application of the remedy should depend upon the condition of the joint. In the condition known as "fungous joint" the injection is to be made into the joint and around the area of disease. If there is fluid this should be aspirated, the joint irrigated with the boric-acid, or mild bichloride of mercury solution, say 1 to 10,000, and the iodoform mixture introduced. The opening is to be sealed with iodoform collodion. If the joint cannot be satisfactorily drained by aspiration, incision should be resorted to, followed by irrigation, the introduction of iodoform, and primary sutures. Moderate rest of the joint after injection is advisable, but it is not necessary to resort to absolute fixation. Massage is not to be recommended, as dissemination of the disease might be thus caused.

De Vos reports sixty-eight cases subjected to this treatment: sixty were joint tuberculosis, six tuberculous fistulæ, and two tuberculous abscesses in connection with diseased bone. Cure is reported in seventy-two per cent. of the cases. The duration of the treatment in the different cases was from nine to three hundred and twenty-five days; the number of injections in a single case from one to twenty; the amount of iodoform used during the treatment of a patient varied between 2 and 67.5 grammes, and the amount of oil from 10 to 385 grammes.

The beneficial effects of the injections consist in a decrease in the pain and swelling, and in connective-tissue formation, at the points of injection. The latter is reported to have been observed in a case which later demanded resection.

De Vos, after conducting a series of experiments on cadavers, recommends the following points for puncturing the various joints: For the *shoulder*-joint, the arm should be adducted and the forearm bent at a right angle across the abdomen. The needle is entered 1 ctm. behind and below the point of the acromion. For the *elbow* a point is selected external to the olecranon, the needle being introduced between the head and the tuberosity of the radius. For the *wrist*, on the radial side, the most dorsal corner of the depression between the extensor tendons at the root of the thumb (*tabatière* or anatomist's snuff-box). On the ulnar side, a point on the upper anterior part of the pisiform bone. For the *hip-joint* de Vos has given the method devised by himself. He first determines a point as broad as the thumb of the patient, external to the middle of the line connecting the anterior superior spine of the ilium and the tuberosity of the pubis. From this point, which lies inside and above the head of the femur, a line is drawn toward the external point of the trochanter major. This latter line is divided into four equal parts. The first dividing point from the trochanter toward the middle is the point which should be selected for puncture. The needle is introduced until bony resistance is felt; the limb should be straight, and the inner border of the foot vertical. This rule holds for the position of the trochanter in the Roser-Nélaton line; but if the trochanter is dislocated, then the starting-point must be transferred in the direction in which the head of the femur is displaced.

Von Büngner recommends Küster's plan, which is as follows: The point at which the femoral artery crosses the horizontal ramus of the pubis is determined by palpation. The puncture is made at the inner border of the sartorius muscle, in the line drawn from the previously determined point to the trochanter major. The needle is passed in a straight direction into the joint. In this position the capsule is punctured at its thinnest point, and in thin persons the head of the femur can be felt. As the capsule extends from the border of the fibro-cartilage of the joint to the oblique line of the femur, a little deviation of the needle will not result in a failure to enter the joint cavity; there are no important structures here to wound, and it is the shortest and most direct route to the joint. For these cases the needle should be from seven to nine centimetres long. Ten grammes of the fluid may be injected at each séance.

For the *knee*, a point between the corner of the upper tibial border, and the ligamentum patellæ; for the *ankle*, a point on the outside of the foot immediately anterior to the point of the external malleolus, the needle being directed toward the calcaneum in order to pass between this bone and the malleolus.

Zinc Chloride.—Lannelongue has proposed the parenchymatous injection of zinc chloride in local tuberculous troubles, and reports good results following its use. His theory is that, as a result of these injections, a mass of new connective tissue is formed about the area, and the organization and contraction encapsulate the focus of disease. He has accordingly applied to this treatment the name "sclerogenous." The remedy is applied by making injections, at several points around the periphery of the diseased area, of a few drops of a 5 to 10 per cent. solution of zinc chloride. These may be repeated at intervals of from one to two weeks, according to the amount of disturbance which follows.

Desguin, Dubois, Coudray, Mauclaire, and other French observers have reported very favorably upon this treatment, but it has not been employed in this country and needs further trials.

Tuberculin.—When tuberculin was first brought to the notice of the profession, it seemed to promise great assistance in the diagnosis and treatment of surgical as well as medical tuberculous diseases. In practice, however, it has been found to be of less service to the surgeon than it was to the physician. Lupus excepted, the treatment of surgical tuberculous affections is much more satisfactorily carried out by other means. At best, under the influence of tuberculin, improvement is very slow, and if the case is amenable to operative treatment this should be resorted to in preference. It is not considered justifiable at present to resort to tuberculin for diagnostic purposes, except in rare cases, although it is probable, as Mr. Watson Cheyney remarks, that the dangers attending the use of tuberculin in surgical troubles have been magnified. A fuller discussion of this subject will be found under "Tuberculin" in this work.

A number of well-authenticated instances are on record in which lupus appears to have been permanently cured by tuberculin, either alone or in conjunction with operative procedures. There is no treatment which has been thus far recommended that would seem to offer as good prospect for cure as the injections of tuberculin, combined with proper surgical measures.

Passive Hyperæmia.—Professor von Esmarch has recently advocated the production of passive hyperæmia as a means of treating local tuberculosis. The theory is based upon the experience of pathologists and clinicians, that the immunity of the lungs from tuberculosis increases with the increase of blood in the lungs, and to the contrary, anæmic lungs are in the highest degree predisposed to tuberculosis.

Bier reports, from Esmarch's clinic in Kiel, 43 cases treated by this method. In 27 of these passive hyperæmia comprised the sole treatment. In the cases of bone and joint tuberculosis the results are spoken of as excellent: inflammation of the sheaths of tendons was improved, a mass of cheesy glands at the elbow became a hard scar, tuberculosis of the skin is reported as cured in two instances. One case of tuberculosis of the cellular tissue was also cured. Lupus was not benefited.

The beneficial results may be explained by the increased nutrition of the part, but a more powerful effect, Bier thinks, is exerted by the passive congestion, which he supposes leads to the formation of connective tissue.

Heller, of Kiel, believes that by the obstruction of the circulation the tubercle bacilli die from their own products. The effect is reported to be better in fresh lesions than those obtained by the use of iodoform.

To induce a condition of hyperæmia, the affected part was subjected to a temperature of from 70° to 100° F. for eight to ten hours, in the first cases. The result was an arterial hyperæmia, with redness, swelling, and

œdema. The results were negative. The plan of treatment adopted at present is the following: Suppose the elbow-joint is the part affected, the fingers, hand, and arm are bandaged up to the articulation, then directly above the joint an elastic band is made to encircle the arm tight enough to impede but not to arrest the circulation. It is necessary to interpose a piece of lint to protect the skin from the direct pressure of the band, and the latter must be changed to a new point from day to day.

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Alfred C. Wood.

TUMENOL. This compound, which is very similar to thiol, has also been proposed as a substitute for icthyol. The mineral oils obtained by the fractional distillation of coal-tar are supposed to contain a class of unsaturated hydrocarbons, which are readily acted upon by sulphuric acid. These hydrocarbons, treated with concentrated sulphuric acid, constitute the active ingredients of tumenol. It differs from thiol by the hydrocarbons not being sulphuretted before the addition of the acid. The process consists in the separation and purification of the hydrocarbons, and then treating them with the acid. The hydro-carbons undergo sulphonation and are separated as a dark, thick liquid, containing sulphone and sulphonic acid, known as *commercial tumenol.* It is a dark-brown, almost black fluid of a syrupy consistency, acid in reaction. *Tumenol-sulphone* and *tumenol-sulphonic acid* may be separated from the commercial tumenol by the addition of soda lye, which combines with the acid to form a soda salt. The mixture is then shaken with ether, which dissolves the sulphone and leaves the salt in solution. The tumenol-sulphone is a dark-yellow, thick liquid; soluble in ether, but insoluble in water. In an aqueous solution of tumenol-sulphonic acid it readily dissolves. Tumenol-sulphonic acid is a dark powder, having a peculiar faintly bitter taste. It is easily soluble in water, and the solution can be evaporated without separation taking place. It is, however, precipitated from solution by the addition of alkalies, with which it combines to form salts.

The therapeutic properties depend upon the antiseptic action and also upon a powerful reducing action which has recently been pointed out. It is recommended in eczema, erosions, ulcerations, and pruritus. In the latter condition it has been found to be particularly serviceable. The value of the compound, as a remedial agent, is not as yet very satisfactorily made out.

The acid and its salts are expensive and have not been employed. The commercial tumenol is that which is generally used. From this two forms of solution are prepared for use, one containing ten per cent. of tumenol in equal parts of ether and rectified spirit and water, and the other containing glycerine in the place of the water. It may also be used as an ointment. The tumenol-sulphonic acid is employed as a powder, or in solutions, of the strength of one or two per cent.

Beaumont Small.

TUNNEL POISONING. Asphyxia, or partial asphyxia, with a general poisoning and consequent disturbance of the system, is frequently met with in the construction of tunnels in the present day, and is due to the use of what are termed "high explosives;" for in the removal of rock in the construction of such work dynamite or nitro-glycerine is used in considerable quantities.

When these are used in open-cut work, as on railroads, after the explosion the gases immediately distribute themselves in the atmospheric air, and no effect has been noticed on the workmen employed. But where it is used in tunnels, as in mining or other partially closed cavities, and the gases or residue are slow to escape from the mouths of the tunnel or up an air-shaft, serious deleterious effects are produced.

Dynamite is composed of nitro-glycerine with some absorbent. There are, for purposes of study, practically two classes of dynamite, which might be termed inorganic and organic, according to the absorbent used. As a type of one class is that made with infusorial earth—Kieselguhr—which is composed of siliceous diatoms, and of the other, that made with ground wood-pulp or sawdust. Others still are made from a combination of both kinds. The results of the explosion, however, are practically the same in either case, except with the organic absorbent we get with the products an additional amount of carbon.

There are two classes of cases of poisoning produced by breathing the products of the explosion of such materials: First, acute cases, where a considerable quantity of the residue is inhaled at one time; and secondly, chronic cases, or where a small amount is constantly breathed for a long time. The acute cases vary according to the amount inhaled.

Where the amount of dynamite used is not large, or where after the explosion a considerable quantity of fresh air has been mixed with the products of the combustion, or where the workman has, after a few breaths, become giddy and is pulled away by others and sent to the surface, the effects produced are a trembling sensation, flushing of the face, succeeded sometimes by pallor, frequently nausea, sometimes vomiting, with throbbing through the temples, and fulness in the head, as if it would burst, followed by an intense headache characteristic of poisoning by nitrites—similar to that of nitrite of amyl, only not so violent, but more persistent, frequently lasting forty-eight hours. The heart's action is increased, and the pulse is full and bounding, though somewhat compressible, and varying in rate from 100 to 140. The condition is described by the workman as a "dizziness." He feels as if drunk, or as if his head is swelled.

In the second class of these acute cases, where a man goes into the tunnel immediately after the explosion, and is brought in contact with a large percentage of the poisonous materials, the effects are giddiness, immediately followed by unconsciousness, and the patient presents the usual appearance of asphyxia.

Sometimes in these cases the pulse is full and bounding, though very compressible, but in most of the cases it is alarmingly weak. Generally there is a great pallor, though this may be partially due to working underground. The comatose condition soon passes away, and is succeeded by drowsiness, languor, cold perspiration, intermittent pulse, and generally nausea and vomiting. Sometimes the breathing is spasmodic, and frequently there is hiccough, and after a time a severe headache.

Nearly all of these cases, however, no matter how serious they seem at the time, recover. Though in cases where death does occur, it is usually several hours after the patient has been removed from the tunnel, and is due to paralysis of respiration.

In the chronic cases, where but little of the products are breathed daily, there are four prominent symptoms: These are headache, cough, indigestion, and disturbances of the nervous system. The headache is usually a continuing one, and varies in degree from a mere fulness to a throbbing pain. The cough is similar in character to the cough of pertussis, or of malaria, and as cases of ma-

laria are frequent upon such works, one may easily mistake the cause.

Next in prominence to these symptoms come disturbances of the nervous system, as trembling, irritability, neuralgia, etc. In fact, nearly, if not all, of the symptoms are attributable to this cause. Even the cough is, in all probability, due to the effect produced on the pneumogastric nerve.

With this nervousness is also associated indigestion, probably due to the same cause. Of course, with this latter symptom, the character of the food and the manner in which it was eaten must be taken into consideration; but as soon as a man with these chronic symptoms is taken from the tunnel and placed at work on top he steadily improves, and finally entirely recovers.

It is also noticeable that those who have previously suffered from dyspepsia, or from tic douloureux, or sciatica, or other form of neuralgia, are made worse by the dynamite smoke.

What are these symptoms due to?

The formula for nitro-glycerine is $C_3H_5(NO_3)3$. And the products from the combustion of this are written: $4(C_3H_5N_3O_9) = 10(H_2O) + 12(CO) + 6(N_2O_2) + O_2$.

In other words, the products are water, carbonic oxide, and nitrogen dioxide, none of which would produce the symptoms above described except asphyxia.

A comparison of the above symptoms in the acute cases, with the phenomena produced by various-sized doses of nitro-glycerine, shows them to be identical. This similarity between the symptoms from inhalation of the products of the explosion of dynamite, and those produced by the nitro-glycerine itself, is so well marked that even miners themselves have noticed it. Frequently, when dynamite is frozen, a miner will place a cartridge in his boot to thaw it out, and the absorption of nitro-glycerine through the skin will produce precisely the same symptoms as in the mild acute cases of the inhalation of the products before described.

Again, as another instance, a miner used his knife to cut a cartridge and afterward ate an apple cut with the same knife. In this case, according to his statement, the symptoms were similar to being "knocked out by powder smoke," only more severe; the headache persisting three weeks.

And on another occasion this same miner cut up some tobacco to smoke with a knife that he had used for dynamite, and was again similarly affected. Here the heat from the tobacco smoke volatilized the fine particles of nitro-glycerine on the tobacco below, and poisoning was produced by absorption through the lung tissue. No other conclusion can well be reached than the fact that there is mixed with the gases produced unexploded particles of nitro-glycerine in a volatile state; and these particles inhaled by the miners produce the effect described.

This fact can be conclusively proved by waving in the fumes, immediately after an explosion, a cold sheet of glass, and thus collecting upon it by condensation a small percentage of the nitro-glycerine itself.

There is no doubt but that the explosion of a large quantity of dynamite would produce sufficient gases of CO and N_2O_2 to produce asphyxia. Here we get the cyanosis and other symptoms of simple asphyxia, and we may get nausea and vomiting; but not the same disturbance of the sympathetic system, nor the continued chronic spasms of the vagus, nor the persistent headache pathognomonic of nitro-glycerine poisoning.

As regards treatment, as a preventive, the use of such apparatus or machinery, whether by blowing or by sucking, that will rapidly clear the tunnel or cavity from noxious gases or fumes, is to be recommended. Where steam drills that are worked with an air-compressor are used, they contribute largely to this end.

Also, it has been found by makers of dynamite that the use of a large cap will explode a greater percentage of nitro-glycerine than a small one, and this, to a certain extent, obviates the trouble. In certain cases, however, for some reason a cartridge does not explode, but burns like a candle, with considerable spluttering. In such an instance the amount of nitro-glycerine volatilized is much greater than if exploded, and consequently the effects are more deleterious. For immediate treatment, such measures as are generally used in cases of asphyxia are of service.

In addition, the use of cold to the head or the subcutaneous administration of atropine, ergotine, or other vaso-motor stimulant, is of necessity indicated and exceedingly efficacious. There is little doubt that the effects of nitro-glycerine are produced from its decomposition and the formation of a nitrite in the body. "Treatment with ammonia restores normal color and normal functional power to nitrite-poisoned blood." So the carbonate and aromatic spirits of ammonia should be used internally, and it is also well for those in charge of such works to recommend to the workmen employed to carry with them small vials of this remedy for use in such cases. *Thomas Darlington, Jr.*

TWIN PREGNANCY, COMBINED INTRA- AND EXTRA-UTERINE. This title is lengthy, but it names its subject completely, *i.e.*, this caption indicates twin gestation, wherein one fœtus is situated normally in the uterus and the other fœtus lies external to the uterine wall, but is abdominally enclosed; or, in other words, there is normal uterine gestation co-existing with ordinary ectopic pregnancy.

This is a rare combination of affairs, and apparently but few are aware that it ever existed, as nearly every observer has stated, voluntarily, that they did not know of such a thing until they met it accidentally in practice. Surely this was the writer's experience in his own and only case, which occurred in November, 1889, and so far as he knows is the last case put on record. The first case for which there is proper authority was reported by Duverney, and occurred in 1708. Twenty-five cases have been reported, and possibly more. The literature is scarce, indeed, upon this subject, only a few of the recent authors treating upon this condition at all, and they rarely do more than merely suggest that such an occurrence has been known.

Cause.—But little can safely be said upon the etiology. It appears that twin pregnancy is much more frequent in extra-uterine pregnancy than in uterine pregnancy, and it has been suggested that one *ovum* obstructs the other in the passage along the Fallopian tube, thus forcing one back into the abdomen or arresting its transit, while the other passes on into the uterus. This could scarcely be so, unless the two embryos develop from different ova, and only one ovary contributes.

Diagnosis.—The symptoms and history by which combined intra- and extra-uterine twin pregnancy is to be recognized, are those of ordinary ectopic pregnancy coupled with normal, or uterine, gestation, which latter, to avoid error in diagnosis, may be entirely ignored. It should be remembered that pain in the lower abdomen and symptoms of internal hæmorrhage, accompanied by evidence of normal pregnancy or a recent abortion, does not preclude the possibility or probability, if the symptoms are marked, of extra-uterine pregnancy coexisting with the uterine pregnancy. In other words, and for the sake of emphasis, it may be repeated, the very fact of uterine conception, or its history existing, may for all practical purposes be disregarded, and the diagnosis of abdominal pregnancy alone be considered in arriving at a correct knowledge of the case.

Should the case continue to the ninth month, which is quite probable unless terminated at about the third month, and after the birth of the uterine child, there will be very little difficulty in concluding the diagnosis, for the second child does not descend, although there may be terrific labor pains in the attempt of nature to throw off the supernumerary fœtus. Then the hand passed into the uterus for exploratory purposes (though probably it will be done for version) will find the uterus empty, and through the thin uterine walls it will be able to make out another child outside of the apartment in which the hand is. The next question to decide is whether the attendant has a *uterus bicornus* to deal with; this he does

by seeking for another *os*. Failing to find this, he need have no doubt as to the nature of the condition.

Treatment.—The fact of normal gestation existing will not excuse one in neglecting the symptoms of extra-uterine pregnancy; and should there arise at the third month, or thereafter, the alarming indications of rupture of the sac and abdominal hæmorrhage, the case should be dealt with in the usual way of treatment for extra-uterine pregnancy; or should the true condition be recognized before rupture occurs the case may be cared for by electrolysis, or otherwise, as the attendant desires.

When death of the fœtus occurs at an advanced state, say from the fourth to the sixth, or seventh, month, it will be found that nature has made an effort to get rid of the dead fœtus, in most of the cases collected, by means of breaking down of tissue, or by finding an exit through the bowels or through the abdominal parietes. The treatment of such a case will be suggested as time advances and the condition of the mother indicates.

Strange to say, very nearly half the cases thus far noted have continued to the ninth month, and over fifty per cent. of this number have made a complete recovery with little other assistance than that of unaided nature.

The great difficulty of doing a primary operation lies in dealing with the placenta. If it is removed the woman dies of hæmorrhage, and if left to come away by drainage and sloughing she dies of septicæmia, an equally insurmountable obstacle. In the writer's case a healthy female infant was born at term, and at the same time a full-grown child was left in its abdominal *sac*. Hard labor pains followed for ten whole nights in succession, with entire intermission in the day-time, and these pains were only controlled by large doses of opium. The woman made a good recovery. Shrinking began at once and continued so that at the end of three months all that was left of the fœtus and its secondines was a mass not larger than the medium-sized fist of a man. This tumor has never given the woman any inconvenience since the first month, though she has not since become pregnant. Out of the eleven cases that have gone to term seven have recovered entirely when treated expectantly, while in every case in which primary laparotomy was performed the mother has died, though both children have been saved.

It is hoped that through the agency of modern surgery and modern cleanliness, some means will be devised for successfully coping with a contained placenta.

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TYPHOID FEVER. During the seven years which have elapsed since the publication of the original article in Volume III. of this HANDBOOK, comparatively few additions have been made to our stock of knowledge with regard to typhoid fever, and these few belong almost wholly in the department of therapeutics. In discussing these new facts we shall follow, as nearly as possible, the subdivisions adopted in the section on treatment, in the original article.

DIET.—In speaking of the employment of milk as an article of diet in typhoid fever, we said that when it was found that even small quantities disagreed with the patient, lime-water or one of the aërated waters might advantageously be added to it, or it might be boiled. We would add that if the milk is very rich it should be skimmed, and the addition of lime-water in the proportion of from one-sixth to a quarter of the volume of milk is generally indicated. Furthermore, it should not be forgotten that a given solid may be more digestible and less irritating in the stomach and intestine than a given liquid, which subsequently becomes a solid.

Diet in Convalescence.—The value of the old rule—to wait a week after the evening temperature has fallen to normal before increasing the diet, either in amount or in-consistency—is still recognized. After this period, however, considerable variety may be introduced into the dietary list. To the items enumerated in the original article, two others may well be added, viz., a tender, juicy chop, or a bird well cut up. In deciding of what the diet shall consist, on any particular day, we must, of course, keep in mind both the vigor of the patient's appetite and the height of the body temperature. Convalescence is sometimes unnecessarily prolonged by the lack of suitable or sufficient nourishment. On the other hand, some practitioners would be even more liberal in their dietary. So good an authority as Peabody, of New York, thinks, "we are accustomed to have too great a dread of doing harm at the site of lesion in the ileum in typhoid fever by giving solid food. If I am correct in my opinion as to the inference to be drawn from hunger in a fever patient, there is even less likelihood of causing damage to an ulcerated ileum by giving finely divided egg or beef or chop to such a patient than by giving him milk; and my experience seems to justify the inference. It has been my practice for years to allow albuminous foods of these descriptions to such patients, even before the fever leaves them, under these conditions. I have at present under treatment several patients with typhoid fever whose temperatures reach 101°, 102°, and 103° F., daily, who are hungry, and who are receiving such solid food once a day. So far as I am aware, I do not have a larger percentage of relapses or hæmorrhages or other serious complications or accidents in my practice than I did before I adopted this plan, or than my colleagues do who have not yet adopted it."[1]

Bowels.—Within the last few years a variety of drugs have been tried with a view to intestinal antisepsis, to the prevention of intestinal fermentation and formation of those poisonous and depressing alkaloids which are supposed to be elaborated freely in the fæces of the typhoidal bowel. In regard to some of these drugs, F. P. Henry[2] says that it is a well-known chemical fact that they destroy the toxic intestinal alkaloids, and that it is admitted by all who have given them a thorough clinical test that they exert a most favorable influence upon the course of typhoid fever. Osler,[3] on the other hand, testifies to the inefficiency of the carbolic acid and iodine and of the beta-naphthol treatment, and congratulates the patient that the majority of these medicines meet one of the two objects which Hippocrates says the physician should always have in view—they do no harm.[3]

Among the various other agents employed may be mentioned thymol, corrosive sublimate, naphthalin, hydronaphthol, the salicins, salol, iodoform, charcoal, sulpho-carbolated water. Henry, in commending Bouchard's dictum, that an intestinal antiseptic should be more or less insoluble and exert no toxic effect on the organism, ranks thymol as the best of these agents. He favors its use as unreservedly as does Brand that of cold water tubbing. In every case in which he has employed thymol in an early stage of the disease, the tongue has become rapidly clean and moist, and has so continued; tympany has speedily subsided, or has never made its appearance; diarrhœa has diminished, without being followed by constipation; there has been no delirium; and finally the temperature has gradually subsided and remained within natural bounds. In a word, the typical symptoms of typhoid fever will, according to his experience, rarely develop if thymol is administered during the first week of the disease. He states that its antiseptic power is four times greater and its poisonous effects ten times less than carbolic acid. It is, secondly, so insoluble as to reach the small intestine, and there exert its antiseptic effect. It should be given in pill form. The usual dose would be one two-and-a-half grain pill every three hours, a maximum dose two such pills every three hours. Each pill should be followed by enough water to insure its rapid passage into the stomach, and thus avoid the disagreeable burning sensation to which it might otherwise give rise.

Pepper, of Philadelphia, is equally convinced of the merits of nitrate of silver, which does not meet Bouchard's requirements of an intestinal antiseptic. He gives

it in pill form in doses of one-fourth to one-fifth of a grain from the earliest moment at which the disease is suspected until the entire close of the process.

Perforation, according to Murchison, occurred in 11.38 per cent. of 1,721 fatal cases collected from various sources; Hölscher[4] found 5.7 per cent. among 2,000 typhoid autopsies at the Munich Pathological Institute; Fitz, of Boston, among 4,680 cases of typhoid fever, tabulated by various authors, finds a mortality of 6.58 per cent. from perforation;[5] and Mason, among 676 cases tabulated at the Boston City Hospital, finds 2.7 per cent.[6] Although this accident occurs most often toward the end of the second, and during the third and fourth weeks, it may take place at any time from the first to the sixteenth week. Immediate laparotomy for the relief of suspected intestinal perforation in typhoid fever is only to be advised in the milder cases of the disease (Fitz[7]). In all others, evidence of a circumscribed peritonitis should be awaited, and may be expected in the course of a few days. Surgical relief to this condition should be urged as soon as the strength of the patient will warrant. Immediate operation may also be indicated when the perforation occurs during early convalescence.

Of 27 cases of peritonitis in typhoid fever, whatever the cause of the former, though often attributed to intestinal perforation, 3 recovered after operation, 17 after resolution, and 9 after the spontaneous discharge of pus.

Van Hook, of Chicago, has reported three laparotomies for perforation, not included in the above, of which two were followed by death and one by recovery.[8] All three operations were performed soon after the symptoms manifested themselves, but in the successful case the perforation occurred on the eighth day of a relapse following three weeks of a first attack.

The positive diagnosis of perforation may be comparatively easy or it may be very difficult, and the diagnosis must justify the operation.

Pyrexia and Hyperpyrexia.—The present tendency of medical opinion is toward the view that pyrexia, apart from infection, is comparatively innocuous; that temperature is an indication, and not a condition; that the reading of the thermometer should be controlled by the character of the pulse and the general systemic condition. It is to be remembered that one patient with a high temperature may be really less sick and in a less dangerous condition than another with a lower temperature. Granted this, however, the temperature is, in a general way, still the index and the measure of the progress of the disease, and of the indications for interference with its natural course where such interference is resorted to, and that whether the therapeutic measure adopted results in heat-repression or heat-abstraction. Moreover, a continuous high temperature is, as a rule, accompanied by a less favorable systemic condition than an intermittent or remittent temperature which reaches temporarily a higher maximum. An evening temperature of 102°, or even 103° F., with a morning remission, may be regarded as the normal and moderate result of the typhoid process. An evening temperature rising above 103° F., especially if the morning remission be slight, suggests the propriety of interference and the abandonment of mere expectancy. The various forms of active interference with the course of the typhoid process, as represented by temperature, may be classed under the two heads of (1) the external application of cold, and (2) the internal exhibition of drugs.

1. *The External Application of Cold.*—Cold may be applied externally by means of sponge baths, the wet pack, sprinkling the exposed surface of the body, putting the patient in the cold bath, exposure to cold air, or the application of coils of tubing. And here we may be permitted to repeat, with certain modifications and additions, what we said on this part of the subject in our first article.

Sponge Baths with water at a temperature of 70° to 75° F. are grateful, refreshing, tranquillizing, keep up the action of the skin, can be given without fatigue to the patient, and, if frequently repeated, will exert a certain positive effect upon the temperature and nervous system. They are not, however, efficient in controlling a marked hyperpyrexia. The wet pack, or sprinkling the body, covered only with a sheet, has a more pronounced action. The cold bath is still more effective.

Cold Baths.—In regard to cold baths, it may be said, in general that mild cases do not require them, and in advanced cases—after the second week—they are less safe. Great care must be exercised in giving them to young children and old persons. The patient should always be carefully watched, and the administration of some form of stimulant, either during or after the bath, is often indicated. The bath should be rolled to the bedside, and at least two attendants are required, that as little fatigue as possible may ensue to the patient when being lifted in and out. The bath may be given as a cold bath, at a fixed temperature of from 65° to 70° at the outset, or as a graduated bath, the water being gradually cooled from 85° to 65° F. The graduated bath consumes more time, and for many patients is quite as much of a shock as the cold bath. With either method the pulse must be carefully watched. In the cold bath, fifteen to twenty minutes will generally suffice to produce shivering, when the patient should be removed. During the bath cold water should be poured upon the head and friction of the surface of the body should be kept up. It is to be borne in mind that the temperature almost always continues to fall considerably after removal from the bath. When the temperature returns to the initial point the bath is to be renewed. In this way five or six baths may be required in a single day. It is claimed by the advocates of this treatment that it should be commenced early in the disease, before the fifth day, and steadfastly persevered in to secure its full advantages. It has been accused of increasing the tendency to relapse and to intestinal hæmorrhage, but statistics do not seem to bear out this view. It certainly involves some disturbance to the patient, and an increase of labor on the part of attendants. Dr. Brand, of Stettin, formulates his method thus: Baths of 64° to 68° F., of fifteen minutes' duration, must be administered from the fifth day of the fever, and be repeated day and night, every three hours, as long as the temperature of the rectum exceeds 102° F.; he also affirms that every case of typhoid treated thus, regularly from the beginning, will be free from complications and will get well.

Since the introduction of the systematic use of cold baths (cold water had often been used in earlier times) in 1861, the typhoid-fever death-rate in the German hospitals, the Prussian and Bavarian armies, has shown, according to most of the available statistics, a very marked decrease. Brand offered (1887), from 23 German and French sources, the reports of 5,573 cases treated by his system of cold baths with a mortality of 3.9 per cent. Eliminating from these the cases imperfectly managed, he reports 1,223 cases treated strictly in all details, according to his rules, by Jürgensen, Vogl, and himself, with a mortality of 1 per cent. In his private practice he reports a considerable series of cases without any death.

In this country, J. C. Wilson reports 226 cases treated by the Brand method at the Germau Hospital, Philadelphia, between February, 1890, and June, 1892, with a mortality of 5.3 per cent. The number of baths in individual cases varied from 1 to 148, the average being about 43. The average number of days in the hospital of the non-fatal cases was about 35. Relapse occurred in 12 per cent. of the cases.[9]

Drs. Peabody and Baruch, of New York, have used the Brand method in hospital and private practice, and are strong advocates of its more general adoption.

Dr. F. E. Hare, of the Brisbane Hospital, Queensland, reports 1,828 cases treated by the expectant or general method, with a mortality of 14.82, and 1,173 cases treated by cold baths with a mortality of 7.84 per cent.[10]

Dr. F. C. Shattuck reports 129 cases treated at the Massachusetts General Hospital in three successive years, without cold baths but with sponging, with a mortality of 8.37 per cent.[11]

Dr. A. L. Mason has tabulated 676 cases admitted to

the Boston City Hospital in 1890 and 1891, and treated without cold baths—sponge baths being used when indicated. The mortality was 10.4 per cent. There were, however, 54 consecutive cases without a death; and the mortality-rate should be considered in the light of the following controlling conclusions:[12]

1. That in the Boston City Hospital the mortality in typhoid fever from patients admitted moribund and with grave complications is 4 per cent.

2. That at least 3 per cent. more die from intestinal perforation and hæmorrhage.

3. That little diminution in the mortality from these causes can be expected under any mode of treatment.

4. That the mortality from renal, pulmonary, and circulatory disturbances, from diarrhœa and pyrexial exhaustion, is about 3.5 per cent.

5. That, excluding deaths from intestinal perforation and hæmorrhage, the mortality among females is 3.4 per cent. greater than among males.

6. That a diminution of 3 per cent. in the general mortality might be expected from the systematic use of cold baths, the reduction being largely in females.

7. That favorable results followed the trial of intestinal antiseptics, but that relapses were not prevented thereby, and that a much wider experience is necessary to determine their value.

L. Riess, of Berlin, has treated typhoid fever with a prolonged bath at a temperature of 88° F. The patient is supported by a hammock and is placed in the bath whenever the rectal temperature reaches 102° F., where he remains during the day and night, if necessary, until the rectal temperature falls to 100° F. The same process is repeated whenever the temperature rises to the initial point. Riess claims a reduction in the rate of mortality and a diminution in the average duration of the disease among 809 cases treated.[13]

Dr. James Barr, of Liverpool, has made use of a permanent bath, and reports 2 deaths out of 71 cases, the most serious of which were treated in this way.[14] The patient, wrapped in a blanket, lies, on bed-ticking stretched across a tank, under water. The head is sufficiently raised. As long as the patient's temperature in the mouth is over 100° F., the temperature of the water in the tank need not rise above 90° to 93° F., but as the body temperature approaches the normal so should the temperature of the water. Barr did not find it necessary to lower the temperature of the water below 90° F., nor to raise it above 98° F. Patients were kept in the tank for varying periods, from a few days up to thirty-one days.

Barr is evidently satisfied with his results, and his "statistics," though based on a small number of cases, are very favorable. He proposes to perfect the details of his method.[14]

It is evident that we have not yet had the last word in regard to the cold-water treatment.

2. *The Internal Exhibition of Antipyretics.*—The internal use of antipyretics, and especially of the synthetic laboratory compounds, has not answered all the expectations which were entertained in regard to them at the time of their first introduction, though I am inclined to think that the reaction against the intelligent use of the best of them has gone somewhat too far. They cannot be used repeatedly and systematically, as can the cold baths, neither do they, in moderate quantities, modify appreciably the course of the disease, as is claimed for the baths. But their occasional administration, under suitable conditions, does substitute calm for excitement and sleep for restlessness, leaving the patient refreshed rather than depressed. The best of them are antifebrin (acetanilide) and phenacetine. The antipyretic action of the former is the more marked, and the analgesic action of the latter. Antifebrin may be given in doses of from two to five grains, and phenacetine in doses of from five to ten grains.

The Poison of Typhoid Fever.—That typhoid fever is a specific disease, propagated by a specific poison, is scarcely questioned to-day. That Eberth's bacillus is constantly present in some of the tissues and organs, and that its presence is in some way responsible for the disease is also pretty generally admitted by the most competent investigators. There are some, however, who, though recognizing its accompaniment of the disease, are unable, from the anatomical point of view, to accept it as a cause of the conditions found. Its pathogenic power may depend upon the formation and absorption of toxic substances resulting from its life processes (ptomaïnes ?) rather than upon the multiplication of the bacillus in the tissues of its victim. Eberth first described this bacillus in 1880, and demonstrated its presence in the spleen and diseased intestinal glands of typhoid cadavers. Gaffky (1884) first obtained pure cultures and determined its principal biological characters.

It is a short, thick rod, three times as long as broad; 3 μ in length, 0.5 to 1 μ broad; about one-third as long as the diameter of a red blood-cell; it has round extremities where spherical or oval refractive granules are often seen, which have been regarded by some as spores and by others as vacuoles. It stains with the aniline colors, but more slowly than many other bacteria, and easily parts with its color when treated with decolorizing agents. The mode of growth on boiled potatoes, as a nearly invisible pellicle, is its most marked culture characteristic, though Babes, Pfuhl, and other bacteriologists, affirm that many bacilli resemble the typhoid bacillus in their growth upon potatoes. It is certainly not easily differentiated from other bacilli (water bacilli) and especially from the bacillus coli communis, and its detection in water is for this, as well as for other reasons, very difficult. Theobald Smith claims (Centralblatt f. Bakteriol., Bd. xii., p. 357) that it may be differentiated from other similar bacilli by the fact that it does not produce gas in culture media containing sugar.

Sternberg found the thermal death-point to be 56° C., and the time of exposure ten minutes.

In his address before the International Medical Congress at Berlin, in August, 1890, Koch made the following statement: A very characteristic example of the difficulty with which the determination of a (bacterial) species is surrounded is exhibited by the bacillus of typhoid fever. If this be found in the glands of the mesentery, in the spleen, or in the liver of a typhoid victim, there can be no question but that we are dealing with the real typhoid bacilli, since no other bacteria have hitherto been found in these regions which could be confounded with these. But when we are dealing with the determination of typhoid bacilli in the contents of the intestine, in soil, in water, or in dust, the circumstances are very different. In such places there are found numerous bacilli similar to those of typhoid which only a very skilful bacteriologist, and even then not with absolute certainty, can distinguish from the typhoid bacillus, since unmistakable and constant characteristics of the latter are, as yet, wanting.

The statements repeatedly made of late that typhoid bacilli have been detected in soil, in water-supplies, or in foods, can, therefore, be accepted only with a reasonable doubt. Babes, while denying that the special single characteristics previously laid down are trustworthy, still thinks that, by taking them altogether, one obtains a very reliable picture of this bacillus.[15]

Sedgwick, from a very careful study of an epidemic in Lowell and Lawrence, Mass., 1890 to 1891, thinks the history indicates that the living and active bacillus can be carried nine miles in river water, and under favorable conditions an even greater distance.[16]

In man it is found most constantly and most numerously in the intestinal contents, in the intestinal and mesenteric lymph glands and nodes, and in the spleen, where it occurs in larger and smaller masses and clusters as scattered colonies. It may be found, though less constantly, in the liver, kidney, and lungs. It occurs in the urine. Statements as to its presence in the blood are contradictory.

Veterinarians do not recognize any disease in animals corresponding to typhoid fever in man. Inoculations of the bacillus into some of the lower animals have caused death with symptoms and lesions which have been re-

garded by some experimenters as resembling those of typhoid fever in man; but there is no consensus of opinion on this point, inoculations with other micro-organisms do produce similar effects, and the evidence is by no means satisfactory.

Nevertheless, the presence of Eberth's bacillus in a *considerable proportion* of cases examined, according to some bacteriologists; its *constant* presence, according to others, in all cases of typhoid fever; the failure to find it hitherto in other diseases; its compliance with many conditions requisite for the "germ" of a disease with the known history, mode of propagation, and life of typhoid; the failure hitherto to establish any probable rival, all tend to support the acceptance of the etiological relation of this bacillus to this disease. Delafield and Prudden consider that the evidence that typhoid fever in man is produced by the "typhoid bacillus," and by this alone, is so strong as practically to amount to a demonstration.

Disinfection and Disinfectants.—The following is substantially the method in use at the Boston City Hospital. The disinfectants used will doubtless vary from time to time, according to the views held as to their action upon the typhoid poison.

1. In all cases of typhoid fever rubber sheets are to be used on mattresses.

2. Bed and body linen are to be changed daily. Bed-spreads, blankets, and rubber sheets are to be removed at once, when soiled by the patient. Avoid shaking any of these articles.

3. All bed-linen, body clothes, and bath towels, soiled by discharges, are to be immediately wrapped in a sheet wet with a solution of corrosive sublimate (1 to 1,000), or carbolic acid (1 to 20), and removed to the rinse-house as soon as possible, where they should be soaked in the disinfectant solution and then boiled before being washed. Rubber sheets are to be thoroughly washed in a solution of corrosive sublimate (1 to 1,000), rinsed with water, dried, and aired for six hours. Bed-spreads and blankets are to be aired as frequently as possible.

4. Feeding utensils are to be thoroughly cleansed with boiling water immediately after using.

5. Dejections are to be received in a bed-pan containing four to eight ounces of disinfectant solution (chloride of lime, 1 to 32) or milk of lime. The nates are to be cleansed with paper, and afterward with a bit of compress cloth wet with the disinfectant solution largely diluted. Milk of lime may be prepared by sprinkling one quart of water gradually upon a quart of quick-lime in broken pieces in a metallic or wooden vessel. When the lime is reduced to powder, three quarts of water should be added, and the whole kept in a covered vessel. Chloride of lime should be fresh.

6. Bed-pans are to be at once removed, being covered with a rubber cover, and taken to the slop-hopper. Add half a pint of disinfectant solution, in divided portions, to the contents of the bed-pan, mix thoroughly by shaking or breaking up solid particles, and throw the liquid into the slop-hopper, which must be previously flushed with running water. The bed-pan, rubber cover, and slop-hopper are to be cleansed with disinfectant solution, and the bed-pan and cover wiped dry. The compress cloth should be burned at once.

7. After the discharge of the patient, mattresses and pillows are to be thoroughly beaten and aired in the open air. The bedstead is to be washed with a solution of carbolic acid (1 to 20).

8. The body of any patient dying of typhoid fever is to be washed in the disinfectant solution, largely diluted, and then wrapped in a shroud-sheet wet with solution of corrosive sublimate (1 to 1,000). *George B. Shattuck.*

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[12] Ibid., cxxvi., p. 329, etc.
[13] Archiv f. Klin. Med., 1889-90.
[14] The Treatment of Typhoid Fever. By James Barr, M.D. London, H. K. Lewis, 1892.
[15] Zeitschr. f. Hygiene, Band ix., 323.
[16] Boston Medical and Surgical Journal, vol. cxxiv., p. 429.

TYPHOID FEVER IN CHILDREN. Frequency.—Typhoid fever occurs frequently in children between the ages of five and fifteen. In those between two and five years cases are rare, and in those below two years extremely rare. Murchison[1] gives a list of the few recorded instances in the fœtus and new-born. Northrup[2] has questioned the existence of the fever in children under two years, pointing out that "swollen Peyer's, mesenteric lymph nodes, and spleen in such cases, cannot safely be interpreted like similar lesions in adults." His reasons are that he has found not infrequently, at autopsies of infants under two years, these appearances following many different intestinal diseases, and that in a number of such instances bacteriological investigation has been made, and in no case has the bacillus of Eberth been found. Neuhauss,[3] however, has found this bacillus in the organs of a four months fœtus, and many pædiatrists have seen cases under two years of age with a history of exposure, a characteristic temperature curve, rose spots, and an enlarged spleen.

Pathological Anatomy.—In children the Peyer's patches and solitary follicles become enlarged, and then frequently undergo immediate resolution without ulceration. In many cases, however, there is some superficial necrosis and sloughing, but the resulting ulcers, as a rule, heal promptly. Rarely is an ulcer deep, and very rarely is there perforation. The spleen is usually, but not invariably, enlarged.

Symptomatology.—In children above ten years the disease tends to take on the adult type. Below that age the course is usually shorter and less marked by severe symptoms, and the prognosis is, as a rule, better.

Prodromal Period. — There may or may not be a prodromal period characterized by fatigue in the daytime, restlessness at night, frequent frontal headache, and no appetite. Prodromal symptoms of any sort are usually absent in the very young, but in older children they continue from a few days to two weeks. The exact beginning of the fever is usually doubtful, and the more doubtful the younger the patient. Sometimes the onset is marked by a chill or by chilly sensations, sometimes by an attack of vomiting. Rarely is there an abrupt rise in temperature. Oftenest there is a gradual rise extending over several days.

Temperature.—The rise of the first few days is more rapid than in adult life, for though the ascent is made in the same way with morning remissions and evening exacerbations, the remissions are less and the exacerbations greater, so that not infrequently a temperature of 104° F. is reached by the evening of the fourth day. This fever is subject to daily remissions of one to three degrees, but continues high for sometimes ten days or longer, and then subsides by lysis, which, like the ascent, is usually much more rapid than in adults. The fall usually takes from two to five days, but there may rarely be a crisis. The fever may subside immediately after reaching its height, so that the normal temperature is regained in two weeks or even less. Remissions and exacerbations are most marked in infantile typhoid, and cases are recorded in which the morning temperature throughout the course rose scarcely above normal, while the evening temperature was 102° to 103° F. Cases are seen, too, in which the temperature during the entire course does not rise above 102° F., though the usual maximum temperature is from 103.5° to 104.5° F. A double daily temperature curve, with the exacerbations at about 4 P.M. and 9 P.M., has been frequently noted, and is considered by Jacobi[4] of diagnostic importance.

Circulation.—Some weakening of the first sound of the heart is common in the second week, but cardiac murmurs are rare, though a faint systolic apex murmur

is occasionally developed during the fever only to disappear during convalescence. The pulse in a general way corresponds to the temperature, and averages between 110 and 130, the younger children having, of course, the higher rate. Exceptions are, however, not uncommon. The rate may be moderate, 90 to 100, with a temperature of 103° F., and Henoch[5] has seen it 180 in a case which recovered. A dicrotic pulse is rarely met; an irregular and scarcely perceptible pulse is not uncommon.

Epistaxis occurs, as with adults, frequently enough to be of value in the diagnosis. It appears usually in the latter half of the first week.

Respiratory System.—The respiratory rate is accelerated with the fever, and there is in considerably more than half the cases a cough. Even when the cough is not present, examination of the bases of the lungs behind will after a few days usually show numerous dry and moist râles.

Broncho-pneumonia is common in weak, poorly-nourished children, and may be developed in stout children if the fever is severe. Lobar pneumonia and pleurisy occur, but are rare.

Digestive System.—The tongue is commonly clean and red at the edges and tip, and has a moist, yellowish-white coat over the dorsum; sometimes there are superficial ulcerations on the surface. The tremor of the tongue which is so characteristic in adults is less frequently met in children. Sordes is uncommon, but the lips are frequently cracked and crusted.

Vomiting is a common, early symptom, but is not severe and rarely persists into the second week. There may be diarrhœa or constipation, and either may persist throughout the disease or be present at any period. It is rare, however, for diarrhœa to be entirely absent. It may be noted simply as slight looseness of the bowels, and it may be shown in fifteen or twenty stools in the twenty-four hours. The stools may be foamy, brown, and offensive, or simply yellow and thin, or absolutely normal in appearance. Typical "pea soup" stools are the exception.

The abdomen is usually very slightly prominent and tympanitic. Sensitiveness localized in the ileo-cæcal region is not marked, and its detection in children is usually doubtful. Slight general abdominal sensitiveness is, however, common. Complaint of some abdominal pain is frequently met as an early symptom, and colicky pains, especially before a movement of the bowels, are not uncommon later. Melæna is rare, but Earle[6] has had a fatal case in a child twenty-two months old.

Spleen.—The spleen may be enlarged so that its tip goes to the edge of the ribs, or from half an inch to an inch beyond. It is palpable in a certain small percentage of cases, and may become so by the third or fourth day, though it is not usually so before the eighth day. Henoch[5] did not find the spleen palpable in half the cases in which a careful examination could be made. Determination of increased size by percussion is extremely difficult, and the result usually unreliable. There is often sensitiveness on pressure over the site of the spleen.

Nervous System.—Frontal headache is nearly constant in the prodromal period and during the first week. Delirium begins earlier than in adults, and slight "wandering" may appear even on the second night. Active violent delirium occurs more in older children, but is not rare. In mild cases, however, by day, the child often wants to sit up and to play, even when the temperature is considerably elevated. In severer cases the child becomes speedily apathetic and somnolent. Crying at night, grinding the teeth, twitching of the muscles of the face and of the wrists, stiffness of the posterior cervical muscles, may all be met in severe cases. Convulsions and coma occur, but are rare. Partial or complete deafness is frequently met during the fever, and may persist for weeks. Aphasia occurs more frequently than with adults, and appears commonly at the end of the fever or during convalescence. It may persist for a few days or a few weeks. Hyperæsthesia is common and unimportant. Involuntary evacuation of the bowels is rare, as is bladder retention, but both occur. Forgetfulness and silliness are apt to be noted for a considerable time during convalescence.

The Skin.—The roseola may or may not be present. If present its first appearance is earlier than in the adult, and may be noted between the fourth and tenth days. The eruption lasts about a week. The spots are not peculiar in children, but their number is usually less, two to ten often; still the crop has been so abundant as to be taken for measles.

Duration.—The duration varies greatly in different cases. Henoch in eighty children found periods varying from one week to seven. Three weeks is an average length for the fever, but if the case has been at all severe prostration is marked and convalescence is slow, frequently lasting four or five more weeks.

Relapses.—Relapses occur as with adults, and usually run a brief and mild course. The interval between the fever and the relapse varies from two or three days to a couple of weeks, and the relapse may last from one to three weeks.

Prognosis.—A larger percentage of children recover than of adults, but under two years the prognosis is grave. Convalescence is long and its period is marked by an increased liability to take other infectious diseases, and by persistent feebleness of the mental faculties. (West.[7])

Diagnosis.—The diagnosis is reached always by exclusion, but the symptoms which are most important for a conclusion are: 1, characteristic fever; 2, gastro-intestinal disturbance; 3, bronchitis; 4, roseola; 5, headache; 6, characteristic tongue.

To be excluded are: pneumonia, gastro-enteritis, influenza, pyæmia, chronic tuberculosis, acute tuberculosis, tubercular meningitis, and malaria. Careful repeated examinations of the chest will decide the question of pneumonia, and examination of the blood will do the same for malaria. Pyæmia is usually secondary to bone disease, and the variations in temperature are more irregular and extreme than with typhoid. Chronic tuberculosis shows marked changes in the lungs, and the temperature is pyæmic. Influenza has the history of an epidemic, and a short course. Tubercular meningitis has more severe and persistent vomiting, an abdomen that is not prominent, a lower temperature and slower pulse, and a delirium which appears later in the course. Acute tuberculosis may present identical symptoms with typhoid without the roseola. Gastro-enteritis also may simulate typhoid so closely as to be indistinguishable from it; here the presence of other cases of typhoid is of decisive importance.

Treatment.—The essentials of treatment are: 1, rest in bed; 2, liquid diet; 3, alcohol when necessary; 4, antipyretic treatment when necessary; prophylactic and symptomatic treatment are also to be considered.

1. Rest should be as complete as possible throughout the fever, and for at least ten days after the evening temperature has reached normal. Absolute confinement to bed with use of the bed-pan cannot of course be enforced with the youngest children.

2. The diet should be liquid, but may well be varied; milk always diluted with seltzer or lime-water, beef-tea, liquid peptonoids, egg-water, kumyss, matzoön, strained mutton, chicken, and oyster broths, are all useful in delicate children, and it is essential to have a nurse who can coax the child to take sufficient food when he rebels against everything. The amount and character of the nourishment should be rigidly prescribed, and the amount taken carefully noted. Liquid diet should be continued a week after the fever has departed, and as with adults the return to solid food be most gradual and guarded.

3. Alcohol should not be given till required, and the time of beginning need is probably best determined by a constant watch over the heart; any weakening of the first sound should be met by small amounts of wine, milk punch, or wine whey, and alcohol in some form is usually necessary during the second week. Marked nervous symptoms, as tremor, delirium, and stupor, also call for alcohol. The amount necessary varies usually from an ounce and a half of such wine as sherry, to four or six ounces of brandy, in the twenty-four hours.

4. Antipyretic treatment includes the use of water and drugs. Water may be applied as tub-baths, packs, sponge-baths, compresses, and cold enemata. Frequent tub-baths are not usually borne well by children ; collapse is more frequent with them than with adults. When they are used the temperature at the start should be 100° F., and he gradually lowered to 80° F. The bath should not last longer than ten minutes, and had best not be given oftener than twice daily. Sponge-baths and packs, however, may be given somewhat more frequently, and are distinctly helpful in quieting the child and making it comfortable. Iced-water bags, compresses, and enemata of three or four ounces, are comforting but not especially useful to lower temperature. Of drugs, quinine in large doses, sodium salicylate, antipyrine, acetanilide, thallin, and phenacetine are all recommended, and phenacetine in particular is widely approved as safe and reasonably efficient. It may be given in two- or three-grain doses to a six-year-old child.

Safety for others demands that in all dirrrhœal diseases the stools, diapers, and bed clothing stained by dejecta should be subjected to antiseptic treatment. Chloride of lime and carbolic solutions are customarily employed to disinfect stools, and clothing is boiled. The buttocks and anal region should also be regularly cleaned with an antiseptic solution.

For restlessness and insomnia, chloral hydrate, one-half to two grains, is usually efficient. Constipation should be avoided by glycerine enemata or suppositories. Diarrhœa may be checked by starch and opium enemata or by Dover's powder by the mouth. Headache may be relieved by local applications or by small doses of phenacetine. Griping pains may be met by the administration of hyoscyamine in quarter-milligram doses (Chauteaud granules). Otorrhœa may often be avoided by keeping the naso-pharynx well cleansed. A belly band forms a useful part of the treatment. *John H. Huddleston.*

[1] Murchison : The Continued Fevers of Great Britain.
[2] Northrup : Trans. Am. Pædiat. Soc., iv. to 109.
[3] Neuhauss : Berl. klin. Wochenschr., 1886, s. 389.
[4] Jacobi : Archives of Pædiatries, ii., 128.
[5] Henoch : Vorlesungen über Kinderkrankheiten.
[6] Earle : Trans. Am. Pædiat. Soc., iv. 112.
[7] West : Diseases of Infancy and Childhood.

TYPHUS FEVER. Typhus fever is not indigenous to the United States, and the few epidemics of which we have record are all directly traceable to importation from Europe. The reports of Dr. R. Robertson, a surgeon in the English navy during the War of the Revolution, show that, in 1776, the fever prevailed among the British and American sailors in the naval hospitals at New York and Newport, but it apparently never spread to the townspeople nor to the armies operating on shore. Nathan Smith, writing in 1824, states that he saw "typhous" fever as early as 1787, in New Hampshire ; but it is evident from his description that it was typhoid fever, and not typhus fever as now recognized.

The first well-authenticated outbreak of the disease was in the year 1807, at Hartford, and two or three other points in New England. The fever was epidemic in Philadelphia in 1812, and again in 1836. It was in the latter year that Gerhard made the observations which have had a large share in establishing a correct idea of the disease. The first considerable epidemic in New York was in 1847, following the Irish famine of that year. In 1861 the disease was again introduced here by Irish immigrants, and did not finally disappear until three years had elapsed. Since that time it has been twice mildly epidemic in this city—in 1881, and again in February of the present year. In all these cases the fever was brought to this country by immigrants from regions where it is endemic. It is an interesting fact that the disease has never become endemic here, but has always disappeared when suitable hygienic measures have been brought to bear upon it. It is believed to be always present in Ireland, Russia, Poland, and Bohemia. This endemicity has been attributed to certain characteristics of the races in those countries, which serve to perpetuate the germ. But we have many thousands of those races here, and yet the disease never breaks out among them spontaneously, nor do they show an especial susceptibility to the imported contagion. In the recent epidemic, indeed, the mortality was much heavier among the Americans who acquired the disease than among the Russian Hebrews who brought it with them. The fact that typhus fever was not introduced into America until comparatively recent years, has probably much to do with our exemption from its ravages. Had the immigrants of the last century been infected with the disease, it might well have obtained a firm foothold among us. But modern sanitation has taught us how to fight such diseases, and it now requires but a comparatively short time to get them under control, provided they are recognized before they have spread too widely.

I have given the above brief historical sketch of typhus fever in this country, as Dr. Chapin did not deal with this aspect of the subject in his article in Volume II. of the REFERENCE HANDBOOK. Dr. Chapin wrote in 1887, and his accurate and thorough description of the disease calls for no modification except in the one point of etiology. During the past five years several important studies of the etiology of typhus fever have been made by different observers. Llava,[1] in Bohemia ; Thoinot[2] and Calmette, in France ; Lewaschew,[3] in Russia ; and Cheesman,[4] in this country, have made careful and extended bacteriological investigations of the disease. These researches were carried on independently of each other, and the results, though not contradictory, are in no sense confirmatory of each other. Each observer made a morphological and biological study of the blood of the cases under his observation.

One or more organisms were found by all, but, as intimated above, these organisms were not the same in all cases. In spite of this lack of harmony in their results, it seems well to make somewhat extended mention of their experiments, as they represent the first efforts made in the way of the bacteriological study of typhus fever.

Llava, in the course of an epidemic of typhus fever in Prague, in 1888, examined the blood and viscera of thirty-three cadavers, as well as the blood of ten cases during life. A bacillus was isolated from the blood of twenty of the cases which had died, and from two of the living patients. This bacillus differed from any known form. Llava described it as an ovoid coccus or a very short bacillus, growing in pairs and in chains. From the latter growth-character, he termed it a strepto-bacillus. Its diameter varied from 0.9 μ to 1.2 μ, its length was about 1.8 μ, while the terminal individuals of the chains grew to the length of 2 to 3 μ. It developed rapidly in broth at a temperature of 37° C., forming chains, and was without visible spores. Platings and sowings were made in glycerine, agar, potato, gelatine, human blood-serum, and human and veal broth. No growth was obtained in gelatine or potato. Plated in agar, the colonies were circular or oval, lace-like, and whitish, with an opaque centre and transparent edges. The diameter of the largest colonies did not exceed 2 mm., and when magnified about one hundred diameters they appeared granular and showed very fine threads on their borders. The growth on human blood-serum presented the same characters. Human and veal broth showed a rapid growth, which settled in the form of a white precipitate, while the fluid above remained clear. The bacilli died in eight days in broth, and in twelve to fourteen days in agar. They stained with all the aniline dyes and by Gram's method. Culture inoculations of the strepto-bacillus were made in rabbits, guinea-pigs, dogs, cats, mice, and pigeons, with negative results. Inoculations in two young pigs gave more positive symptoms. In one case the temperature rose to 41.4° C. on the eighth day, and for sixteen days remained above 39° C. On the fifth day small reddish spots appeared on the skin, and disappeared after three days. In the other case no spots appeared. Loss of appetite and emaciation were marked in both cases. The animals were killed, and on autopsy showed degeneration of the kidneys and enlargement of the spleen. The

bacilli were not found in the blood or spleen, but were found in the kidneys of one case, and in an area of broncho-pneumonia in the injected lung of the other. Virulence of the cultures for young pigs was lost after a short time.

Thoinot and Calmette made a microscopical and bacteriological study of the blood of six cases of typhus fever during an epidemic of the disease on the Island of Tudy, in the spring of 1891. Five of the cases were under observation during life. In the sixth case the blood was taken from the heart and spleen about three hours after death. Platings and sowings were made from the blood of all these cases, but no growth was obtained. Inoculations were also made in rabbits, guinea-pigs, and pigeons, with negative results. The only positive results were obtained by the microscopic examination of the blood soon after it was taken from the body. The blood obtained by spleen puncture during life, and from the heart and spleen after death, gave the same results in all cases, namely, marked leucocytosis and the constant presence of small refracting granules, 1 to 2 μ in diameter, usually provided with short, thread-like prolongations. Sometimes the prolongations or filaments terminated in a little swelling. These minute organisms were in constant rapid movement among the blood-cells. After twelve to twenty-four hours, the granules were no longer seen, but only the long filaments. After forty-eight hours, neither granules nor filaments were to be seen. Thoinot and Calmette consider these organisms as specific elements, though they resemble forms seen in various other diseases, such as relapsing fever, pneumonia, typhoid fever, diphtheria, and erysipelas.

Lewaschew had opportunity, during the winter of 1891–1892, to observe many cases of typhus fever in Casan, Russia. He took the blood from the finger and spleen during life, and studied it microscopically and bacteriologically. In the fresh blood he found peculiar small, round, strongly refracting bodies which were constantly in active movement. The longer the blood had left the body, the slower became the movements, until finally they stopped entirely. Sometimes these bodies were completely black and filled with minute granules of black pigment, probably—in Lewaschew's opinion—blood-coloring matter. On careful study, it appeared that these bodies were provided with slender, thread-like prolongations, the latter also in constant motion. These thread-like bodies were also seen detached from the round bodies. Lewaschew considers that the cocci, the cocci with thread-like attachments, and the free motile threads, are all forms of the same micro-organism. The number of these minute organisms varied greatly. Few in number at the beginning of the disease, they increased rapidly during its farther development, and diminished as the temperature declined. These organisms were not so numerous in the finger-blood as in that obtained by spleen puncture, nor were they so constantly present. Lewaschew also obtained positive results from his cultures of typhus blood. As typhus fever does not develop in animals, he decided to use human serum for his culture medium. He made use of the fluid of ascites taken from several patients. Characteristic cultures were obtained in from twenty-four to forty-eight hours, at a temperature of 36° to 37° C. They remained sterile at room temperature. The growth was most rapid in one per cent. serum agar, very poor in one and a half per cent.

The cultures showed at the place of puncture a small grayish-white cloud, which at first was usually half transparent. The shape was sometimes round, of the size of a small hazel-nut; in other cases of the same size, but cylindrical in shape. This size was attained in the first days after sowing, there being no increase later. The cultures only grew in the lower part of the agar, and never in the upper layers. Cultures were obtained both from finger and spleen blood. The microscope showed the colonies to be composed of a pure culture of minute cocci of the size of 2 to 5 μ. The cocci were generally separate, occasionally in pairs, and still more seldom in small chains. They were usually in active motion. Some were seen to have slender prolongations, with a length equal to six or eight times the diameter of the cocci. These thread-like tails were also in constant motion, resembling the spirillum of relapsing fever. The cocci are held by Lewaschew to be a specific micro-organism, micrococcus exanthematicus, or coccospirillum when provided with tail resembling the spirillum. The bacteriological findings thus confirmed the results of direct examination of the blood. In the latter a magnifying power of from 1,000 to 2,500 diameters was used. The cocci were present in the blood from the beginning of the disease until shortly before the end. They sometimes changed during the course of disease, the body of the coccus becoming larger and the thread-like attachments thickened, so as to be evident to the eye under a lower power. Sometimes the prolongations lost their even, regular shape, and showed one or more thickenings at different points, some even as large as the coccus itself. The movements were still energetic in all directions. If the blood is observed for several hours, the movements of the prolongations gradually cease, and it finally falls into granules. It is difficult to identify the tail in dry, stained preparations, as it is so delicate in structure.

Cheesman's investigations were made during the recent outbreak of typhus fever in New York City. He made a morphological and biological study of the viscera from three cadavers, and of the blood obtained by finger-puncture from six living patients, during the height of the disease. Platings and sowings were made from the viscera of the three cadavers, but with negative results. The platings were made on beef blood-serum and on six per cent. glycerine agar, in Petri dishes, and in Blücher's anaërobic plates. The sowings were in beef blood-serum, both fluid and coagulated, in sealed and unsealed tubes; in beef-broth and glycerine agar tubes; by deep puncture in alkaline agar tubes, and in Nikiforoff's anaërobic tubes, charged with six per cent. glycerine beef-broth. All of these cultures were kept at 37.5° C., and were studied daily for sixteen days, many of the tubes for a much longer period. In no case was there any growth, except some scattering later contaminations on the plates. Sections of the spleen, liver, and kidney from these cases were stained by Gram's method, and examined under a one-sixteenth oil immersion lens for any micro-organism which might be present, but none were found. The blood, obtained by finger-puncture under the usual antiseptic precautions from the six living patients, was streaked on six per cent. glycerine agar plates and smeared on sterilized cover-glasses. The cover-glass preparations were dried in the air, fixed in alcohol, and stained in Czenzynski's solution for eighteen hours, at room temperature. Careful examination with the immersion-lens showed a few blue-stained bacilli on about one-half of the cover-glasses, never more than eight or ten on a cover. In length they were usually about one-sixth of the diameter of a red blood-cell. They were round-ended, and were usually found singly, lying apart from the blood-cells, but in a few cases groups of from three to six bacilli were seen. The platings, made from the blood of six patients, were kept at 37.5° C., and showed a growth of colonies in from two to four days. The number of colonies varied on the different plates, from sixty or seventy in one case to a single colony in another case. These colonies, though thus varying in numbers in all of the six cases, presented the same general appearance. Cover-glass preparations showed that the colonies were formed of small bacilli, and subsequent morphological and biological study proved them to be identical in all the different cases. The diameter of the bacillus varied from 0.5 μ to 0.8 μ, and the length from 1.0 μ to 2.5 μ. It occurred singly and in pairs, rarely in chains of six or eight. It was often club-shaped, and was found to be ovoidal in young cultures. It stained readily with the ordinary aniline dyes, and retained the color after staining by Gram's method. Under the most favorable circumstances growth was not voluminous. The most abundant growth obtained was on beef blood-serum at 37.5° C. The colonies growing on

six per cent, glycerine agar plates presented to the naked eye, in about eighteen hours, in oblique light, a scanty growth, consisting of minute bluish-gray translucent spots. Older colonies appeared dry and scaly to the naked eye, were flat, whiter, and more opaque, and never exceeded 2 mm. in diameter. When examined under a hand magnifying-glass, they showed a central thickening. When magnified about 100 diameters, the surface appeared coarsely granular and the edge was formed of short, coarse, irregular spiculæ. Glycerine agar tubes at 37.5° C., showed the same surface growth appearances as the plates. In the line of puncture small, white, isolated colonies occurred, and in the condensation water there was a white deposit, quite perceptible in twenty-four hours, the fluid above remaining clear. On coagulated beef blood-serum, at 37.5° C., the growth is slightly elevated, white, and shiny. In beef broth the growth is slight, and settles in the form of a white precipitate, the fluid above remaining clear. In milk the growth appears as a white deposit; the milk itself undergoes no apparent change. No visible growth was obtained on potato or on macaroni. Inoculations of broth-culture were made in eight rabbits, two guinea-pigs, and two white mice. All the animals showed marked emaciation, and with the exception of two rabbits, all the animals experimented upon died in fourteen to twenty-nine days. The inoculated bacillus was recovered from the heart's-blood of two of the rabbits that died. The bacillus found by Cheesman bears considerable resemblance biologically to the "strepto-bacillus" of Llava; morphologically it differs, being somewhat smaller and showing but very slight tendency to the formation of chains. A striking difference is also shown in the effect of its inoculation in animals. Cheesman himself does not believe this bacillus, for which he suggests the name of bacillus sanguinis typhi, to be identical with the strepto-bacillus described by Llava. Cheesman concludes his paper as follows: "The fact of finding a new species of bacillus in the blood of six consecutive patients, with uncomplicated typhus fever, in the height of the disease, seems significant, and is suggestive of an etiological relationship of the bacillus found to the disease. This relationship cannot be determined by a single limited research. The proof must be furnished by an accumulation of evidence, either along lines such as have been pursued in this investigation, or in directions which may present themselves as our knowledge increases."

John Winters Brannan.

[1] Archives Bohèmes de Médecine, 1889-90, vol. iii., p. 122 (Sborink Lekârsky).
[2] Annales de l'Institut Pasteur, tome vi., No. 1, January, 1892.
[3] Deutsche med. Wochenschr., Bd. 18, No. 13, p. 279, 1892.
[4] The Medical Record, New York, June 25, 1892.

ULCERS. The treatment of ulcers has been somewhat altered by the topical use of the newly introduced chemicals and by newly suggested or revived methods of dressing. Of the more recently introduced antiseptics we must mention peroxide of hydrogen, the aniline dyes (pyoktanin, methyl-violet, malachite-green, etc.), and aristol. Peroxide of hydrogen is especially indicated in foul sloughing sores, and should be applied in full strength directly to the surface of the ulcer until effervescence ceases, when one of the ordinary wet dressings can be applied. The aniline dyes are employed in tolerably strong (ten per cent.) solutions, or a gauze prepared with them may be used. They are good absorbents, and appear to exercise a certain astringent and perhaps stimulating effect upon the ulcer. Aristol is antiseptic and stimulating, but its cost will prevent its common use.

Dermatol is another newly introduced chemical, said to be a sub-gallate of bismuth. It has been recommended as an odorless substitute for iodoform, but its antiseptic qualities are of the feeblest. It is, however, an excellent astringent application for ulcers when used in the form of a powder, and will cure many which resist other applications. Strict antiseptic precautions should be observed in treating ulcers with it, as the writer has known of a case in which erysipelas developed in a granulating surface dressed daily with this powder.

Massage has been successfully employed in the treatment of ulcers of the chronic variety, and is an excellent adjuvant to other methods of treatment, as it disposes of the œdema and thickening and induration about the ulcers, and so places them in a condition more favorable for healing. But before massage can be used, the ulcer and its surroundings must first be made perfectly aseptic by thorough cleansing, and shaving if necessary, followed by the continuous application of antiseptic dressings for some days beforehand, otherwise septic infection of the glands and even of the entire system might follow. When asepsis has been secured the surroundings of the ulcer are massaged, using lanolin as the emollient, and beginning with very light strokes—"effleurage" (Appenrodt, *Wiener med. Wochenschr.*, 1888, p. 1010; and *Deutsche med. Wochenschr.*, 1888, p. 478). Even the surface of the ulcer can be subjected to the massage by protecting it with a few layers of gauze and operating through them, thus reaching the induration so frequently found at the base of the sore.

As early as Sir Everard Home's time (1797) lead plates were applied to the surfaces of ulcers, and a recent revival of the idea is seen in the use of tin plates, as suggested by Moras (*Medical News*, Philadelphia, 1890, lvii., p. 626) and others. A piece of ordinary sheet-tin is cut to fit the shape of the ulcer and large enough to project one-quarter of an inch beyond it on all sides, and the edges are turned back a little so as not to cut into the skin. The tin plate is then covered on the side next to the ulcer with rubber tissue, and secured upon the sore by strips of adhesive plaster, so as to make firm and even pressure. An absorbent dressing of gauze, or of gauze and cotton, is applied over this with a bandage. The parts should be thoroughly cleansed before applying the tin, and the outer dressing must be changed frequently if the discharge is profuse. As the ulcer heals, the plate should be cut smaller. Good results have followed the use of this method in some cases upon which it was tried under the observation of the writer.

The principles of asepsis and occlusion are followed in a method of dressing ulcers recently highly recommended by Morton (*Times and Register*, Philadelphia, 1892, xxiv., p. 672), and resembling that advocated by the writer in the main work, but he does not lay sufficient stress upon infrequent dressing—that is, rest for the sore. In a dressing made with Unna's oxide of zinc gelatine, reported by Heidenhain, the idea of rest and occlusion is well carried out (*Berliner klin. Wochenschr.*, 1892, p. 323). The leg is given a very thorough washing with soft soap for twenty or thirty minutes and is then well scrubbed, even over the ulcer and any eczematous spots which may be present, with a 1 to 1,000 bichloride of mercury solution. Iodoform, dermatol, or any other topical application is applied to the surface of the ulcer, and then the entire leg is painted with the oxide of zinc gelatine, rendered fluid by standing the pot containing it in warm water, and applied with a stiff brush. A starched (crinoline) bandage is then applied smoothly over this layer from the toes to the knee, and is in turn painted until four layers of gelatine and starched bandage have thus been laid on alternately. An ordinary bandage is applied outside of all, and in fifteen minutes the patient can be allowed to walk. The dressing is changed twice a week at first, later only once, and finally it can be worn for five or six weeks without renewal.

It is important to emphasize the fact that when skin-grafting has been employed for chronic ulcers of the leg, prolonged and careful after-treatment is necessary, else the poor circulation in the extremity will cause the new skin to fail, and disappointment will result. Various observers have reported as many as fifty per cent. of failures in these cases. To avoid such poor results, stringent precautions are necessary, and Urban thus describes the preparatory and after-treatment of these cases in Thiersch's own clinic (*Deutsche Zeitschrift für Chirurgie*, xxxiv., p. 187): "Whoever wishes to undertake successfully the healing of large ulcers of the leg must,

in order to be sure of his ground, demand in the first instance a course of treatment lasting from three to four months, that is, six to eight weeks for the preparation of the ulcer, and the same time for healing after transplantation. During the entire time the patient remains in bed. . . . The patient receives a warm bath for the leg twice daily, from the beginning of treatment. The dressing is a compressive dressing with a non-irritating fluid, generally Thiersch solution (Ac. salicyl., 1 ; ac. boric., 6 ; aquæ, 300 parts). . . . When the surface has become clean, and all sloughs have separated, and the granulations are growing in a healthy manner, the latter are cauterized twice a week with nitrate of silver. The rest of the treatment remains the same—a bath and compressive dressing applied twice a day. This treatment is continued until all signs of inflammation have disappeared from the surroundings of the ulcer, cicatrization is proceeding on the edges, and the granulations are firm and secrete little pus. Finally the surgeon may attempt to reduce the thick cicatricial infiltration in the neighborhood by gentle massage or by the use of the rubber bandage. After this preparatory treatment has lasted six to eight weeks, according to circumstances, the skin-transplantation is carried out strictly according to rule. . . . Reckoning from the day of skin-transplantation, the patient must submit to at least six weeks of continuous rest in bed. While the patient may be allowed to get up to go to stool during the preparatory period, the stools must now be had with the aid of the bed-pan, lying down. . . . After four weeks he may be lifted into the bath, but standing up, or the assumption of the erect position in any way, must be carefully avoided. . . . Six weeks after the operation the patient is allowed out of bed for the first time. A flannel bandage is firmly and carefully applied beforehand, from the toes to the middle of the thigh. From that day on, he spends a little longer time out of bed every day, and in a few days begins to walk. . . . Even for small ulcers of the leg due to varicose veins, the patients must under no circumstances leave the bed before four weeks after the operation. After completing the course of treatment, the patients are directed to bandage the leg properly every morning for some months.

Keating (*Lancet*, 1890, i., 231) has described a method of amputation for cases of ulcer, a very rare operation in modern surgery. He takes a flap from the sole or the dorsum of the foot, according to the situation of the ulcer, or even from both in ulcers surrounding the limb, and by using these flaps to cover the denuded surfaces a much longer stump can be obtained than by the ordinary methods. But we must refer to the original paper for details and diagrams explaining the technique.

B. Farquhar Curtis.

URAL. URALIUM. This drug is also known as chloral-urethane, and, as its name implies, is a compound of urethane and chloral. Chloral at ordinary temperatures, or melted chloral-hydrate, dissolves urethane ; this product, treated with hydrochloric acid and sulphuric acid, produces an oily liquid, which subsequently crystalizes and forms this new compound. It occurs as a white crystalline body, readily soluble in alcohol, but almost insoluble in water. It is decomposed by hot water.

Ural was introduced by Dr. Poppi, of Bologna, as a better hypnotic for neurotic patients and the insane than most of the drugs employed for this purpose. He considered it to be more active than urethane and more safe than chloral, and better borne by the stomach. It does not exert any action on the heart or influence blood-pressure. He had employed it in a large number of cases of insomnia, in inebriates, in phthisis, and in heart and nerve diseases, in doses of from thirty to forty-five grains, with an almost invariable good result.

In the hands of others it has not furnished such favorable results, and has not secured any position as an hypnotic remedy. Drs. Schmitt and Parisot, of Nancy, tested the drug in a variety of cases with very little satisfaction. They administered it in alcoholic solution, and found that the smallest dose capable of producing any effect was fifteen grains, but doses of even thirty-eight grains were by no means always successful. It also proved very disagreable to take and disturbed the digestion, sometimes causing vomiting, followed by nausea. In some cases vertigo was complained of. As a result of their researches they arrived at the following conclusions : 1. Ural, like chloral, is a soporific. 2. According to the dose employed, a profound sleep is produced, accompanied with anæsthesia, abolition of the reflexes, slowing of the respiration and pulse, depression of the temperature, and lowering of the arterial pressure. 3. Toxic doses produce death by respiratory failure, the heart being arrested in diastole. 4. Like chloral, it acts successively on the cerebrum, the medulla, and the spinal cord. 5. Ural has no advantage over chloral, and has the inconvenience of being insoluble in water.

Beaumont Small.

URETHANE. This hypnotic has not proved a very serviceable drug, and is gradually falling into disuse. Many observers, however, are very pleased with its action and place great reliance upon it in cases where the more powerful and active hypnotics cannot be employed. The chief objection to its use is the uncertainty of its action. In health it has no soporific effect, and, in the insomnia of disease and in mental disorders it very frequently fails to produce the desired effect, and, in many cases in which sleep has followed its administration, it has only lasted for a short time. A rapid tolerance of the drug has also been noticed. In numerous instances, where full doses have produced several hours of tranquil sleep, the continued use, even in larger doses, has failed to exert any hypnotic action. It is to be valued as a mild but very safe hypnotic in simple cases of insomnia in persons of a nervous temperament, and in cases of melancholia. It is also recommended as a very safe drug in the insomnia of cardiac troubles, particularly aortic insufficiency. In the diseases of children it is particularly suitable. The sleep which is produced by urethane is always pleasant and tranquil. The patient awakes without any confusion of ideas, dizziness, or headache. The only unfavorable effect produced by its employment is a derangement of the digestive organs, but in occasional and moderate doses this is not noticed to any extent.

The safety of urethane has led to combinations with chloral, which are supposed to be more efficient and safer than either of the component drugs when administered separately. See Somnal and Ural.

The dose of urethane must not be less than from thirty to sixty grains, which may be given in watery solutions flavored with peppermint, cinnamon, bitter orange, or any aromatic.

Beaumont Small.

UTERUS, CARCINOMA AND FIBROID TUMORS OF THE. I. Carcinoma.—Recent development in the pathology of carcinoma or cancer of the uterus makes it desirable to drop the names scirrhus, colloid, and medullary, as tending to confusion. They are neither scientific, nor distinctive. As adjectives descriptive of the appearance of a given specimen they might be convenient, but as generic terms they are inadmissible.

Cancer of the Body of the Uterus.—From a clinical as well as an anatomical standpoint, we may separate these cancers into corporeal and cervical.

Corporeal carcinoma is met with in two varieties : the glandular cancer, or adeno-carcinoma corporis ; and the cancer of the mucous membrane, or epithelioma corporis. Again, this latter variety may occur in a circumscribed and in a diffuse form.

The adeno-carcinoma is the development of cancer upon a glandular endometritis. By unlimited proliferation the columnar epithelial cells fill the glandular tubules instead of merely lining them, while the tubules themselves expand at the expense of the surrounding connective tissue. Some, becoming contorted, divide up, press against and communicate with neighboring ones, while others maintain the form of distended tubes. The cells are multi-nucleated, enlarged, and become compressed

into various shapes. From this time on, the changes are identical with the primary cancer of the mucous membrane.

Diffuse epithelioma of the corpus uteri is characterized by an exuberant development of villi over the whole mucous membrane. The glandular tubules are more or less filled with cells, while some are stopped up and form cavities containing also some mucus. The abundance and large size of these cells, and the scarcity of the surrounding stroma, give the growth a soft medullary character. Fat-cells, pigment, and granular detritus are also found. The uterus is softened, enlarged, and filled to the internal os, but not beyond it. In the later stages, however, the cervix becomes invaded, and nodules appear in the uterine walls and surrounding lymphatics. The diseased action respects no longer any barriers.

Circumscribed epithelioma of the corpus uteri exhibits about the same histological features as the variety just mentioned, but projects from only a limited portion of the endometrium. After a time the cancerous changes invade the uterine parenchyma, and progress with about equal rapidity in all directions, not hesitating to pass straight through to the serous surface.

Some authors claim that the disease may commence in the form of cancerous nodules, developed primarily in the connective tissue of the uterine walls, as occurs in the cervix.

The characteristics of all these growths, as of all cancers, consist in an exuberant atypical growth of epithelial cells within a fibrous stroma of small alveoli. This stroma contains the nutrient blood-vessels, until nutrition is cut off by the over-accumulation of cells, and necrosis results. Encapsulation never occurs. But all this does not establish the disease, unless coupled with the power of invading contiguous tissues.

For a time, corporeal epithelioma also respects the internal os, but finally invades the cervical walls, reaches the peritoneal surfaces, and causes agglutination and fixation of the uterus to the bladder, rectum, and upper bowels. The uterus does not always enlarge greatly, for necrosis and excavation take place, limiting the growth, and opening into the surrounding viscera. Thus a large cavity may be created, which is the common receptacle of urine, fæces, and the horribly fetid ichor and detritus which come from the cancer.

Etiology. — This disease would seem to be closely connected with degenerative changes in the uterus, such as attend the menopause. But few cases occur before forty, and the majority have been observed in women at and beyond fifty. Nullipara are not infrequently attacked. That endometritis remaining uncured at the change of life is more difficult of cure than earlier, is a significant fact.

Malignant disease of the uterine body occurring before the age of forty is usually found to be sarcoma. In young people, the tendency to the development of an excess of connective tissue in the diseased uterus may possibly be the factor determining toward sarcoma. However, there is still much to be learned and unlearned with regard to the malignant diseases. Whether a microbe is necessary to their development is an open question, and will probably so remain until inoculation experiments have been made upon diseased (not healthy) tissue. Negroes are said to suffer less from corporeal and cervical cancer than whites, but I have seen so many cases among negroes that I am led to doubt it.

The disease is not, strictly speaking, hereditary, although it is possible that a susceptibility to it may be.

Diagnosis.—The diagnosis of cancer of the body of the uterus, while easy in the advanced stages, is often exceedingly difficult at or near the onset of the disease. The enlarged and softened uterus, the repeated hæmorrhages between the menstrual periods (or after their cessation for months or years), the abundant ichorous and foul-smelling discharges, recurring pains of a cramping character in the lower abdomen, pelvic infiltration, and anæmia, all go to make up a constellation of symptoms easily recognized. If the finger can be pushed into the softened cervix, and the soft pultaceous or friable mass felt, the diagnosis, if not already certain, can be made so by microscopical examination of removed tissue.

A sloughing, intra-uterine fibroid, or one with a sloughing capsule, may present itself at the os and simulate cancer, but the chronicity of the symptoms of pain and hæmorrhage, and absence of infiltration of the uterine walls, together with the microscopical examination, will remove all doubt. These conditions are seldom found after the menopause, unless the symptoms of the disease have dated back to, or before, the menopause, while there is usually no continuity of the signs and symptoms of uterine cancer and those previously noticed during the menopause.

Before the disease has become so pronounced it may often be differentiated from chronic disease of the uterus and appendages, in old people, by the fact that the symptoms come on after a long period of immunity from pelvic disturbance. In cases of senile metrorrhagia, leucorrhœa, and pelvic pains, an almost uninterrupted connection between the former inflammation and the present symptoms may be traced. When old and long quiescent pelvic inflammatory disease assumes activity, anodynes, laxatives, fomentations, counter-irritation, and rest in bed, cause the inflammation to subside rapidly. A local examination will often discover more disease in the uterine appendages than in the uterus itself. Cancer of the uterus progresses steadily and rapidly, and is therefore never a very old affection.

Most important, however, is the diagnosis of the disease in its incipiency, when a radical cure is possible. Metrorrhagia, beginning many months or years after the menopause, usually indicates cancer, and always calls for a local examination. If no cause outside of the uterus be found, the uterus should be curetted and the removed particles examined. Usually there will be some enlargement or softening of the uterus, a musty or perhaps cadaverous odor, and some irregular projections from the endometrium as felt by the probe or penetrating finger.

In all cases of metrorrhagia in patients over forty years old, in whom this or other symptoms belonging to carcinoma rapidly assume an active character without discoverable cause, the uterus should be thoroughly curetted. The case should be carefully watched afterward, even if the microscopic examination prove negative. In old people the uterus has several times been taken out for the symptoms of persistent hæmorrhage after curetting, and the cancerous nature of the disease discovered then only.

The presence of large inguinal glands denotes an advanced stage of the disease; and if accompanied by deep-seated lumps in the iliac region with pain and lameness in the limb of the same side, indicates that a fatal termination is not far off. Uterine hæmorrhage and general weakness do not always allow the local disease to progress thus far. Infiltration of the pelvic connective tissue first occurs in the form of nodules in the broad ligaments in corporeal carcinoma, and in the sacro-uterine and bases of the broad ligaments in the cervical disease. They are detected by a rectal examination.

We should be on the lookout for early symptoms, for a late diagnosis is all but valueless to the patient. It should also be remembered that glandular endometritis may exist as such for a time and finally undergo malignant transformation.

Treatment—Curetting, and the intra-uterine application of styptics, such as the liquor ferri perchloridi fortior, are palliative, and should only be employed preparatory to a radical operation, or after the time for such operation has passed.

The only real treatment is a hysterectomy, and usually, a total extirpation per vaginam. If the diagnosis were made early, such an operation would yield a mortality of less than five per cent. in the hands of the experienced gynecological surgeon, and the permanent cures would not be infrequent; for all diseased tissue would be removed, and with it the danger of a recurrence.

Vaginal hysterectomy is a comparatively simple opera-

tion, fully as easily performed as high amputation of the cervix, and almost as safely. The steps are as follows: After a thorough disinfection of the parts, the cervix is drawn down by vulsella or sutures, and incision is made two-thirds around the cervix, from one-third to one-half inch from it, anteriorly and laterally. The bladder is separated from the uterus by the finger or knife handle until the peritoneal cavity is entered, and the peritoneal opening is enlarged laterally with the fingers. The incision around the cervix is then completed, and the recto-uterine pouch opened close behind the cervix, and the opening enlarged laterally with the fingers as far as the sacro-uterine ligaments. Now the left forefinger is carried behind the attachment of the left sacro-uterine ligament, and the thumb in front of the broad ligament, and a ligature carried through the connective tissue as far from the cervix as practicable, so as to include a portion of the bases of each, and tied. Then the remainder of the sacro-uterine and the base of the broad ligament are similarly ligatured, and the ligatured tissues cut through close to the cervix. The manœuvres are now repeated on the other side, and the cervix is loosed so that it can be drawn down outside the vulva, and the remaining portions of the ligaments ligatured in one, two, or three parts according to their size, and the uterus cut out. Bleeding from the raw connective tissue or vaginal edges may be controlled by sewing the vaginal and peritoneal edges together with catgut. Give extra attention to bleeding vessels under the sacro-uterine ligaments.

Adhesions or indurations may diminish the elasticity of the connective tissue, so that even after the cervix is liberated, the uterus cannot be pulled down. In such cases we may have to place forceps upon the remaining portions of the broad ligaments, one on each side. Occasionally, the vagina will be narrow, and the pelvic connective tissue so rigid that we cannot get the cervix down well enough to apply the ligatures firmly and safely. In such cases we can apply a pair of large hæmostatic forceps to the bases of the ligaments on each side, and another pair to the upper portion. Bleeding from the smaller arteries about the vaginal edges is then controlled by small forceps.

A strip of iodoform gauze two inches wide should be tucked into the vagina as far as the stumps, but it should not project up between the intestines.

The small forceps should be taken off in twenty-four hours, those on the broad ligament in forty-eight hours. The ligatures or sloughs from the forceps come away in about two weeks.

Vaginal hysterectomy has proved to be so safe an operation, that some have advocated its performance even after a nodule or two can be felt in the connective tissue by rectal indigitation—these glands being enucleated if possible. This might prolong the patient's life for a year or so, and should be considered seriously before she is turned away.

II. Fibroid Tumors.—One of the characteristic triumphs of the last decade has been the improvement made in the treatment of uterine fibroid tumors.

In order to better comprehend the therapeutics of these growths we will make a clinical division into five main varieties, viz.: (1) The fibroma uteri, composed largely of connective tissue, and with a well-defined capsule; (2) the myoma uteri, composed mainly of muscular tissue, and without any well-defined capsule; (3) the fibro-cystoma, or a fibroma containing, or connected with, one or more cavities of fluid; (4) the œdematous, or soft fibroma, which is a fibroma infiltrated with fluid; (5) the myo-cystoma, or sac of fluid contained in the greatly enlarged uterine wall. These tumors may undergo fatty, calcareous, sarcomatous, myxomatous, septic, or gangrenous degeneration.

The myoma contains connective tissue, but in small quantity as compared with the fibroma, which in turn contains muscular tissue in comparatively small quantity. The fibromas are found much more frequently than all the other varieties together. They may occur as large numbers of small or moderate-sized nodules, either grouped together or scattered throughout the uterus, or as large single masses. The myo-cystoma is a round cyst projecting from the uterus, and covered usually by quite a thick layer of muscular tissue. Smaller cysts with thin septa sometimes project into the main cyst. The uterine body is somewhat enlarged. They are undoubtedly the result of early complete cystic degeneration of fibromas, leaving nothing but cysts surrounded by the myomatous tissue of the uterine walls. They grow rapidly. I removed one the size of a six months fœtus, that within eight months had grown from the size of a hen's egg. The teleangiectatic or cavernous fibroid is a rare growth, whose interior is traversed by large blood-sinuses.

Differential Diagnosis.—When large enough to extend above the pubes, the myoma, the myo-cystoma, and the single fibroma give rise to globular tumors that feel and appear, as far as the shape and position are concerned, like the pregnant uterus. They are, however, all harder, with outline more easily definable, can usually be felt to extend down into the pelvis in the median line just behind the pubes, and can be rocked a little from side to side. The myoma and myo-cystoma, and the œdematous fibroma, give an obscure sense of fluctuation, while the fibroma is hard. The multiple fibroma is hard, irregular in shape, often extending higher on one side than in the middle, usually less movable than the others, and dips into the pelvis on one or both sides, as well as in the median line. Large fibro-cystomas are apt to fill the lower abdomen, and fluctuate the same as ovarian tumors.

Vaginal indigitation in the cases of myoma, myo-cystoma, and single, intra-uterine, or submucous fibromas finds a similar shape as in the case of pregnancy, except that both cervix and tumor are harder. The bulging of the tumor may, however, commence low down, so as to leave but a very short cervix below it, or high up, so as to leave the uterus, at or just above the internal os, small. In pregnancy the bulging begins at the internal os, and feels softer. These tumors may cause the bulging to be a little greater on one side than on the other. Fibromas developed near or at the external layers of the lateral uterine walls first bulge to one side, then push the cervix in a direction opposite to their growth, usually toward the opposite groin, or a little more forward, and then lift the cervix up toward the pelvic brim. When tumors grow into both broad ligaments the cervix remains near the median line, usually somewhat forward, and, as it ascends, often gets somewhat behind the pubes. The uterus, on account of the tension of the broad ligaments, is quite immovable. Tumors in the uterine cavity, or in the anterior uterine wall, as they grow large, tip the fundus forward and the cervix backward, unless retroversion already exists.

The uterine cavity is much elongated in the polypoid submucous and intra-mural fibroma, but little in the subperitoneal and intra-ligamentous fibromas, and moderately, when at all, in the myomas and myo-cystomas.

Treatment.—Electrolysis has been revived by Apostoli, and has taken a place among the therapeutic agents used for the cure of fibroid tumors. For a while it was thought to symptomatically or practically cure the great majority of cases, and many went so far as to say that all tumors should be treated with electricity before being removed. But a reaction has set in. The failures are being discovered, and the imperfect character of the cure is being acknowledged, so that there is a danger of electrolysis losing the place it deserves.

In the first place, according to the experience of F. H. Martin, of Chicago (personal communication), electricity is useless in all cases of cystic fibroids and intra-uterine polypi. Subserous fibroids, particularly the multiple variety, are but little affected by it. This would leave it to be used in the myomas, which are rare tumors, and the interstitial and submucous fibromas, or a little more than half the cases. Its action on the hard tumors causes but little diminution in their size. A few of the small and softer fibroids are said to disappear after electrolysis. The most that is accomplished, however, in the most favorable cases of large tumors, is a cessation of the hæmorrhage and a slight diminution of their size. Often the growth is merely arrested.

Electrolysis may therefore be tried in all but the cystic, multiple, subperitoneal, and polypoid varieties, with the end in view not of curing them, but of arresting their growth, diminishing their vitality, curing the metrorrhagia, and thus rendering them harmless until the conditions attending the menopause shall supervene and aid in the process of retrograde metamorphosis. When, after a trial of a few months, electrolysis fails to check the growth or restrain the hæmorrhage, or if it increases the latter or the sensitiveness of the tumor, its use should be abandoned.

The true electrolytic action does not produce much effect, excepting upon the parts near the negative intra-uterine pole. The positive pole, however, may be used to cicatrize and contract the inner surface of the uterus, and thus diminish, to a certain extent, the vascularity and vitality of the tumors. Contractions of the uterus are also produced by the current, and may affect the vitality of the parts somewhat as ergot does, although less continuously.

The technique of uterine electrolysis need not be given here, for no one should undertake to use the method without a study of the subject in some work devoted especially to that purpose. The principle consists in using large volumes of galvanic electricity, and in its exact dosage. From fifty to three hundred miliampères are used with the aid of a milliampère-meter. One electrode should be introduced into the uterine cavity, and another placed on the abdomen. An insulated uterine sound, a large flat abdominal electrode, and other special appliances are needed. Electro-puncture is, I think, a dangerous procedure, and should be employed only by the specialist.

After the failure of other remedies to check the growth of a fibroid tumor, the knife should be promptly resorted to, unless the patient is very near the menopause. Delay may mean increase in size, adhesions, subperitoneal development, cystic or malignant degeneration, and consequently a much more dangerous operation. The mortality of abdominal section in cases properly chosen need not, at present, be over five per cent. In neglected cases it is about twenty per cent. Tumors not larger than the fist, when accompanied by menorrhagia, may be cured by an oöphorectomy, to bring on the menopause. Large tumors are not always helped by this operation. As a rule, a tumor should not be allowed to become as large as a six months pregnant uterus before being removed. When first brought to our notice at that size, we should watch them closely and treat them vigorously by ergot or electricity, and, if their growth is not soon arrested, operate before they become much larger.

Until within the last few years, it was generally the practice to wait until the tumor grew so large as to menace life, and then to operate. But few died of the disease, for most of them died of an operation done too late. Now we understand better how to select the cases that are not amenable to treatment, and operate before the tumor becomes too formidable. Abdominal hysterectomy has become so far perfected that we can operate upon such cases with a mortality on a par with that of ovariotomy.

Intra-uterine fibroid polypi should be removed as soon as discovered. Subperitoneal fibroid polypi should be removed when they become large enough to cause much inconvenience. All cystic fibroids should be removed as soon as diagnosed. Simple myomas and simple intramural fibromas in young people, should be treated with electricity and ergot; but if, after a long course of treatment, their growth is not checked, they or the ovaries should be removed. Rapidly growing fibromas, with many subperitoneal nodules, should be operated upon early if the treatment does not check their growth, for their numerous foci often cause them to grow very large and rapidly, and to assume such relationships as would early cause trouble, and render an operation difficult. Very slowly growing fibromas with numerous scattered nodules, may interfere with uterine circulation and nutrition, so as to lead to a cessation of their growth. As a rule, fibroids, excepting the cystic and intra-uterine polypoid, which are observed near the change of life, should be patiently treated with the hope that the menopause will cure them. Development in the broad ligaments forbids a long delay in operating.

Uncontrollable metrorrhagia, unbearable pains, rapid growth, often determine an operation. Occasionally it becomes necessary, on account of symptoms, to remove a fibroid when still small. In such cases, a vaginal hysterectomy is preferable to abdominal section, as being safer. The existence of polypi, whether projecting into the uterine cavity or into the peritoneal cavity, does not call for a hysterectomy. Sometimes, one or two subperitoneal fibroids may be enucleated, and the bed sewed up without sacrificing the uterus. The myxo-fibromata, fibro-sarcomata, septic and gangrenous fibroids, should be removed when discovered early enough.

Cervical fibromas are usually single and can be enucleated without danger. The bed should be sewed up or thoroughly packed to prevent hæmorrhage, for cervical tissue does not readily contract. When a cervical tumor projects up into the cul-de-sac of Douglas and gets quite large, a hysterectomy is occasionally required.

Henry T. Byford.

VACCINATION. In the article upon Vaccination presented in the seventh volume of the REFERENCE HANDBOOK, a brief history of the subject was given, together with such data relative to the prevalence of small-pox at different periods as the subject required, since a correct and thorough understanding of the value of vaccination cannot be had without a corresponding knowledge of the prevalence of small-pox, not only at different periods of time, before and after the introduction of vaccination, but also in different countries, under different degrees of legal enforcement and in the absence of all laws.

The Pre-vaccination Period.—The data relative to actual deaths from small-pox in the pre-vaccination period are meagre, but those which have been brought to light are of great value. The most valuable of these statistics have been published in the "Report of the British Parliamentary Commission on Vaccination, of 1871," and in those of the present commission, appointed in 1889, but still in session (1893). A portion of the former was quoted in the seventh volume of the REFERENCE HANDBOOK, pp. 223–234. In addition to the statistics of Geneva, mostly of the seventeenth and eighteenth centuries, and of the town of Kilmarnock, from 1728 to 1763, the following account of "Small-pox Mortality in Pudsey a Century Ago," is given by Dr. W. L. Hunter, *British Medical Journal* (1892). This brief history covers the period from 1777 to 1813 inclusive (thirty-seven years). The curate of Pudsey, Mr. Howarth, kept a careful record of burials, giving names, ages, sex, and as far as could be known, the cause of death. The record is incomplete, since it refers only to those who were buried in the chapel yard. Many other burials took place in other yards. The average population of the town was 4,200. The total number of small-pox burials recorded was 239 out of 1,743 burials in all. For the thirty-seven years 137 per 1,000 of the deaths of those buried (13.7 per cent.) were caused by small-pox. During the nineteen small-pox years 23.6 per cent. were caused by small-pox, and during the eight worst years the ratio of small-pox burials was 34 per cent.

The following table presents the comparative ratio of small-pox deaths to deaths from all causes in the pre-vaccination period in certain communities where records were kept:

COMPARATIVE RATIO OF SMALL-POX DEATHS TO DEATHS FROM ALL CAUSES.

	Deaths from all causes.	Deaths from small-pox.	Ratio per 1,000 deaths from all causes.
Pudsey, 1777–1813	1,743	239	137
Kilmarnock, 1728–1764	3,860	622	161
Chester, 1774	546	202	369
London, 1779–1813	668,888	55,178	82

CONTRIBUTIONS OF DIFFERENT AGES TO 1,000 SMALL-POX DEATHS AT ALL AGES.

		Under one year.	Under five years.	Under ten years.	Over ten years.	Age not stated.	Total.
Pudsey. 1777–1813.	Deaths	38	192	219	4	15	239
	Deaths per 1,000	170	861	982	17	...	...
Kilmarnock, 1728–1764.	Deaths	118	563	606	7	9	622
	Deaths per 1,000	192	918	988	11	...	...
Chester. 1774.	Deaths	51	180	202	..	...	202
	Deaths per 1,000	252	891	1,000	..	...	...

To the foregoing may also be added the figures for Geneva for the period 1580 to 1760, which showed that in that period 961 out of every 1,000 deaths from small-pox were those of children under ten years of age.

"In the town of Pudsey," says Dr. Hunter, "the epidemics prevailed every three, four, or five years, and were present in half the years of the period, which simply means that small-pox, having cleared off all the available or susceptible children, had to wait until more children came into the world for it to prey upon." In this town small-pox caused more deaths than any other disease, the whole number being 239, while consumption, the next most destructive disease, caused only 173 deaths.

Vaccination in Different Countries.—At the present day vaccination laws are enforced more rigidly in Germany than they are in any other country. In Germany revaccination is compulsory, as well as vaccination. In Sweden and Great Britain the laws are not so rigidly enforced. The following statistics relative to the mortality from small-pox in these countries and in other countries where the laws are not compulsory are instructive, and have an important bearing upon the value of vaccination. The figures are from the "Report of the Imperial Board of Health of Germany for 1890," as presented by Dr. Rahts.

MORTALITY FROM SMALL-POX IN 1890.

	In Germany.	In 229 German cities.	In 57 Austrian cities.	In 12 Hungarian cities.	In 15 largest Swiss cities.	In 69 Belgian cities and towns.	In 93 French cities of over 20,000 inhabitants.	In 28 English cities.	In 69 chief Italian cities and towns.
Census population	49,205,373	11,349,568	3,010,472	882,395	480,388	1,992,601	7,204,254	9,715,559	5,180,748
Deaths from small-pox, 1890.	58	29	473	29	13	220	1,058	10	1,306
Death-rate per 100,000	0.12	0.26	15.7	3.3	2.7	11.04	14.7	0.1	25.2

The following table gives the data for twelve principal countries of Europe for the four years 1886–1889:

Countries.	Population.	Deaths from small-pox.				Yearly average.	Average annual death-rate per million inhabitants from small-pox.
		1886.	1887.	1888.	1889.		
Germany	47,923,735	197	168	112	200	169	3.5
Belgium	5,940,365	1,213	610	865	1,212	975	164.0
England	28,247,151	275	506	1,026	23	457.5	16.2
Scotland	4,013,029	24	17	....	6	11.75	2.9
Ireland	4,808,728	2	14	3	....	6.0	1.0
Italy	29,717,982	....	15,249	18,110	13,416	15,925	536.0
Holland	4,450,870	72	18	1	10	25.0	5.7
Austria, about	23,000,000	8,794	9,591	14,138	...	10,841	471.0
Russia (European)	92,822,470	16,938	25,884	....	....	21,411	231.0
Sweden	4,746,465	1	5	9	2	4.25	0.9
Switzerland	2,922,430	182	14	17	3	54.0	18.5
Spain (36 provinces)	11,864,000	....	....	14,378	8,472	11,425	963.0

In the vigorous discussion which took place May 5, 1891, in the French Academy of Medicine upon the advisability of compulsory vaccination and revaccination, the question was finally put to vote, and resulted in an almost unanimously favorable vote; there were only five negative votes.—*Bulletin Acad. Méd.*, 25, 710, 1891.

The following statistics which were brought out in that discussion are worthy of note:

MORTALITY FROM SMALL-POX IN PRUSSIA PER 100,000.

(*Bulletin de l'Acad. de Méd.*, 25, 95, 1891.)

Year.	Army.	People.
1835	3.7	27.1
1840	1.6	16.0
1850	0.8	15.7
1862	0.5	21.1
1870	2.0	17.5
1871	30.5	243.2
1872	5.4	262.4
1873	3.4	35.6
1874*	0.4	9.5
1875*	....	3.6
1880*	....	2.6
1885*	....	1.4
1886*	....	0.5

* Period of thorough enforcement of compulsory statutes.

Annual small-pox mortality per 100,000 of the population. Austria, for the period 1850 to 1874, 53; for the period 1875 to 1884, 62. Prussia, for the period 1850 to 1874, 49; for the period 1875 to 1884, 2 (period of enforcement of compulsory vaccination).

DEATHS FROM SMALL-POX PER 100,000 IN CERTAIN CITIES IN 1886, 1887, AND 1888.

	1886.	1887.	1888.
Germany.			
Berlin	0.007	0.07	0.1
Hamburg	3.6	0.6	... ..
Breslau	.....	.....	.....
Munich	0.8	0.4	0.7
Dresden	9.0	.....	.....
Leipzic	1.7	.....	.....
Cologne	.....	.....	0.4
Frankfort a. M.	....	....	....
Königsberg	5.3	18.1	4.5
Bremen	0.8	.....	.....
Dantzic	0.9	.....	.....
Stuttgart	1.7	.....	.....
Magdeburg	2.1	.....	.....
Great Britain.			
London	0.6	0.2	0.1
Liverpool	4.9	.....	.....
Sheffield	....	87.9	127.0

DEATHS FROM SMALL-POX PER 100,000 IN CERTAIN CITIES IN 1886, 1887, AND 1888.—(*Continued.*)

	1886.	1887.	1888.
France.			
Paris	9.0	17.2	11.0
Marseilles	545.3	16.7	32.0
Rheims	121.3	.....	41.0
Havre	.. ...	55.3	133.0
Amiens	.....	.....	141.6
Belgium.			
Brussels	11.4	.....	0.6
Antwerp	31.7	.....	.....
Switzerland.			
Zurich	98.1	.....	.....
Austria.			
Vienna	26.2	8.2	8.0
Prague	55.5	84.9	250.0
Pesth	368.7	72 3	3.0
Trieste	.....	.....	163.0
Italy.			
Rome	134.3	115.1	22.0
Genoa	153.8	120.4	74.0
Venice	51.6	.....	.....
Russia.			
St. Petersburg	15.3	24.6	6.0
Moscow	34.1	.....	3.0
Odessa	25.2	.....	.....
Warsaw	32.5	152.6	69.0

One of the most valuable reports of modern times, bearing upon the subject of the value of vaccination, is the report of Dr. F. Barry, upon the epidemic of small-pox in Sheffield, in 1887–88. Dr. Barry, who is an inspector of the Local Government Board of England, was instructed to inquire into every influence which could possibly bear upon the epidemic of small-pox at Sheffield. After making a most thorough and searching investigation, as his report shows, no influence could be discovered beyond the single dominating one of vaccination.

Dr. Buchanan's introductory to this report sums up the results as follows :

	PER 1,000 OF EACH CLASS STATED.			
	Attack-rate.		Death-rate.	
	Vaccinated.	Unvaccinated.	Vaccinated.	Unvaccinated.
Up to ten years	5.0	101	0.09	44
Living in invaded houses	78.0	869	1.0	381
Over ten years	19.0	94	1.0	51
Living in invaded houses	281.0	686	14.0	371
All ages	15.5	97	0.7	48
Living in invaded houses	230.0	750	11.0	372

In the foregoing table the figures represent the rates per thousand of the child population under ten years, of persons over ten years of age, and of persons of all ages ; first, as applying to the population of the borough generally, and secondly, as applying to the enumerated population of the invaded houses. In a brief summary Dr. Buchanan further says, " the vaccinated children had, as compared with the unvaccinated in the same town, a twenty-fold immunity from attack by small-pox, and had a four-hundred-and-eighty-fold security against death by small-pox ; that in the invaded houses the vaccinated children had, as compared with the unvaccinated, an eleven-fold immunity from attack by small-pox, and a three-hundred-and-eighty-one-fold security against death by small-pox, and that as regards all ages the vaccinated among the population generally had as compared with the unvaccinated, a six-fold immunity against attack, and a sixty-four-fold security against death."

In a valuable report upon the subject of vaccination made by Dr. A. Proust, to the Consulting Committee of Public Hygiene of France, in May, 1889, he states that it is impossible to know the exact number of deaths from small-pox in France. The following, however, were known to have occurred in the fifty-three principal cities in 1886 and 1887. There were 2,991 deaths from this cause among 6,337,772 inhabitants in these cities in 1886, and 1,955 deaths among 6,361,011 inhabitants in 1887. In Paris there were, in 1870, 10,549 deaths from small-pox, and 2,777 in 1871.

A large portion of Dr. Proust's report is devoted to the demonstration of the fact that Prussia, with an almost absolute practice of vaccination and revaccination, has had a nearly complete immunity from small-pox mortality, which is very striking when compared with the deaths from small-pox in other and neighboring European countries under optional laws.

Dr. Düms, a German staff officer, communicates to the *German Quarterly Journal of Hygiene*, vol. xxi., 1889, the following statistics relative to Leipsic during the period 1872–74.

The percentage of *vaccinated* school children in Leipsic for the three years previous to the introduction of compulsory vaccination, was as follows :

1872..... 94.97 per cent.
1873..... 93.83 " "
1874..... 91.20 " "

This falling off was due to the spread of anti-vaccination sentiments.

Out of this number the percentage of those who contracted small-pox was as follows :

1872..... 0.7 per cent.
1873..... 1.0 " "
1874..... 0.9 " "

Of the *unvaccinated* children (according to their parents' statements) the percentage of those who took small-pox was as follows :

1872..... 44.1 per cent.
1873..... 44.6 " "
1874..... 63.4 " "

A paper by Surgeon-General Sir William Moore, in the *Sanitary Record* of October 15, 1891, treats of the prevalence of unchecked small-pox, and of the effect of vaccination in India. In reply to a general question sent to the sanitary officials of India as to what diseases have been lessened in India by sanitary measures, all specified small-pox. The Sanitary Commissioner of Madras stated that the city of Madras afforded an excellent example of the protection afforded by vaccination.

The following table gives the deaths from small-pox in each year in Madras, from 1871 to 1890. The population in 1881 was 405,848.

Years.	Deaths from Small-pox.	Years.	Deaths from Small-pox.	Years.	Deaths from Small-pox.
1871.....	234	1878.....	447	1885.....	56
1872.....	658	1879.....	910	1886.....	1
1873.....	1,062	1880.....	869	1887.....	13
1874.....	809	1881.....	1,654	1888.....	36
1875.....	196	1882.....	355	1889.....	45
1876.....	421	1883.....	1,957	1890.....	69
1877.....	6,758	1884.....	4,064		

Vaccination was made compulsory in Madras in 1883.

The following figures furnished by the Sanitary Commissioner of Berar, show the results of vaccination in that province :

Five-year period.	Mean ratio per 1,000 of the population successfully vaccinated.	Mean death-rate from small-pox per 1,000 of the population.
1868–1872	8.9	2.02
1873–1877	25.7	1.56
1878–1882	31.2	0.58
1883–1887	34.6	0 38

The decrease of the small-pox death-rate, conjointly with the increase in the vaccination-rate, is strikingly illustrated in the foregoing table.

The following table presents the progress of vaccination at decennial periods in the different provinces of British India:

Provinces.	Number of Successful Vaccinations at the Periods Mentioned.		
	1870–71.	1879–80.	1889–90.
Bengal	324,266	1,363,925	1,769,525
Madras	282,942	587,810	831,499
Bombay	397,622	581,051	890,820
N. W. Provinces of Onde	237,298	530,806	710,849
Punjaub	292,689	444,710	764,282
Central Provinces	102,035	288,367	350,528
Berar	17,476	74,303	92,629
Coorg	534	3,417	7,165
Assam	.....	21,170	134,922
British Rajpootana	5,996	3,695	11,510
Burmah	.....	65,293	112,428

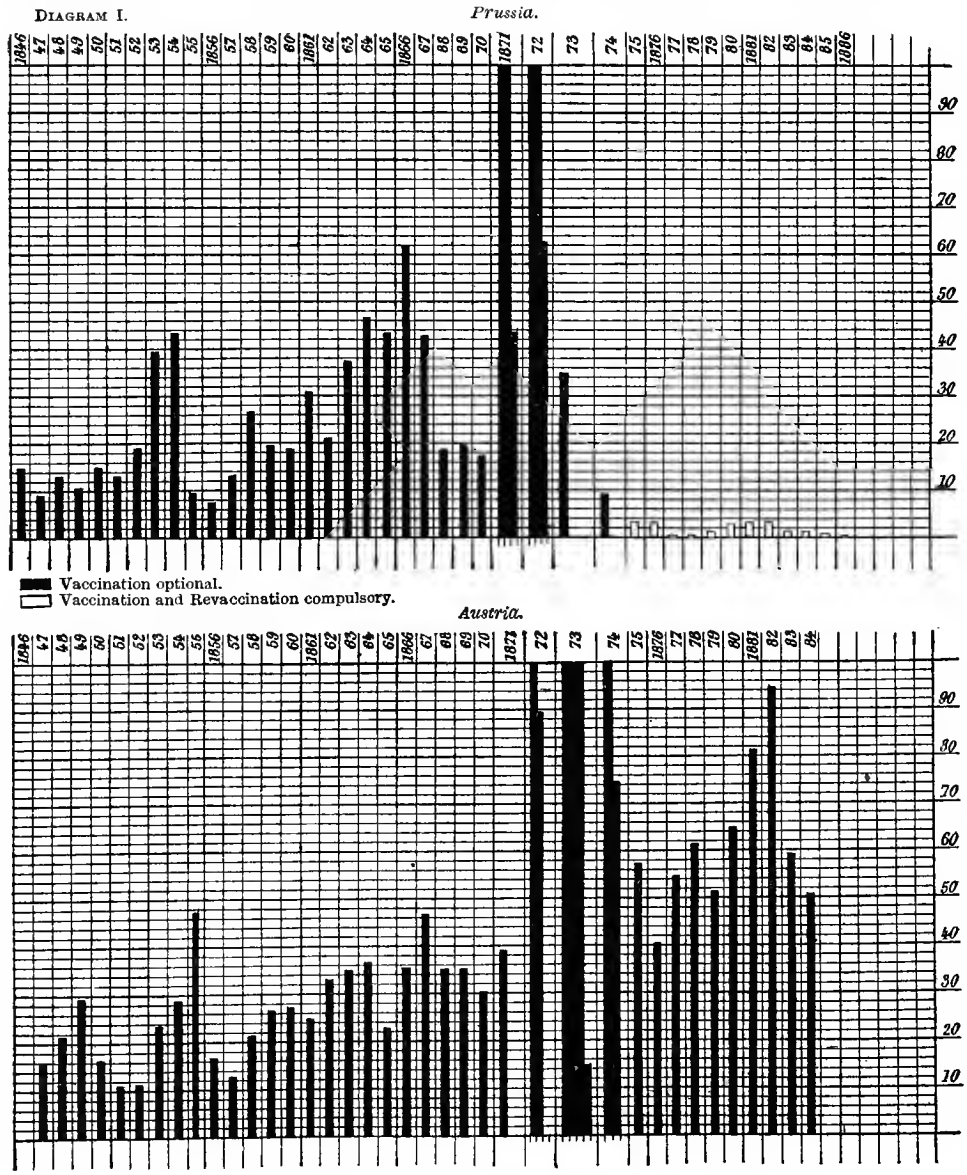
The last annual report of vaccination for the whole of India gives a total of 5,709,462 successful cases, varying in the different provinces from fifty-six to seventy-three per cent. of births.

Surgeon Moore testifies that this large yearly ratio of vaccination in India has had a very marked effect in the reduction of small-pox in that country.

He also states his experience in India before vaccination had been generally introduced. He says he marched during an epidemic of small-pox a distance of one thousand miles, surrounded by small-pox. "Those suffering from the disease in a minor degree were in the streets, generally children, occupied in their accustomed play; or if too ill, lying neglected on the ground; and these represented a portion of the whole suffering from small-pox, the remainder, unable to leave their dwellings, awaiting death in their houses. Any one cognizant of the after-effects of small-pox will at once understand the amount of suffering which must occur among those recovering from the immediate disease. The consequent effects on the eyes, the ears, the skin, the limbs,

MORTALITY FROM SMALL-POX IN PRUSSIA, AND IN AUSTRIA, PER 100,000 INHABITANTS, FROM 1846 TO 1886.

DIAGRAM I.



the joints, and the general constitution, at least equal in gravity the direct consequences of the disease. Roughly speaking, from calculations based on observing the people passing through the streets of certain cities, ten per cent. had lost the sight of one or both eyes, and an equal number had permanent injury of some organ or member; and of these affections the great majority could be traced to small-pox. From special inquiry I found nearly eighty per cent. of the population were more or less marked with small-pox."

According to the *British Medical Journal* there were in the last epidemic of small-pox in Guatemala twenty-five thousand deaths from the disease. In that country there are no vaccination laws. Its population is about one-half as large as that of New England, in which there have not been so many small-pox deaths in the last seventy-five years combined. The *Journal* characterizes Guatemala as an "autivaccination paradise." (*Brit. Med. Journ.*, 2, 1891, p. 1135.)

On the Prophylactic Power of Vaccination.—At the Tenth International Medical Congress in Berlin, in 1890, Dr. Victor Desguin, of Antwerp, said that the medical inspection of schools in that city had been organized in a very complete manner since 1882, at which time revaccination was ordered for all school children who were twelve years old. It is performed with lymph, under every possible condition of security. It is furnished by the Central Vaccinal Institute of Belgium, and before delivery of the lymph, an autopsy is made upon the animal from which it has been taken, to determine its condition of health, none being issued if the animal is found to be diseased. So that there is no danger of communicating either syphilis or tuberculosis.

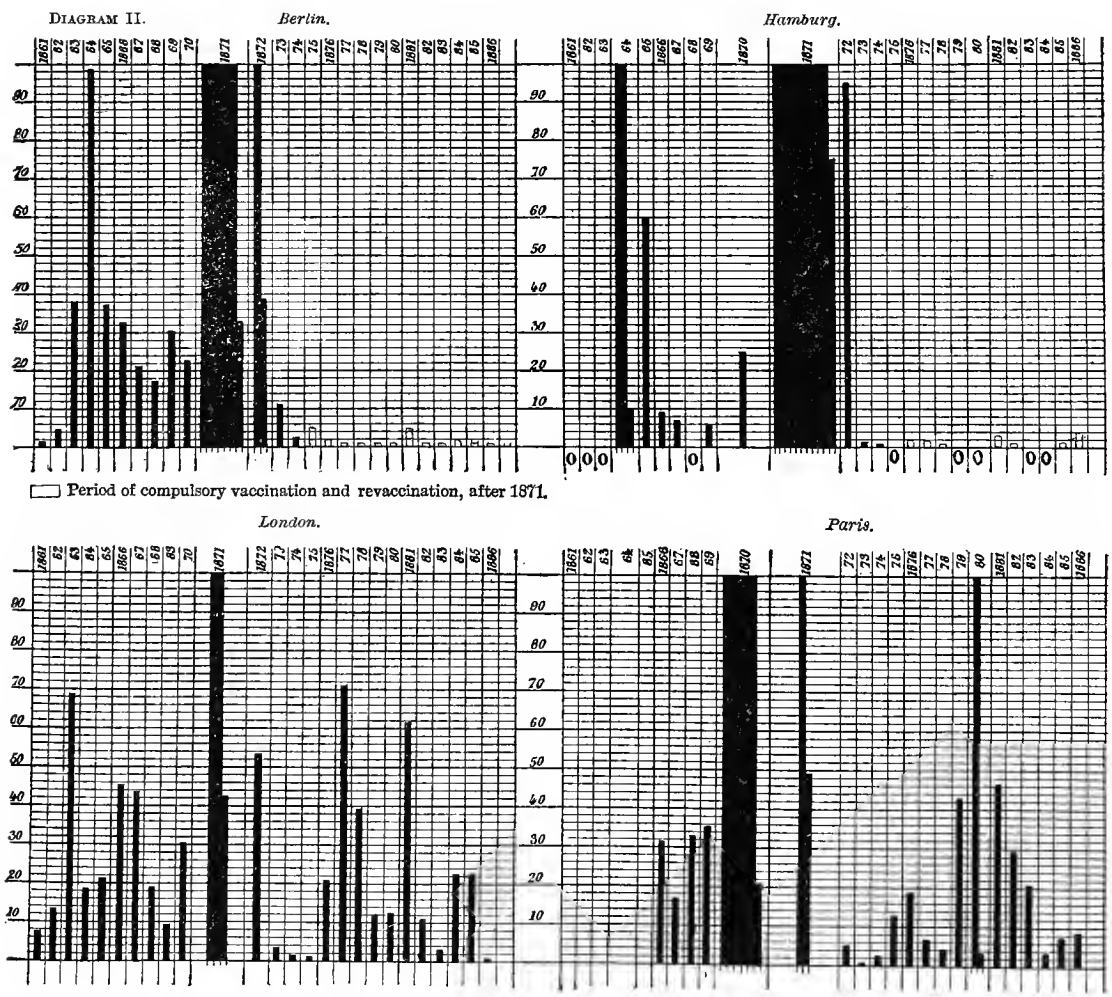
In nine years, fifteen thousand two hundred and fifty-nine children have been vaccinated, of which eight thousand and thirty-three, or fifty-two per cent., were successful. He says this ratio of success in revaccination is probably due to the fact that a considerable number of children enter the schools with false certificates of vaccination, either on account of inefficient performance, or by reason of its omission.

Revaccination was not followed in any case by unusual results, beyond what could easily be controlled, the school registers giving the particulars as to absence in all cases.

Moreover, he says that revaccination has never been followed by the development of scrofulous symptoms; a fact which he attributes to the plan adopted for strengthening feeble school-children by proper medical means.

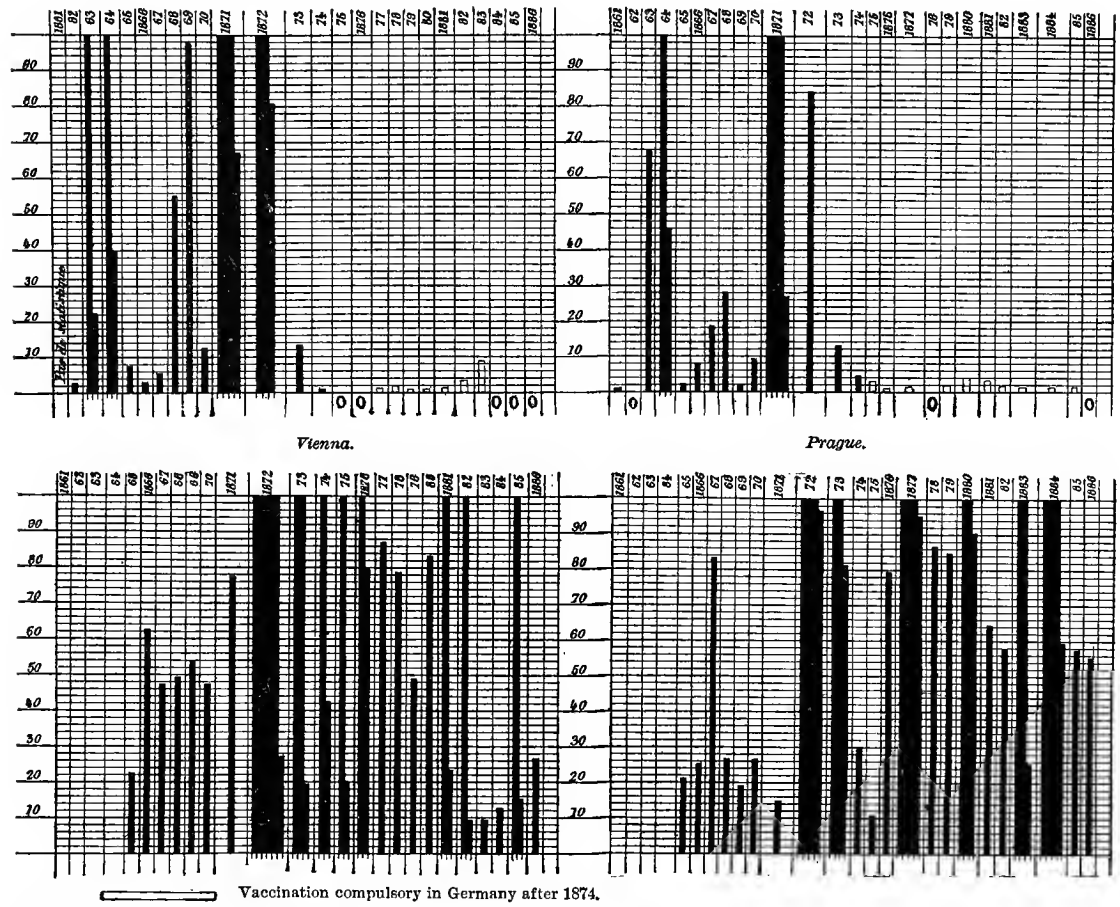
During this period of nine years there were in Antwerp four hundred and ninety-seven deaths from small-pox, only two of which were those of school-children. They were children of seven and eight years, neither of whom had been revaccinated, and one had never been vaccinated. During this period there were, among an average annual school population of thirteen thousand five hundred and six children (subject to yearly renewals and changes), fifty-three cases of small-pox, none of

Mortality from Small-pox in Several Large Cities per 100,000 Inhabitants.



MORTALITY FROM SMALL POX IN SEVERAL LARGE CITIES PER 100,000 INHABITANTS.

DIAGRAM III.



which were among revaccinated children. (Transactions of Tenth International Medical Congress at Berlin, vol. v., No. 15, p. 144.)

As an illustration of the convincing effect which a severe epidemic of small-pox has upon a population but partially protected by vaccination, the experience of Montreal may be cited, the following quotation being taken from the health officer's report for 1891. The loss by small-pox in Montreal in the epidemic of 1885, was 3,164, or about two per cent. of the whole population of the city.

"The prejudice which existed against vaccination at the time of the last epidemic is disappearing year by year. The past year, and particularly in the autumn, when the cases of small-pox scattered throughout the Province, gave reason to fear that Montreal would again be invaded by the loathsome disease, a vast number of people who hitherto had refused to submit to vaccination, not only gladly accepted the services of the vaccinators when they presented themselves, but many of them applied to the health department to have the vaccinators sent to their homes. The vaccinators had to keep their offices open every evening up to nine o'clock, even Sundays and holidays, for the convenience of those who were unable to go at a more suitable time. It is to be hoped that the small number of people yet opposed to this measure may continue to decrease, and then we shall be able to flatter ourselves that we have a city the best protected against small-pox of any on the American continent."

The advantages of a system of compulsory vaccination and revaccination in protecting large communities from small-pox are clearly shown in the diagrams presented upon pages 928, 929, 930, and 931, copied from Schulz, Impfung, Impfgeschäft und Impftechnik, Berlin, 1888, and the 19th Report of the Consulting Committee of Public Hygiene of France, 1889.

Diagram I. presents the statistics of mortality from small-pox in Prussia, and in Austria, showing the death-rate per 100,000 from this cause in each country for a period of nearly forty years, 1846 to 1886, in Prussia, and 1847 to 1884, in Austria. Vaccination was optional for the civil population in Austria for the whole period, while in Prussia it was compulsory after April 1, 1875.

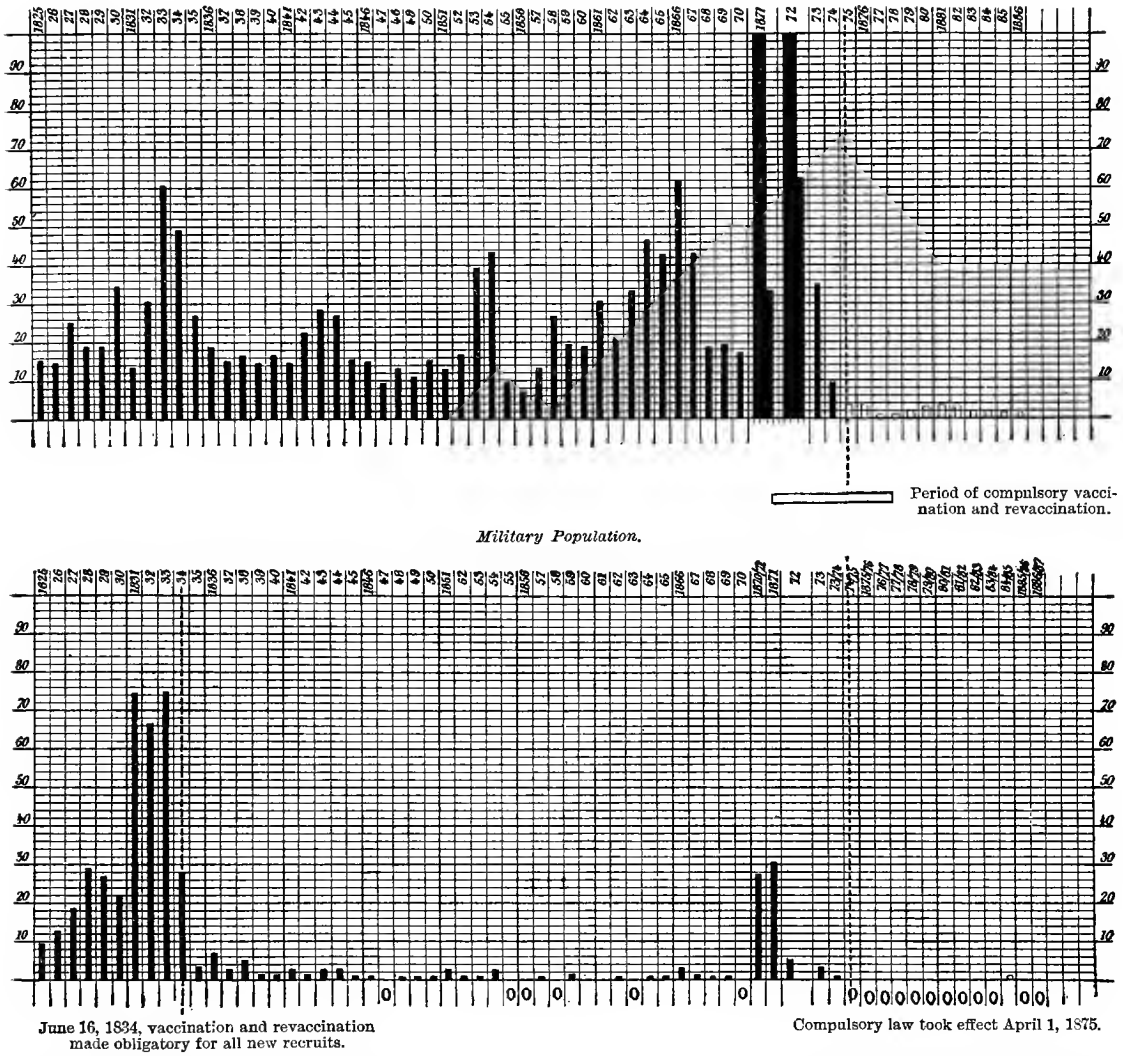
Diagrams II. and III. present the comparative mortality from small-pox, of four German cities in which vaccination was compulsory after 1875, and that of four other large European cities in which it was either optional, or optional in the case of revaccination for the whole period (1861–1886) as it was in London.

Another diagram, No. IV., presents the condition of the civil and military population of Prussia, with reference to the same subject, for the period of sixty-two years, 1825–1886. Vaccination and revaccination of all new recruits was required by law after June 16, 1834, but not for the civil population till 1875. When the law requiring all persons to be vaccinated in infancy, and revaccinated at twelve years, became operative, it appears to have reduced the small-pox mortality to very small limits among the civil population, and to a still greater extent among the military population (one death only from this cause in thirteen years).

The renowned statistician Körösi, of Buda-Pesth, has

MORTALITY FROM SMALL-POX PER 100,000 INHABITANTS IN THE CIVIL, AND THE MILITARY, POPULATION OF PRUSSIA, FROM 1825 TO 1886.

DIAGRAM IV.



continued his convincing series of statistics (mentioned in Vol. VII. of the REFERENCE HANDBOOK, p. 528), adding to the published data of 1886 those also of 1887 and 1888, which were derived from the hospitals and cities of Hungary. He contends that the ordinary comparisons of small-pox mortality in the periods before and after the introduction of vaccination, and the mortality from small-pox in countries and cities well or poorly vaccinated, do not constitute convincing proof of the value of vaccination. He entertained the idea that the proof could only be sustained when, in populous districts, the total number of the vaccinated and the unvaccinated is known, from which it would be easy to learn the mortality from small-pox among the vaccinated and the unvaccinated. But to obtain these figures from whole countries is not an easy task. The author's new method permits of a proof in figures of the influence of vaccination without a necessary knowledge of the number of the living vaccinated and unvaccinated. Until his inquiry was made, the vaccination question had been made to depend on the number sick or deceased from small-pox.

The tables which Körösi has published contain the number of persons treated for the most diverse diseases, and dying of the most diverse causes, their ages, and also whether vaccinated or unvaccinated. One table contains the condition as to vaccination of 53,320 persons treated in 1886, 1887, and 1888, in nineteen Hungarian hospitals. The second table presents the statistics of 5,518 deaths in the same hospitals, and for the same period. A third table gives the statistics of 58,639 deaths in ten Hungarian cities for the same years, from different causes.

Of the persons sick with different diseases in the hospitals, 11.75 per cent. were unvaccinated. If vaccination had no effect upon small-pox *morbidity*, then the unvaccinated would have shared to the rate of about 11.75 per cent. in the contemporaneous 1,912 cases of small-pox. In other words, there would have been two hundred and twenty-five cases of small-pox among the unvaccinated. Instead of this the number of cases of small-pox among the unvaccinated was seven hundred and twenty-six. The neglect of vaccination, therefore, increased the liability to small-pox 3¼ fold. In the same manner the author concludes that the danger of death from small-pox is six times as great among the unvaccinated.

He also estimates that skin diseases destroy two per-

sons out of every million, while by vaccination two thousand are saved.

COMPULSORY VACCINATION.—Dr. Brouardel, in a spirited address before the French Academy of Medicine, March 3, 1891, advocated compulsory vaccination in the most eloquent language. He laid much stress upon the results of Dr. Barry's inquiry as to the prevalence of small-pox at Sheffield. He attacked the position of M. Fort, who claimed that the diminution of small-pox at the present day is due to isolation and disinfection, and not to vaccination.

He said that the display of quarantine flags or signals could not avail in all cases to prevent access to those who were ill with infectious diseases. When the Queen of Holland was attacked with measles, "the flag did not keep people away from the palace. Anyone went to see her."

Furthermore, he said, "I attach great importance to the German law of 1874. All children attend school, all children must be revaccinated. That is just what we need in France."

With reference to the prevalence of small-pox at Leicester, England, in common with other English towns, in November, 1892, *The Lancet* says (November 19th): "Dr. Coupland has visited Leicester on behalf of the Royal Commission on Vaccination. The results of his inquiry are unknown; but they may be taken to include an account of the failure of the much-vaunted quarantine system on almost the first occasion when that scheme has been put to any semblance of a real test."

PRESENT PRACTICE OF VACCINATION IN DIFFERENT COUNTRIES. GERMANY.—Undoubtedly Germany has at the present day the most thoroughly vaccinated population in the world, since the compulsory law of that country is the most efficiently enforced.

The following figures present the numbers of the vaccinated and revaccinated, for the years 1888–89:

Total number liable to vaccination, 1888	2,678,056
Total number liable to primary vaccination, 1889, after excluding exempts	1,458,393
Total number liable to revaccination, 1889	1,224,507
Total	2,682,900
Total number vaccinated in 1888	2,487,484
Total number vaccinated (primary), 1889	1,299,981
Total number revaccinated, 1889	1,185,504
Total	2,485,485
There remained unvaccinated (primary), 1889	158,412
There remained unvaccinated subject to revaccination, 1889	39,003
Total	197,415
Of the foregoing there were vaccinated with humanized lymph, in 1888, a total of	545,231
Those vaccinated with humanized lymph in 1889 were	135,259
Those revaccinated with humanized lymph in 1889 were	123,942
Total	259,201
The total number vaccinated with calf lymph in 1888 was	1,942,356
The total number vaccinated with calf lymph (primary) in 1889 was	1,168,003
The total number revaccinated with calf lymph in 1889 was	1,057,193
Total	2,225,196

England and Scotland.—In England, in 1889, the statistics were as follows:

Number of births	885,909
Successfully vaccinated	707,161
Reported as insusceptible	1,758
Had small-pox	2
Died unvaccinated	88,995
Vaccinations postponed	13,366
Remaining	74,627

The percentage of children not accounted for, as compared with the births, was 9.9; that of 1888 having been 8.5.

VACCINATIONS IN SCOTLAND, 1885*–1890, AND PERCENTAGES TO BIRTHS.

	Successfully vaccinated.	Vaccination postponed.	Insusceptible. From constitutional insusceptibility.	Insusceptible. From having had small-pox.	Insusceptible. From previous vaccination.	Died before vaccination.	Removed from district before vaccination, or otherwise unaccounted for.	Total births.
1885...	109,866	2,073	225	0	228	10,872	2,888	126,152
1886...	110,864	2,325	201	0	241	11,282	3,055	127,968
1887...	107,077	2,465	236	0	373	11,269	3,047	124,467
1888...	106,734	2,417	216	0	397	10,434	3,096	123,294
1889...	104,931	2,692	235	0	256	11,479	3,226	122,849
1890...	103,635	2,710	222	2	248	11,779	3,016	121,612
PERCENTAGES OF BIRTHS.								
1885...	87.1	1.6	0.2	0	0.2	8.6	2.3	100.
1886...	86.6	1.8	0.2	0	0.2	8.8	2.4	100.
1887...	86.1	2.0	0.2	0	0.3	9.1	2.4	100.
1888...	86.6	2.0	0.2	0	0.3	8.5	2.5	100.
1889...	85.4	2.2	0.2	0	0.2	9.3	2.6	100.
1890...	85.2	2.2	0.2	0.002	0.2	9.7	2.5	100.

* See p. 521 of Vol. VII. for statistics of earlier years—1880–1884.

If the number of births who died in each year before they could be vaccinated is deducted from the total number of births, the number successfully vaccinated is found to be about ninety-four, or ninety-five per cent. of the surviving births for Scotland for the period 1885 to 1890.

Japan.—The following table, presenting the number of vaccinations in Japan in 1888 and 1889, may be compared with the statistics of the same country for the period 1875 to 1879. (See REFERENCE HANDBOOK, Vol. VII., p. 522.)

TOTAL VACCINATIONS IN 1888 AND 1889.

	Successful. 1888.	Successful. 1889.	Unsuccessful. 1888.	Unsuccessful. 1889.
Primary	923,358	849,921	123,975	117,221
Revaccinations	419,825	285,869	828,830	564,371
Total	1,343,183	1,135,790	952,805	681,592

THE SAME BY AGES—1888.

Age.	Successful.	Unsuccessful.	Total.	Not vaccinated on account of sickness or otherwise.
Under 1 year	506,598	52,800	559,398	211,585
1 to 2 years	290,598	65,194	355,792	119,608
2 to 5 years	179,877	152,264	332,141	147,499
5 to 10 years	175,621	289,641	465,262	225,648
10 to 15 years	115,463	240,821	356,284	216,191
Over 15 years	75,026	152,085	227,111	.....
Total	1,343,183	952,805	2,295,988	920,531

1889.

Age.	Successful.	Unsuccessful.	Total.	Not vaccinated on account of sickness or otherwise.
Under 1 year	466,286	50,305	516,591	228,050
1 to 2 years	270,028	55,850	326,778	132,187
2 to 5 years	149,468	110,218	259,686	150,630
5 to 10 years	133,007	218,667	351,674	218,920
10 to 15 years	80,837	168,663	249,500	204,017
Over 15 years	35,264	77,889	113,153	.....
Total	1,135,790	681,592	1,817,382	933,804

Austria.—(*Recueil des travaux du Comité Consultatif d'hygiène publique de France.* 19, 1889.) There were in 1885, 15 vaccinal institutes in Austria: 3 in Vienna, 3 in Prague, 5 in Styria, 2 in Galicia, 1 in the Tyrol, and 1 in Linz.

The number of persons vaccinated in Austria in 1885 was 951,364, or 4.3 per cent. of the population. The number of unsuccessful vaccinations, so far as it was known, was 19.8 per cent., as compared with 18.9 per cent. in the previous year, and 19.2 per cent. in 1883.

Seventy-one and three-tenths per cent. of the vaccinations were made with liquid, and 28.7 per cent. with solid vaccine, the latter mostly in Gallcia and Bukowina.

The expenses of vaccination amounted to 183,127 florins (about $85,000). The cost of each vaccination varied from about six cents in Bukowina and Lower Austria to twenty-eight cents in Trieste.

France.—Dr. Proust's report to the French Consulting Committee of Public Hygiene presents many valuable tables relating to vaccination, of which a condensed summary is herewith given.

The number of vaccinations gratuitously furnished by the Academy of Medicine, from 1871 to 1887 inclusive, including primary vaccinations and revaccinations, was 82,553. During the same period the Academy distributed gratuitously portions of vaccine lymph as follows:

Plaques	182,651
Tubes	27,315
Points	96,718

The Academy of Medicine also furnishes the following statistics for France:

1875 to 1885.

Years.	Births.	Vaccinations.	Revaccinations.	Cases of small-pox.	Deaths from small-pox.	Percentage of vaccinations to births.
1875.....	803,243	554,773	13,710	4,103	698	69.1
1876.....	716,988	558,855	6,453	7,211	1,068	77.9
1877.....	773,208	578,969	14,883	9,510	1,662	74.9
1878.....	799,270	604,182	8,734	14,181	3,300	75.6
1879.....	771,424	588,348	8,115	8,478	1,302	76.3
1880.....	739,436	658,987	49,842	17,579	2,997	89.1
1881.....	752,287	631,122	29,079	14,103	3,430	83.9
1882.....	734,628	601,508	34,949	34,746	2,297	81.9
1883.....	517,456	460,813	45,518	6,125	1,517	89.1
1884.....	720,454	587,761	28,317	8,910	2,104	81.6
1885.....	737,246	611,190	30,990	8,948	1,727	82.9
	8,065,640	6,436,508	270,590	133,894	22,102	79.8

Dr. Proust also presents a table of the vaccinations and revaccinations performed in the city of Paris from 1877 to 1886, and in the hospitals and bureaus of charity from 1886 to 1888. The least number was 27,689 in 1877, and the greatest 69,309 in 1888.

Cases of Vaccinia in the Cow.—In the seventh volume of this work mention was made of various attacks of cow-pox among the herds in different dairy-farms, both in Europe and in America. Scarcely a year passes without the report of one or more cases. The disease rarely becomes epidemic over a territory of considerable size, but is usually confined to the milk-giving animals in one dairy. It was once common to apply the term "spontaneous" to these cases. Present knowledge of the natural history of infectious diseases, however, teaches us to discard the use of this term, which appears to have been employed as a confession of ignorance as to the cause of the disease. Even if we know no more as to the true cause of diseases than was known half a century since, this may be said: The absence of knowledge as to a pre-existing cause does not by any means justify us in asserting that such cause does not exist.

A very careful report of an epidemic of vaccinia is presented in the Eighteenth Report of the Local Government Board of England (Supplement containing the report of the Medical Officer for 1888). It was reported to that Board in June, 1888, that an eruptive disease was prevailing among the cows at a certain dairy in Alderley, a small town in Gloucestershire. The farmer's son and several other persons had contracted an eruption while milking this herd. Dr. Klein visited the place, and on inspecting the herd and the milkers, concluded that it was vaccinia. Most of the persons had nearly recovered from the eruption. But one girl, aged twenty, had a recent eruption on the right thumb consisting of one vesicle. Dr. Klein obtained a capillary tube of lymph from this vesicle, together with some crusts from the cows which had been attacked. The vaccinations with the crusts failed completely, but some which were removed at an earlier stage from other animals gave striking and positive results of true vaccinia. The lymph from the vesicle upon the thumb of the milk-maid also produced positive results. From these other calves were inoculated, and tests were made of the lymph obtained. The final results were those of typical vaccinia. Dr. Klein's observations were confirmed by those of Drs. Cory and Messrs. Murphy and Collins. In Dr. Buchanan's comment upon this case he says, the disease "had the characters of that 'variolæ vaccinæ' which Jenner discovered in the same county in the last century, and which he put to the purpose of protecting against small-pox."

Not far from the foregoing case, at Cricklade, in the neighboring county of Wiltshire, other cases of cow-pox were discovered in the autumn of 1887, of which an account is given in the second volume of Crookshank's "Vaccination: Its History and Pathology." This region also is not far from the district in which Jenner made his early observations. In a herd of one hundred and twenty cows here, all were attacked except a dozen, which proved refractory. Vesicles appeared on the teats, two, three, four, or more on each teat. These were soon broken in milking, and irritated into sores, which became covered with thick crusts. From four to six weeks elapsed before they healed. The cows generally appeared to be in good health. The milk-supply was slightly diminished, so that by a rough estimate the owner estimated his loss of milk in the whole herd at £50. A striking characteristic of this outbreak was the communicability of the disease to the milkers, of which Dr. Crookshank details eight well-marked cases.

Successful vaccinations of calves were made from this outbreak.

The Question of Unity or Duality of Variola and Vaccinia.—In 1865 a commission at Lyons published the following conclusions relative to the relation of these diseases to each other:

1. Cow-pox and small-pox can be inoculated in bovine and equine animals; the first energetically, the second feebly.

2. Whatever may be their successive transmissions, direct or crossed, these two diseases breed true on every soil.

3. The protection from one by the other is assured in every case.

Some interesting experiments have been recently made by Haccius and Eternod, of Geneva, which tend to confirm those already published by Fischer in the *München med. Wochenschrift*, and make the identity of variola and vaccinia more than probable. The conclusions at which Thiele, Ceely, Voigt, and Depaul arrived many years ago, namely, that cow-pox is a modified form of small-pox, attenuated by its passage through the organism of an animal, were disputed by the Lyons commission, which adduced seemingly unimpeachable experiments of their own, contradictory to the observations of the earlier experimenters.

Haccius and his colleague, following the operative method of Fischer, claim that they have succeeded in imparting small-pox to animals, and in transmitting it through several generations, the disease finally manifesting itself in a mild form not distinguishable from true cow-pox, and like it, conferring immunity from variola.

Believing that the method of inoculation by pricks and incisions practised by the Lyonese commission was insufficient, and that experiments based upon this method

were inconclusive, these later experimenters resorted to a procedure which they call *vaccination in surface*, or *vaccination by denudation*. Fischer's method was by extensive scarification. Haccius and Eternod denude the skin of the animal over an extent of several square centimetres by means of a thin glass scraper. A little hemorrhage follows, and then some oozing of serum, which they carefully wipe off by means of a sterilized cloth. Then they rub the denuded surface with a spatula charged with the small-pox virus. They assert that by this procedure they have never failed to obtain success, while the method by pricks and incisions is apt to fail.

They found that in the first generation there is produced a local eruption accompanied by "spontaneous" pustules, always small in number, the entire eruption having an aspect but little typical, somewhat abortive, and this, they think, was what led the Lyons commission into error. If from the product of these papules another series of inoculations is practised, and then another from the results of the second, the appearance soon changes; at the end of the second or third generation the pustulation tends to become typical, by taking on more and more the mode of evolution and the characters of the vaccinal eruption. After the third generation, "an expert would assuredly have difficulty in distinguishing the pustules in these animals from those that are obtained in the vaccinal institutes by the inoculation, in the first generation, of spontaneous cow-pox."

In each animal the counter-proof was carefully made with animal vaccine. All the animals that had been before inoculated with small-pox virus were invariably refractory to vaccine.

In one of these series of experiments, Haccius and his colleague succeeded in transmitting the small-pox virus from heifer to heifer to the fourteenth generation; and side by side with a set of similar observations where vaccine virus was used, they had a series under observation where the heifers were inoculated with virus from a case of confluent small-pox. Lymph from "the fourth generation" has given the results of ordinary vaccine when used for purposes of vaccination.

Their conclusions were as follows:

1. Variola is inoculable *with certainty* on the bovine species when the operative method is such as it should be, and the virus is collected at the opportune moment.

2. The inoculation of small-pox to the heifer constitutes a precious source for new reinforcements of animal vaccine. This may be of great practical benefit, not only to the vaccinal institutes of Europe, but also to tropical countries, where small-pox is endemic, and where the generations of vaccine tend rapidly to deteriorate.

3. Small-pox inoculated in the heifer becomes transformed into vaccine in the course of several generations, by transmission through the animal. *Duality is thus disproved.*

4. Our practical conclusions confirm the views enunciated by Depaul, in 1863, to the Academy of Medicine of Paris.

Following these experiments Chauveau obtained lymph from the Genevan professors and submitted it to experiment. It was the product of the eighth transmission from heifer to heifer. Chauveau's trials were made exclusively on subjects of the bovine species. The primary eruption which follows the inoculation constantly maintains special characters which, in his opinion, differentiate it from the vaccinal eruption. At the same time, this special eruption is the result of an infection which has close relations with vaccine, for it is no longer possible to *vaccinate* animals thus *variolized*. M. Chauveau finds no evidence of that transformation of small-pox into the vaccine disease which the Genevan professors claim to have effected by passing their lymph through a succession of cattle, the original virus being variolic. The experiment was a repetition of experiments which, as one of the members of the famous Lyons commission, he had performed many years before.

M. Chauveau's paper (*Sur la transformation des virus à propos des relations qui existent entre la vaccine et la variole*) was presented at the sessions of the Academy of Medicine of October 20 and 27, 1891. His conclusions are as follows: (1) Vaccine virus never gives small-pox to man. (2) Variolic virus never gives vaccine to the cow or horse. (3) Vaccine is not even *attenuated small-pox*, and cannot be compared to the benign anthracoid infection which is communicated to animals by inoculation with *attenuated anthracoid virus*. (4) If vaccine is a derivative of small-pox it is by reason of a *radical transformation* of the variolic virus, a transformation thus far unattainable by experimenters. (5) These last propositions lead to another more general proposition, which is this: the *attenuation* of virus is not a physical process which can be identified with the *transformation* of virus.

This being granted, how, it may be asked, does vaccine virus confer immunity from small-pox?

If we do not know exactly the mechanism of this immunity, the essential cause on which it depends is well known. On reviewing all the systems of preventive inoculation, we come upon three methods which may be treated under the following heads:

(*a*) Fabrication of prophylactic substances by pathogenic agents outside of the organism to be rendered immune, and the introduction into this organism of the said substances in sufficient quantity to confer immunity, these substances having been, by the proper manipulations, freed from the virulent elements properly so called, and rendered inoffensive.

(*b*) Fabrication in the organism to be protected of prophylactic substances by the pathogenic agents with the germs of which inoculation has been made, under conditions which insure the benignity of their infectious effects.

(*c*) Fabrication of the vaccinal substance by a virus very like the virus against which immunity is sought, but belonging to another species.

In this latter category, Chauveau places the microbe of chicken-cholera in its function of conferring immunity against charbon. Here, also, he would put the virus employed as a preservative from small-pox. Whatever, in fact, may be the origin of vaccine, though we were to admit it to be a derivative of small-pox, in his opinion it none the less constitutes in reality a morbid species distinct from the latter. The two viruses, vaccinal and variolic, are, according to Chauveau, irreducible into one and the same infectious entity.

Satisfactory experiments of this kind are difficult of performance, for no experimentation on animals can be regarded as complete whose results have not been checked by inoculations practised on the human subject. Now, Haccins and Eternod did not try their lymph—rendered vaccinal, as they believed, by several removes—on the unvaccinated child, nor did Chauveau make any such trials. (*Boston Med. and Surgical Journal*, 1891.)

On the other hand, it appears that the experiment has been tried upon unvaccinated children in Calcutta, as detailed by the experimenter, Dr. W. J. Simpson, medical officer of health of Calcutta, at a meeting of the Calcutta Medical Society, April 13, 1892.

Dr. Simpson comments upon Chauveau's experiments as follows: "Seventeen animals were inoculated by that commission with lymph from virulent cases of small-pox, and some small papules were obtained, the secretions from which, when inoculated into other cows, gave rise to papules of an insignificant kind, but which when inoculated into children gave rise to small-pox. On this slender foundation the theory has been based, and is very forcibly put forward, that small-pox in man produces a real small-pox in the cow totally differing in every respect from cow-pox.

To those who have studied the subject these experiments are by no manner of means conclusive. They only show that Chauveau with his coadjutors failed to inoculate the cows successfully, and that the papules raised were rather due to the irritation of the points of insertion by the small-pox lymph, and that the serous matter taken out of these papules was the small-pox lymph itself, which had remained in them unchanged; and under these conditions it was not surprising that

small-pox was produced in the children inoculated with this virus.

Nothing further was attempted in the way of experiment until Dr. Klein, in 1879, inoculated thirty-three cows with small-pox lymph, but failed to raise any vesicles on the cows. Papules appeared in some of the cows at the seat of inoculation, but these were not considered to have turned the experiments into a success, and no serum was taken from these papules and inoculated into children. If such a procedure had met with favor, there would probably, as in Chauveau's cases, have been an after-history of small-pox in the children inoculated.

Dr. Klein's failure served to accentuate the theory based on Chauveau's disaster, and both failure and disaster were employed as a basis on which arguments were founded against the pathological identity of small-pox and cow-pox. So confident have the supporters of this view since become, that strong doubts have been expressed by them as to the genuineness of the experiments performed by previous observers. A favorite argument appears to be that what was accomplished in the earlier part of the century cannot be done now, and therefore the experiments are not altogether to be trusted. The reason of this is not far to seek. All the conditions under which the cow may be successfully inoculated are not known, and hence it is not every cow that can be inoculated with success. This entails on the investigator much expense, the exercise of a great deal of trouble and patience, and of course it is much easier to read up the subject as Professor Crookshank has done, and side with the view for which you may have the greater predilection, than thoroughly to investigate the subject, not being satisfied with dubious results.

Apart from the controversial question, it has for a long time been a matter of thought with me as to whether there is any relationship between cow-pox, horse-pox, sheep-pox, and small-pox; whether these four diseases have for their cause a common origin which may be designated by the letter x, this common origin having not yet been discovered; or whether horse-pox, cow-pox, and sheep-pox, or any of them, are descendants of small-pox; or thirdly, whether small-pox may be looked upon in the light of a parasitic disease which comes to its full development in man, enters some animal as the cow, losing that which gives it its infectious properties, and then in some other animal unknown as yet, or in the soil, regains that element which it had lost in the cow, and which once more renders it infectious.

I am inclined to think that it is in this latter direction that investigation will ultimately succeed in discovering the cause of the periodicity of small-pox.

Vaccine and chicken-pox have always seemed to be two elements of small-pox which have become separated in some unknown way, the vaccine retaining the peculiar qualities belonging to the small-pox which affects the body in such a manner as to render it immune from a second attack, while the chicken-pox has none of these qualities but has retained the infectious element. If this were true, it might seem to be easily proved by experiment. I have tried the experiment by mixing the two viruses, but without success. There is a difference, however, between mixing and combining, and it is possible that the conditions which affect this have to be found in some other less simple way.

It is for the reasons stated, and for some others which I need not mention here, that I have been engaged for years, as opportunity arose, in experimenting with small-pox on animals.

When in Aberdeen I used to search the farms in the country for cow-pox, and not without success. I have inoculated cows, horses, sheep, pigs, goats, fowls, monkeys, and dogs with small-pox virus to ascertain the result, and in these experiments I have succeeded incidentally; for it was not the primary object for which I began the investigation, in converting small-pox into ordinary vaccine by passing the virus from an unprotected small-pox patient through the cow.

In December, 1884, I first succeeded in raising a vesicle in a cow after inoculation with small-pox virus. The lymph was transferred to a ewe lamb, and raised a vesicle in every appearance similar to a vaccine vesicle. This lymph was taken and introduced into a young pig six weeks old, and here it was lost.

In November, 1885, with small-pox lymph from an unvaccinated patient, I inoculated a cow with fifth-day lymph, and a ewe with eight-day lymph from the same patient. Both presented vesicles on the seventh day, the lymph of which I sent to London to be used by Dr. Cory, the director of the Animal Vaccine Institute in London. This calf-lymph, which Dr. Cory passed through a second calf before using on children, was the starting of a new stock of vaccine at the Institute.

Between November 21, 1885, and May 6, 1886, 1,247 children had been vaccinated with this lymph, and gave 98.4 per cent. insertions of success. Meantime another observer has come forward with experimental evidence as to the close relationship between small-pox and vaccine.

Dr. W. G. King, of Madras, inoculated a calf with small-pox lymph of five days' duration, and in this a crop of secondary vesicles appeared on the eighth day. From this lymph another calf was inoculated, and there was also in this second calf a crop of secondary vesicles, with the addition that every insertion had also taken. A third and fourth generation was passed through other calves, with the insertions always taking, and no appearance of secondary vesicles forthcoming; after which the lymph in the fifth generation was used on children with the most satisfactory results. From this stock 4,240 British and native soldiers have been vaccinated, and a very large number of the native civil population, with most gratifying results, the percentages of success being much above that which was obtained from the lymph in use.

On March 4th, in the presence of three physicians of Calcutta, I inoculated a young calf with lymph from a small-pox patient on the fifth day of the eruption. On the three following days other calves were inoculated with lymph from the same patient, with lymph respectively aged six days, seven days, and eight days.

As these three last were unsuccessful, nothing further need be said concerning them. The history of the first case and the appearances noted day by day, I need not give here in detail. Suffice it to say that on the 9th of March, that is, on the sixth day of inoculation, three papules appeared in the groin and abdomen at places where there had been no punctures or incisions, and that these three papules developed the next day, on the 10th of March, into vesicles. Two of the incisions and one puncture also contained lymph. Lymph from these was taken and inserted into another calf, designated calf No. 5. Whether the papules which developed into vesicles were secondary, or caused by the rubbing of the loose skin of the abdomen, it is difficult to say. The secondary vesicles appeared on a part where the folds of the skin were likely to come in contact. Three days later, on the 13th, the vesicles, notwithstanding the fact that lymph had been taken from them on the 10th, had developed still more. On the thigh also had appeared another well-marked vesicle. With lymph from each of the vesicles a second calf, calf No. 7, was inoculated. On the 14th of March two other apparently secondary vesicles made their appearance. From the lymph extracted from one of these a child was inoculated, but it failed to take.

Both calves Nos. 5 and 7 took successfully. From calf No. 5, on March 15th, that is, the sixth day of inoculation, lymph was taken from some of the vesicles and inserted into a male child named Bonwari, and also into calf No. 10, and on the evening of the 16th lymph was taken from the other vesicles and inserted into the arm of child No. 2, Rukhua by name, and also into two calves, calf No. 11 and calf No. 12.

Calf No. 10 showed signs of being ill a day or two after, and only gave very indifferent results. The child Bonwari had, however, at the points of insertion two splendid vesicles, which ran the ordinary course of vaccine vesicles. Calf No. 11 was not successful. But calf No. 12 showed very fine vesicles indistinguishable from

those in ordinary calf vaccination. This was transferred from calf to calf through several generations.

The child Rukhua had excellent vesicles. There appeared on its body a slight lichenous eruption, but nothing more.

From Bonwari there has, up to now, been a direct descent of nine generations in children, each showing splendid vaccine vesicles, much more typical in every respect than that obtained from the lymph which had been previously in use.

From Rukhua there have been made direct nearly the same number of generations in children, and with equally satisfactory results. I stated that No. 7 calf, inoculated three days later than calf No. 5 from calf No. 1, was also successful. From calf No. 7 lymph was taken and inserted into the arm of Bassunto, child No. 5, on March 19th, and at the same time three calves were inoculated.

The three calves took, but since they were not in very good health, I thought it best not to use the lymph. (We had, unfortunately, got rinderpest among the calves.)

The child's arm, however, took splendidly, and from it other children were vaccinated with good results.

A curious incident occurred in the course of these investigations. My wife, who drew for me the vesicles on the calves, got two well-marked vesicles on her upper lip. In pointing out the parts to her on calf No. 7, I used her pencil, passing it over the vesicles. In using the pencil she put it to her lips. In a few days after there appeared on the lips two vaccine vesicles, one of which, in spite of applications of corrosive sublimate and carbolic oil, went through its natural course.

This very clear statement by Dr. Simpson was corroborated by the testimony of four other English physicians and several native physicians of Calcutta, who witnessed the experiments and testified that the result of passing small-pox virus through these calves was to produce typical vaccine vesicles.

In reply to inquiry as to precautions taken, Dr. Simpsou stated that at every stage of the procedure new lancets were used, and that the first calf was taken directly into a small-pox ward and inoculated from the pustules of a small-pox patient." (*Practitioner*, vol. xlix., July, 1892, p. 73.)

Still more recently, Dr. Thomas W. Hime, of Bradford, England, communicated an article to the *British Medical Journal*, in July, 1892, in which he details certain experiments of a similar character. He inoculated a calf with variolous lymph, and succeeded in obtaining a product which, when inoculated upon three other calves and one man, produced the characteristic symptoms of vaccinia. Seven persons were vaccinated from one of these calves with the same results, good vaccine vesicles being thus produced.

ANIMAL VACCINATION.—Public vaccinal institutes for the propagation of bovine lymph exist in Italy, Russia, Belgium, Germany, England, Switzerland, India, and Japan.

The places in Italy where such institutes exist, and the dates of their establishment, are as follows: Naples, 1849; Bologna, 1868; Milan, Bergamo, 1869; Ancona, Foggia, Genoa, Venice, Arezzo, and Verona, 1870; Vicenza, 1871; and Rome, 1872.

Those of France are located at Lyons, Saint-Etienne, Montpellier, Toulouse, Bordeaux, and Lille. There are also several private establishments in Paris.

In Germany the use of animal lymph for vaccination is yearly becoming more general, and is encouraged in the orders of the Imperial Board of Health, which makes an annual report upon the subject. The last report of that Board gives the statistics of twenty-five German cities in which are establishments for the production of animal lymph under careful supervision. Each establishment has a director, assistant, veterinary surgeon, and one or more attendants.

Only strong and healthy calves were employed for the purpose, the average cost of each being 9 to 12 marks ($2.10 to $2.75).

The principal expenses of these establishments were as follows: Salaries—director, from $115 in Weimar to $1,200 in Berlin; veterinary surgeon, $26 in Weimar to $350 in Darmstadt; clerk, $23 in Weimar to $108 in Munich; rent of establishment, $35 in Weimar to $370 in Stuttgart; procuring animals and transportation, $42 in Schwerin to $425 in Munich; care of animals, $25 in Weimar to $825 in Oppeln; heating, light, and water-supply, $2.50 in Cannstadt to $80 in Munich; cleaning, washing, and disinfection, 70 cts. in Bautzen to $35 in Berlin; packing lymph and postage, $10 in Cannstadt to $250 in Berlin; expenses of instruments, apparatus, etc., $2.50 in Bautzen to $190 in Stettin; miscellaneous, $3.00 in Schwerin to $350 in Munich.

Feeding.—The calves used for vaccination were usually fed with warm cow's milk. In the case of animals which were not very strong, two or three eggs daily for each animal were added. In the majority of instances the calves increased in weight while at the establishments, the average increase being about 2.5 kilos. (5½ pounds).

The number of animals employed in all the twenty-five cities during the year 1891 was 1,272. The greatest number employed in any one city was 149 in Cologne, and the least number, 5, in Lubeck. Their ages varied from two or three weeks to two years. The greater number were about three months old. In Stuttgart and Carlsruhe, heifers of one or two years were employed. Most of the animals were of Dutch breed, and weighed about 80 kilos. (170 pounds).

The average temperature of animals at entrance was 39.3° C. (102.8° F.), and the average temperature at the time of taking lymph was 40.4° C. (104.7° F.).

For the vaccination of animals, calf lymph was used in the greater number of instances. In some cities both humanized and animal lymph were employed. No humanized lymph was used for the purpose in Berlin, Oppeln, Leipzig, Stuttgart, Cannstadt, Carlsruhe, Lubeck, Bremen, Hamburg, and Metz.

In Munich, 76 animals were vaccinated with glycerinized human lymph.

For the purpose of vaccination, scalpels were usually employed, and these in some instances were preferably dull, the skin being scarified or slight incisions were made. In some instances instruments specially designed for animal vaccination were employed. In some of the cities disinfectants were used for cleansing the hands, instruments, and occasionally the skin of the animal. In Munich, the instruments were carefully sterilized with steam or dry heat. The place selected for vaccination was the belly from the navel backward. The milk-mirror was found to be less fitted for vaccination in consequence of its loose structure and tendency to scab or crust.

It was generally found that diarrhœa among calves stopped the development of lymph vesicles.

Product of Vaccine Establishments.—The amount of lymph obtained during 1891, in those establishments where the product was carefully weighed, was about 12,000 grammes, being an average of about 10 grammes per animal. The whole amount was sufficient for the vaccination of nearly four million children.

Collection and Preservation of Lymph.—Considerable difference prevailed in the different cities, as to the time in which lymph was considered to be sufficiently mature for collection. The following are noted with reference to the principal cities:

In Königsberg, 73 to 119 hours after insertion of lymph.

In Berlin, usually 72 hours. In a few cases 6 hours earlier, or 3½ hours later.

In Hanover, 96 hours, in a few cases 82 hours.

In Munich, at end of the fourth or beginning of the fifth day.

In Dresden, 3 to 4½ days.

In Bautzen, 86 hours.

In Cannstadt, 87 to 97 hours.

In Carlsruhe, as a rule 84 hours.

In Darmstadt, 72 to 135 hours.

In Weimar, 84 to 96 hours.

In Lubeck, 5 times 24 hours.

In Hamburg, 5 times 24 hours in winter. 4 times 24 in summer.

In Strasburg, 117 to 144 hours.

The variability in time is partly explained by the more rapid maturing of the vesicles in summer than in winter.

In Berlin, portions of the lymph collected were made into dry preparations, and the balance was prepared as an emulsion with glycerine. For this purpose Döring's lymph mill was quite generally employed. This machine is represented in Fig. 653. This preparation contains 1 part crude lymph, 2 parts glycerine, and 2 parts of distilled and sterilized water. It is quite liquid and is readily used. It settles or separates a little on standing, so that the mixture must be shaken before it is used. The separation has not resulted in any failure in practice. The machine for preparation of the lymph has usually worked well.

In Cologne, before gathering the lymph, the animals were slaughtered outside the vaccine establishment, and were then laid upon a portable stand arranged for the purpose. It consists of a trestle or frame made of wooden slats, placed in an inclined position, and hollowed out to allow the water used in cleansing to run off. Under this is a sheet of metal, also curved, which catches the water and conveys it to a receptacle which also holds the head of the animal and its blood. An iron upright at the centre and side of the frame is used to fasten the right leg of the animal. This apparatus can be cleaned easily, and needs but little repairing.

Delivery of the Lymph.—A careful record is kept at each establishment of the date of sending, quantity, recipient, and other important items. By far the greater quantities were furnished in the months of May and June. The recipients were classified into public vaccinators, private physicians, and military physicians. The former class used by far the greatest quantity of lymph.

Sending and Packing of the Lymph.—The usual mode of sending lymph from the stations in the German cities is by mail in capillary tubes, usually containing about enough for 5 vaccinations, and in large glass tubes containing 50 or 100 such portions. These are securely packed in wooden or pasteboard boxes, with directions for use accompanying them.

In most of the cities, test vaccinations were made upon calves for the purpose of proving the efficiency of the lymph before forwarding it. In times of unusual demand, however, this practice was omitted.

The Efficiency of the Vaccinations.—The results are stated with great care, both as to the number of persons vaccinated, as well as the number of insertions or separate scarifications made.

The superintendent of the vaccine establishment at Halle made 804 revaccinations, with the following results:

Number of children.	Number of vesicles.	Description of the vesicles.
418	2,371	Like those of primary vaccinations.
211	1,095	Fully developed vesicles, but in shorter time.
123	667	Producing crusts which covered the entire scarified surface.
52	306	Nodules with reddened areolæ.

In Leipzig observations were made upon 22,158 primary vaccinations, in which the successful vaccinations amounted to 21,982, or 99.21 per cent.; partially successful, 145, or 0.65 of one per cent.; and unsuccessful, 31, or 0.14 of one per cent. Of the revaccinations, 15,115 out of 16,706, or 90.48 per cent. were successful.

Duration of Efficiency.—Lymph, when carefully preserved at an even and low temperature, retained its efficiency from two to four months, and even longer.

Lymph used at stations was usually quite fresh, but private physicians often found it efficient at the age of several months. Tests were made at Stettin of lymph, 46, 81, 102, 138, 153, 175, 178, 229, and 249 days old, and in each case it was found to be efficient. The lymph was preserved in glass tubes.

Some lymph was sent to Madras from Berlin, February 17, 1891, and a calf vaccinated with this lymph on the 17th of March, had 101 good vesicles out of 121 insertions. This was also successfully transmitted from this calf to others. In some cases lymph sent to places in hot climates proved without effect.

Diseases Following Vaccination.—Vaccine physicians are instructed to make special observations upon this point. Out of the immense number of vaccinated persons in Germany, but very few cases of erysipelatous eruptions, swelling of the axillary glands, and slight skin eruptions of a temporary character were recorded, and no cases of syphilis were mentioned.

Preparation of Lymph.—The following account of the method of preparing vaccine lymph at Berlin is given by Professor Albert Guttstadt, in an article entitled "Das Impfwesen in Preussen in 1887–88," in the "Zeitschrift des Konigl. Preuss. Statistisch Bureaus, 1890."

The skin of the calf is first washed with warm soap and water. The incisions then show clearly, and the lymph is taken out with a sharp spoon, shaped like a potato-borer.

The lymph was at first mixed with glycerine in a porcelain mortar, but afterward a machine was employed which was designed by the assistant, Dr. H. Döring.

This apparatus, the "Döring Lymph-mill," is the result of several trials, and consists of an iron frame fastened to an iron plate, supporting four cylinders of porcelain having roughened surfaces. These cylinders are removable, and may be sterilized.

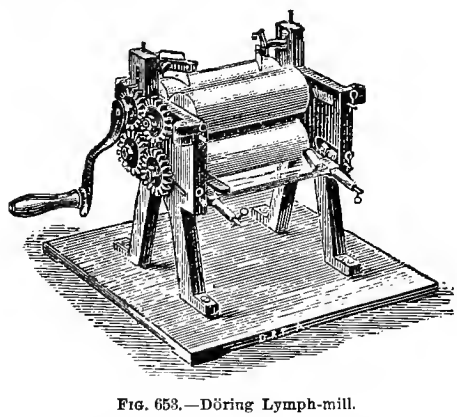


Fig. 653.—Döring Lymph-mill.

The difficulty of obtaining porcelain cylinders of regular shape necessitated careful adjustment of the iron axes. Each cylinder, therefore, must be placed in its own socket, and the axes are adjusted by springs. The slots in which the cylinders play are so arranged as to bring the cylinders into close contact.

The lymph, when introduced, passes between the cylinders, and is scraped off by a glass plate which is held against one of the lower cylinders. It then falls into a rectangular glass dish. In order to keep the lymph from spreading out at the ends of the cylinders, glass shields at each end keep the mass within bounds. The cylinders are easily removed and replaced.

The lymph is first mixed by light stirring with one-third of its weight of glycerine, and is then placed on the line of contact between the cylinders, a little at a time, while an assistant turns the handle. In a few moments the finely mixed lymph mass is scraped off from the last cylinder by the glass shield, and caught in the dish below. After the whole mass has passed through the apparatus, it is stirred with a glass rod, with the addition of more glycerine, and is passed through the mill again. It is advisable, after emptying the lymph upon the cylinders, to scrape the dish to avoid loss. The lymph is then ready for use. The loss is at the utmost 0.5 per gramme. From 20 and 25 grammes of raw

lymph may thus be easily prepared for use in thirty-five minutes.

On May 22d, there was prepared 200 grammes of raw lymph from ten calves, making in all 800 grammes of finished product in two hours.

The apparatus, exclusive of the plate in which it stands, is about twenty centimetres (eight inches) in each dimension. Accompanying each apparatus are two rectangular dishes and glass scrapers, a spatula to collect lymph, a clamp, screw-driver, and oil-can.

The apparatus is sold by Julius Schober, Adalbert Street, 39, Berlin.

In May and June the delivery of the lymph was limited almost wholly to a mixture of the product of several animals. Sometimes 2, 3, 4 or 5 animals are required, and once a mixture of the lymph of 13 animals was used.

The form of lymph used has been almost wholly the glycerine emulsion. A small quantity was employed in the form of powder. For the purpose of preservation, Erlenmeyer flasks were used, sterilized, stopped with sterilized wadding, covered with a rubber cap, and placed in a refrigerator. Just before sending out, the emulsion is put into small sterilized bottles, stopped with corks. Capillary tubes are rarely used.

In Hamburg lymph is gathered by means of forceps. It is collected on the fourth or fifth day. An emulsion is made by rubbing with a rough glass pestle in a roughened glass mortar, the proportions being one part of the raw lymph and two parts of purest glycerine. The finished product is deposited in an ice-chest.

The following simple method is employed in Hamburg for transferring the emulsion to small glass receptacles.

A thick glass tube, shaped like a glass syringe, bent, and without a piston, is employed. The cylinder is 8 ctm. in length ($3\frac{1}{5}$ in.) and 12 mm. in diameter ($\frac{1}{2}$ inch). The point is bent at an angle of about fifty degrees from the axis of the cylinder, and consists of a tube 4 ctm. ($1\frac{2}{5}$ inch) long, by 3 mm. ($\frac{1}{8}$ inch) interior diameter.

The mouth of the tube is stopped with a cotton pledget. The cylinder holds 10 gms. or more. The finger is applied to the top of the cylinder, and the emulsion allowed to flow out, the finger controlling the flow. (Fig. 654.) The hands must be disinfected, and the tube and receptacles sterilized by boiling.

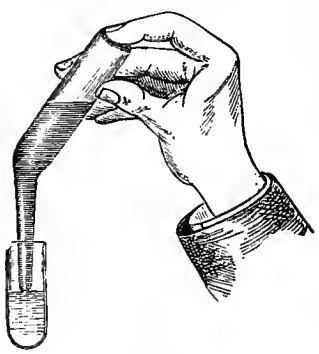


Fig. 654.

The apparatus is sold by L. Bartels, of Hamburg, Grossereichen Strasse, 67. Price, 20 pf. (5 cents) each.

In commenting upon the different forms of employing lymph Layet states three general modes of use :

1. Lymph diluted with a convenient excipient.
2. Pulp resulting from scraping or shaving the vesicles.
3. Lymph dried and reduced to a powder.

Layet does not approve of ivory points as a successful method of employment. (Nevertheless, ivory points to the number of several millions have been used for vaccination with good success in the United States, where they have constituted the chief method of using lymph since 1871.)

In describing the different modes employed in Europe Layet enumerates the following, some of which are merely experimental and but little used :

The *pâte Milanaise* is made by scraping the vesicles and the surrounding skin, and mixing the whole with glycerine in the proportion of $\frac{1}{2}$ gm. to each vesicle. This pulp should be used immediately, or within a very few days.

Reissner's powder (Darmstadt), consists of lymph dried under a bell-glass in the presence of sulphuric acid, and reduced to a powder. When used it is mixed with equal parts of glycerine and water. (For further information in regard to this powder, consult Reissner : Über eine einfache Methode zur Aufbewahrung thierischen Impfstoffs, Deutsch. Med. Woch., 1881.)

The extract of Pissin is another form of dried lymph.

The pâte and powder of Schmitt & Wolfberg, of Bonn, is a mixture of powdered lymph and dextrine dried, with or without the addition of bicarbonate of soda. Moistened with a little water it makes a syrupy mixture and it is claimed to be active for six months. (Schmitt & Wolfberg : eine Modification der Reissnerschen Methode zur Gewinnung anim. Lymphstoff, Berlin. klin. Woch., 1886.)

Vaccination in Japan.—Vaccination has made rapid progress in Japan since its introduction there. It appears from the Government reports that calf-lymph is now very largely used. The vaccine farm was at first under control of the Government, but was finally intrusted to a private association. February 16, 1888, a commission was appointed to investigate the subject of the preservation of lymph, so that it could be distributed to distant places and still be used with efficiency. This commission proceeded to the pasture-ground of Misawa Mura, reaching it March 25th, from which date their experiments were continued through the summer. The experiments were in two series, one extending over one hundred and four days, and the other for four hundred and fifteen days, and the experimenters concluded that stored lymph could be successfully used for two hundred days.

Information is not given as to the mode of preservation.

The instructions issued to the association when the work was intrusted to it, were as follows :

1. The business of the farm shall be under the control of the Director of the Sanitary Bureau.
2. The association shall not neglect to make improvement, but shall endeavor to supply good and efficient vaccine lymph.
3. The vaccine lymph shall always be stored in sufficient quantities to meet the demand.
4. The regulations of the vaccine farm shall be made by the association, and shall be reported to the Director of the Sanitary Bureau, and a similar report shall be made if they should be altered.
5. The principal of the vaccine farm shall be appointed by the association, and his appointment shall be reported to the Director of the Sanitary Bureau.
6. The price of lymph shall be fixed by the association, and shall be reported to the Director of the Sanitary Bureau, and the same shall be done if the price should be altered.

In a report upon the subject of compulsory vaccination and revaccination by Dr. E. Deschamps, before the Society of Public Medicine and Professional Hygiene, April 22, 1890, the writer sums up the advantages of animal vaccination briefly as follows :

Ease of production in unlimited quantities, good prophylactic power, and impossibility of transmitting diseases peculiar to man, and especially syphilis.

With reference to the question of the possibility of transmitting tuberculosis, he first says, that if tuberculosis is transmissible by bovine lymph, there is no reason why it should not be just as transmissible by humanized lymph.

But experiments show that the bacillus tuberculosis does not readily find its way into vaccinal lymph. L. Meyer, in 1892, examined the vaccine lymph of four tuberculous adults and found no tubercle bacilli. Experiments of Josserand in Chauveau's laboratory demonstrated that vaccine lymph from tuberculous subjects, inoculated in guinea-pigs, in the conjunctiva and peritoneum, did not produce tuberculous infection. In 1884 Strauss examined the vaccine lymph of five women well advanced with phthisis, without finding tuberculous bacilli. This lymph inoculated upon rabbits did not render them tuberculous.

In summing up the question, Dr. Deschamps con-

cludes that "Vaccination, especially when followed by revaccination, prevents the spread of small-pox.

"In countries where vaccination and revaccination are obligatory, small-pox has almost entirely disappeared.

"When performed in a proper manner, with calf-lymph, they are devoid of danger. Compulsory vaccination and revaccination should be legalized in France."

On the Preservation of Lymph in Glycerine.—Dr. Sclavo, in a paper on the preservation of different kinds of virus in glycerine, mentions the quality which glycerine possesses, of preserving the effective quality of virus for a considerable length of time. He quotes the experience of Roux and of Uffreduzzi, the latter having preserved the virus of rabies unaltered for six months.

He was induced by these facts to extend his experiments to other pathogenic bacteria and to test the effect of glycerine upon them.

Three different kinds of pathogenic bacteria were thus subjected to this experiment by Dr. Sclavo. He concluded that if later research should confirm his experiments and prove that glycerine has the power of preserving the vitality of other micro-organisms, the bacteriologist would thus have a preservative which might serve to maintain some of the germs which, like the diplococcus of Fraenkel, rapidly lose their vitality in the ordinary culture media. This property would prove an efficient aid when it should be necessary to transport pathogenic virus from one place to another for purposes of study and experiment.

Dr. Deschamps, in an article in the *Revue d'Hygiene*, August, 1892, relates an instance in which M. Trapp and Dr. Kireger were experimenting with vaccine lymph in Strasburg, in 1876. The latter put some glycerinated lymph into a vial closed by means of a pledget of cotton. This vial was mislaid in a closet, and was not found again until M. Trapp found it in 1887, eleven years after. Meanwhile the closet had been exposed to extremes of temperature in summer and winter. The contents of the vial remained unchanged.

The lymph was used to vaccinate a calf, and produced normal pustules.

Dr. Deschamps quotes the advice of several prominent vaccinators as to the period during which glycerined lymph should be used. Le Clerc, Deutl, Vallin, Warlomont, Vaillard, and Mangenot give different periods, from eight days to several months.

Chambon and St. Yves Menard have sent their preserved lymph to many distant countries—Madagascar, North and South America, Brazil, the West Indies, and the islands of the Pacific, in some of which it was used successfully, where the heat was 135° F. in the sun and 90° F. in the shade. Dr. Deschamps concludes that this form of prepared lymph can be safely used during the six months after its collection, and preserves its efficiency during that time.

Bacteriological Investigations.—The following brief summary presents the principal points relating to the bacteriology of vaccine lymph:

Cohn distinguished, under the name of the vaccine micrococcus, round bacteria, united together in chains or little rolls, which he observed in the lymph of vaccine vesicles (*Virchow's Archiv*, 1872).

Quist, of Helsingfors, made a culture of vaccine in serum of beef with glycerine. At the end of eight or ten days a thin pellicle of micrococci had formed. A child inoculated with this culture had a true vaccine vesicle, with immunity against revaccination. This experiment was not confirmed (*St. Petersburg Med. Woch.*, 1883).

Ferré detected in vaccine lymph a peculiar microbe, rounded or crescent-shaped, very movable, and provided with two little projections on opposite sides. A similar microbe has been described by Professor Jolyet, of Bordeaux (*Revue Sanit. de Bordeaux*, 1873).

Voigt mentions three species of micrococcus, one liquefying gelatine, another non-liquefying, and still another having no special characteristics (*Deutsch. Med. Woch.*, 1885).

Bauer found in vaccine lymph, besides other ill-defined organisms, spherococci, solitary or disposed in groups of two or four, or in the shape of little chains. The groups of four appear in fresh lymph, and the chains in old lymph (*Centralblatt für d. Ges. Therapie*, 1885).

Other observers (German and Italian, in 1886 and 1887), Tenhot, Garré, and Marotta, claimed the discovery of certain micro-organisms in vaccine. Garré succeeded in producing good vesicles in the calf and immunity, but was not able to produce them in man (*Deutsch. Med. Woch.*, 1887).

Pfeiffer found in vaccine lymph a fungus which he called *saccharomyces vaccinæ*, also the sarcina lutea and s. anrantiaca, common in air, and micrococcus pyogenes aureus and *cereus albus*.

For several years the Grocers' Company of London has offered a prize of £1,000 ($5,000) to any one who should discover a method of culture of vaccine outside the living animal organism. Patient investigators are busily employed with this end in view. In commenting upon this inducement, Professor Layet says: "C'est là un sérieux stimulant, mais nous doutons fort que quels que soient le microbe reconnu spécifique et les procédés de culture employés, on puisse jamais reproduire la substance vaccinale chimique qui seule s'élabore au sein des tissus vivants dans la zône lymphogène de la pustule."

Analysis of vaccine lymph to determine its physical properties.

Messrs. Schulz and Weyl, contribute to *Koch's Zeitschrift für Hygiene* the following:

Analysis of Reissner's lymph powder: A portion weighing 2.95 gm. was examined, and found to be a colorless, partially powdered, and filamentous mass. It was ground fine in an agate mortar, and one part (0.924 gm.) was dried at 105° C.

The second part (1.903 gm.) was boiled in 200 c.c. of absolute alcohol for two hours. The residuum was treated for two hours more in the same manner and evaporated at 80° C.

The following was the result of the analysis:

Reissner's Lymph Powder.

	Containing water, per cent.	Water free, per cent.
Water	10.22	.....
Ash	4.7	5.2
Ash, soluble	12.6	12.6
Ash, insoluble	87.3	87.3
Alcohol extract	2.5	2.8
Ether extract	35.3	39.35
Insoluble tissue	47.28	52.65

The amount of ether extractive is noteworthy. An experiment with dialysed lymph inoculated upon three children, and also upon calves, was without any result.

Another experiment was made in which lymph was filtered through a Chamberland filter. The product was clear, colorless, and germ-free.

Humanized and bovine lymph were both filtered in this manner, and the filtrate inoculated upon children and calves without result, proving that the efficiency of vaccine lymph is due to germs which cannot be filtered through.

Experiments in Immunity.—Certain experiments in vaccination by Strauss, Chambon, and Menard are detailed in the "Transactions of the Soc. de Biologie," December 20, 1890 (*Compt. Rendus*, "Soc. de Biolog.," 1890, p. 721), of which the following brief summary is presented:

1. Inoculation of vaccine lymph upon the cornea of a calf produced intense iritis with opacity of the cornea. Immunity also resulted in the case of this animal.

2. Intravenous injection of vaccine lymph into the jugular vein also produced immunity in another animal.

3. Transfusion of one thousand grammes of the blood of a calf at the time of the height of the vaccine eruption into another calf gave negative results. The second calf was found capable of contracting cow-pox.

4. Injection of sixty grammes of the blood of a calf at the full eruption of vaccinia was made under the skin of

another calf without results. This second calf was afterward successfully vaccinated.

5. Transfusion of the blood of a calf having vaccinal immunity into another unvaccinated calf. This experiment demonstrated that almost all of the blood (*la presque totalité*) of a calf having vaccinal immunity might be transfused into an unvaccinated calf without producing immunity in the latter.

6. An experiment in which filtered vaccine lymph was subcutaneously inoculated into a calf showed that immunity was not conferred by this process.

Alleged Harmful Results of Vaccination.—At least seven hundred thousand vaccinations were performed in England and Wales in 1888, according to the Report of the Local Government Board upon that year, and in the course of the year representations were received by the Board from ten sources, alleging injury of one or another kind to have resulted from vaccination. Inquiry showed that two of these cases were measles and whooping-cough concurrent with vaccination, two were skin eruptions following vaccination, and the remainder were cases of erysipelas or similar disease.

Mr. Jonathan Hutchinson, a member of the Royal Commission upon Vaccination, and an acknowledged authority upon the subject of vaccinal eruptions, stated that although three-quarters of a million vaccinations have been made annually for several years, the Local Government Board had not found a single instance of syphilitic communication by means of vaccination (*Lancet*, i., 1891, p. 204).

At the annual meeting of the British Medical Association at Birmingham, in 1890, Dr. Malcolm Morris read a paper upon the subject of vaccination eruptions in which he presented the following conclusions :

1. That pure calf-lymph should be used when possible.

2. That it is desirable that vaccination should be performed in children not later than six weeks after their birth.

3. That strict antiseptic and protective treatment should be carried out immediately the vesicles have developed.

4. That the cases should be seen by the vaccinator until the wounds have healed.

5. That eczema, psoriasis, and other skin diseases should be treated immediately they appear.

A full discussion of the subject endorsed the foregoing conclusions (*Brit. Med. Jour.*, 1890, ii., 1229).

The British Parliamentry Commission of 1889.—From the very beginning of the introduction of vaccination opposition has been manifested to its practice, the degree of resistance differing much in different countries. In England several Parliamentary inquiries have been held upon the subject, the general result of which has been a confirmation and strengthening of existing laws upon vaccination. The last Parliamentary Commission appointed to consider this subject was that of 1889, and this commission has not yet reported in full. The commission consists of fifteen members, of which Lord Herschel is chairman. It has published several reports of evidence but no final conclusions. One interim report (1892) relates entirely to the question of repeated penalties and the treatment of prisoners under the Vaccination Acts. Many witnesses have been examined by this commission, including such noted experts as Sir John Simon, Dr. Ogle, of the Registrar-General's Office ; Dr. Buchanan, Dr. Thorne Thorne, Dr. Corey, Dr. Barry, and other officials of the Local Government Board of England. The principal advocates of repeal of the compulsory laws were Alfred Russell Wallace, LL.D., Messrs. Alexander Wheeler, William Tebb, and others.

The points which this Commission was charged to consider were the following :

1. The effect of vaccination in reducing the prevalence of, and mortality from, small-pox.

2. What means, other than vaccination, can be used for diminishing the prevalence of small-pox, and how far such means could be relied on in place of vaccination ?

3. The objections made to vaccination on the ground of injurious effects alleged to result therefrom ; and the nature and extent of any injurious effects which do, in fact, so result.

4. Whether any, and if so, what means should be adopted for preventing or lessening the ill effects, if any, resulting from vaccination ; and whether, and if so, by what means, vaccination with animal vaccine should be further facilitated as a part of public vaccination.

5. Whether any alterations should be made in the arrangements and proceedings for securing the performance of vaccination, and, in particular, in the provisions of the Vaccination Acts with respect to prosecutions for non-compliance with the law.

At the time of making its brief interim report, April 21, 1892, the Commission had held ninety meetings and examined one hundred and thirty-five witnesses, and had not then completed the evidence upon any one of the points to be considered. The two recommendations which it has made were substantially as follows :

1. It appears that the Courts had so construed the laws as to warrant repeated orders in respect to the non-vaccination of a child and the imposition of a penalty for the disobedience of each of such orders, notwithstanding that previous penalties have been inflicted. The Commission agreed that the imposition of repeated penalties in respect to the non-vaccination of the same child should no longer be possible. They arrived at this conclusion independently of the question whether vaccination should continue to be compulsorily enforced.

Those who favored the view that vaccination ought not to be compulsory were naturally opposed to repeated convictions ; while those who inclined to the opposite view believed that any advantage which could arise from the tendency of repeated convictions to increase the number of the vaccinated, is more than counterbalanced by the resentment and active opposition to vaccination which they engender.

2. The question having arisen whether a person committed to prison on account of failure to pay the penalty imposed under the Vaccination Laws, should be treated as a criminal or not, the Commission expressed its opinion that such persons "should no longer be subjected to the same treatment as criminals. Many of the victims of such imprisonment regard the practice of vaccination as likely to be injurious to the health of their children, and are well-conducted and in other respects law-abiding citizens. Even those who consider that the course which such persons adopt is a mistaken one, may nevertheless well be of the opinion that they ought not, during their imprisonment, to be subjected to the treatment awarded to criminals, such a proceeding not being calculated to secure obedience to the law or to add to the numbers of the vaccinated."

Dr. Alfred Russell Wallace appeared before the Royal Vaccination Commission, in 1890, as a convert to the principles of anti-vaccination, and was hailed by the opponents of vaccination with great triumph. Dr. Wallace confidently expected to demolish the arguments in favor of vaccination upon scientific principles, and appeared before the Commission with a long array of tables of statistics and diagrams which fill many pages in the Third Report of the Commission. The principal part of these statistics relates to vaccination in the departments of France for a period of about twenty years. The data presented for each department are the number of births, number of vaccinations, and number of deaths from small-pox for each year, the object being to show that vaccination increases small-pox.

These tables were taken up and carefully considered by the Commission, and, so far as Dr. Wallace's hasty conclusions were concerned, they were found to be absolutely worthless. This witness finally admitted, after retreating step by step, that his tables were "not perfect," that "the imperfection is very great and irregular." He also admitted that, if his entry of "no deaths" often meant nothing more than that there had been "no returns" (which was actually the case), "then, of course, the whole thing is imperfect," and that in view of such

a defect, which was vitally important, "the whole thing is valueless."

Criticism followed upon criticism, and at last Dr. Wallace asked that he might make a few personal concluding remarks, the pith of which had to do with suggestions from the Commission that he must have "taken up this subject and written upon it without full and accurate information befitting a man of science." And, in making the personal explanation, the previous declarations as to the absolute need for a scientific accuracy such as had controlled the labors of Darwin seems to have been forgotten, and in their place came the frank admission, "My answer is that I did not take it up as a question of pure science."

Thus ended the "absolute test and demonstration" held out at the previous session of the Commission, and the result is that the opponents of vaccination still lack a scientific statistician as an exponent of their views (editorial in *Practitioner*, 1891, vol. xlvi., p. 465).

The small-pox statistics of Prussia, which Dr. Wallace presented to the Commission, were brought down to the year 1874, and there discontinued. The compulsory law of Prussia was enacted in 1874, and Dr. Wallace admitted that "he had heard of it," but had not seen any evidence that it made any important difference.

On the contrary, there are nowhere to be found any statistics so absolutely conclusive of the value of vaccination as the comparative statistics of Prussia for the two periods before and after the enactment of the compulsory vaccination law of 1874.

The London *Lancet*, in commenting upon the testimony of this witness, says that Dr. Wallace's theory was based upon "blunders that would hardly be expected of a school-boy," and in a concluding paragraph upon the same subject affirms, "if this is all that science can do for the anti-vaccinationists, the scientific value of vaccination stands more than ever confirmed."

In commenting upon this Fifth Report of the Parliamentary Commission a well-known English physician (Dr. Dudfield) says: "It is to be regretted that at a time when, as we have seen, small-pox threatens to assume an epidemic form, a retrograde step should have been taken by the Royal Commission which is not unlikely to be attended with disastrous results, by encouraging disobedience to the law in respect of vaccination, the only, and all but specific, protection against the most loathsome of diseases."

With reference to the interim recommendation of the Commission, Dr. Dudfield further says: "Exemption from the operation of the compulsory vaccination law (and incidentally the power to spread disease, deformity, and death among the community) would be purchaseable at the cost of one pound sterling—to be paid, doubtless, by anti-vaccination societies."

It appears that the previous Commission of 1871 had made a recommendation of similar character, which was rejected by Parliament. "Whatever the decision of the Government, or of Parliament acting independently, in this question, it must surely be felt that the recommendation of the Commission is ill-timed; and, should small-pox become epidemic, may prove disastrous.

"There is only one consolation in view of this contingency, and it is that people who reject the boon of vaccination, when they have no fear of small-pox, very commonly hasten to secure its protection when the disease is prevalent, if indeed they are not, as often happens, already protected. This applies most, perhaps, in the case of the well-informed among the anti-vaccinators, the brunt of the epidemic usually falling on the poor and ignorant."

Leicester has been quoted by the opponents of vaccination as a large non-vaccinating town. (The children "unaccounted for" in the vaccination returns of Leicester, for 1883 to 1887, were 56.9 per cent. of the births, as compared with only six per cent. for all England and Wales for the same period.) "It can hardly be doubted, however, that a time will come when all the admirable precautions taken at Leicester will prove unavailing, and that its rulers will have cause to regret their disregard of Jenner's beneficent discovery, which, with a minimum of risk, which might be avoided by the use of calf lymph, has conferred incalculable benefit in every civilized community in the world, and just in proportion to the efficiency with which it has been applied."

The principal modern opponents of vaccination who have published their views upon the subject, are Professor E. M. Crookshank, Dr. Charles Creighton, Mr. William Tebb, Professor A. Vogt, of Berne, and Lorinser, of Vienna.

Dr. Creighton's views upon vaccination are sufficiently set forth in his article in the twenty-fourth volume of the "Encyclopædia Britannica," and in his book entitled "Cow-pox and Vaccinal Syphilis." In the former he takes the ground that there is neither identity nor even affinity between vaccinia and variola. He also asserts his belief that the diminished activity of variola is due to epidemiological laws, and not to vaccination. In his exceedingly superficial statement of the practical working of vaccination laws, like Dr. Wallace, he omits reference to the convincing experience of Prussia since the enactment of more efficient laws in 1874, although a dozen years or more had elapsed from that date to the publication of his article in the "British Encyclopædia."

The various publications issued by the opponents of vaccination are characterized mainly by the absence of facts, and the presentation of an abundance of theory. For example, a recent work by Mr. William Tebb, intended to prove the "synchronicity between the spread of leprosy and vaccination," introduces many arguments in support of an alleged connection between the one and the other. But leprosy produced its most disastrous effects in the twelfth, thirteenth, and fourteenth centuries, when vaccination was unknown. There were then 19,000 lazarettos in Europe. Now that the human race is much more widely distributed over the globe, leprosy is far more rare, and exists to its greatest extent in countries where vaccination is but little practised. In the United States, where probably more than three-fourths of the population is vaccinated, leprosy is confined chiefly to a very small number, among whom the disease was introduced directly from other and infected countries.

Leprosy has for many years been prevalent in Bombay, but since the introduction of vaccination there, by the British Government, the ratio of lepers has gradually diminished. The census of 1871 showed that the ratio of lepers was 8.5 per 10,000 of the population. In 1881, it was 6.1, and in 1891, only 5.3 per 10,000. The *Sanitary Record*, June 15, 1893, in commenting upon this fact very justly says: "This certainly does not indicate that there is any necessary connection between the appearance of leprosy and the practice of vaccination, unless it be that the latter is the cause of the decrease of the former. There seems to be no reasonable ground for alarm about an alleged recrudescence of leprosy."

One of the most notable publications of the past decade upon the subject of vaccination is that of Professor E. M. Crookshank, entitled "The History and Pathology of Vaccination," two volumes.

The chief value of this publication lies in the collecting together of many of the early English writings upon the subject in the second volume of the work. Jenner's original essays are here republished, together with those of Ceeley, Badcock, Estlin, Auzias-Turenne, and others.

The author himself opposes vaccination mainly upon theoretical grounds; of the practical operation of vaccination in civilized countries, he has very little to say.

He avows his belief that variola and vaccinia are entirely distinct diseases, having no relation to each other. In commenting on Ceeley's and Badcock's experiments, the latter having successfully inoculated thirty-three out of two hundred cows with small-pox lymph, and furnished lymph to four hundred practitioners for use in vaccinating fourteen thousand people, Professor Crookshank explains the matter by saying that these people were not vaccinated, but "variolated." What, then, prevented these people from spreading small-pox by infection? Professor Crookshank advocates the inoculation of

nurses in small-pox hospitals with "attenuated" variolous lymph, but advocates notification and isolation everywhere else as the chief measures of prevention.

RECENT LEGISLATION RELATIVE TO VACCINATION.—No very great or decided changes have been made in the vaccination laws of the principal civilized countries during the past five years. Public vaccination has been encouraged by the establishment of vaccinal institutes for the propagation or production of bovine lymph.

In the main, the tendency of civilized governments has been toward increasing stringency in the matter of compulsion, and at the same time a greater use of calf lymph as compared with humanized lymph.

Attempts were made to repeal the compulsory law in Holland in 1890, but without success. A meeting was held at Utrecht September 7, 1890, at which the directors of the various vaccine establishments of Holland opposed the repeal of the law. (*Practitioner*, 1890, p. 470.)

A fresh departure has been taken by the Italian Government, and the new law of Italy, adopted in 1891, is herewith presented in full.

MINISTRY OF THE INTERIOR.
DEPARTMENT OF PUBLIC HEALTH.

Special Regulations as to the Preservation of Lymph and Compulsory Vaccination.

The Secretary of State for the Interior having regard to Articles 51, 52, 53, and 62 of the Law for the "Protection of Hygiene and Public Health," after consultation with the Board of Health, decrees that these consolidated Special Regulations as to the preservation of Lymph and Compulsory Vaccination have received his approval.

G. NICOTERA,
Home Minister.

ROME, June 18, 1891.

Special Regulations for the Preservation of Lymph and for Compulsory Vaccination.

I. PRESERVATION OF LYMPH.—Article 1. By the terms of article 52 of the law for the Protection of Hygiene and Public Health, the lymph shall be preserved by the medical officer of the administrative sanitary authority for the province under the direct supervision of that authority, and the expenses incident thereto shall be charged to the province.

Article 2. The provincial authorities are empowered to preserve and provide both animal and humanized lymph to the communal authorities and to private medical practitioners.

Article 3. Animal lymph may be preserved by the aforesaid medical officer of the province, either at an institute for the production of lymph established by the provincial authority, or at an existing private institute for the production of lymph which has received official recognition from the provincial authority. In either case the institute must be put under the supervision of the medical officer. The medical officer is also empowered to make use of the National Vaccine Establishment at the office of the Department of Public Health (in Rome).

Article 4. The provincial authorities desirous of establishing an institute for the preservation and production of animal lymph, must take care to provide premises with proper stabling for the animals to be inoculated, and with suitable accommodation for the process of inoculation and the collection, preparation, and preservation of vaccine.

Article 5. The provincial authorities who desire to give official recognition to an already existing private institute shall, before giving their recognition, obtain a written certificate from the medical officer of the province, to the effect that the institute fulfils the requirements as to the premises and staff referred to in the preceding article, and that it can produce vaccine of good quality and sufficient in amount to meet the wants of the locality.

Article 6. By-laws, approved by the prefect after consultation with the medical officer of health of the province, will regulate the administration of the institute, whether established by the provincial authority or merely recognized by it, setting out the technical rules and administrative principles of its management.

Article 7. The provincial authorities desirous of making use of humanized lymph shall provide the requisite staff, premises, and materials, according to the instructions given for that purpose by the medical officer of the province.

The same officer shall supervise, or cause to be supervised, the selection of children from whom the lymph is to be obtained, and shall see that proper precautions are taken to insure a good quality of lymph and its perfect preservation.

Article 8. The provincial authorities who intend to obtain animal lymph from a private institute, or from the National Establishment in Rome, shall intrust to a specially selected sanitary inspector the duty of obtaining and distributing the lymph according to local requirements, and of supervising its use in the interests of the province. This officer is also required to collect the statistics of vaccination and small-pox in the several communes of the province, according to the reports to be furnished to him by the sanitary officials of the communes (see Articles 19–22).

Article 9. The said sanitary inspector, who shall act as the representative of the province in matters of vaccination, shall be nominated by the Prefect after consultation with the provincial board of health, and shall receive a salary from the funds of the province proportionate to the importance of his work, and officially his post shall be subordinate to that of the medical officer of the province.

Article 10. The procedure to be followed in obtaining the lymph from the National Vaccine Establishment, and in reimbursing out of the provincial funds the cost to the treasury, is set out in the instructions contained in the memorandum of the Department of Public Health to the Ministry of the Interior.

II. VACCINATION.—Article 11. By the terms of Articles 51 and 52 of the law for the protection of hygiene and public health, it behooves the communal authority in every contingency to provide for the vaccination of all inhabitants within their area, and to take care that the obligation to undergo this practical prophylactic treatment, which has been imposed by the law, is respected by all, according to the instructions in these regulations.

Article 12. The sanitary regulations for the commune shall impose the responsibility for the observance of this legal obligation upon the parents (or their representatives) of all children born in the commune till they are of age.

Article 13. All children must be vaccinated within the solar half-year subsequent to the date of their birth (see Article 18), with the exception :

(1) Of such children as have in the meanwhile been attacked by small-pox.

(2) Of children with regard to whom a medical certificate can be produced, to the effect that they are in such a state of health as renders it dangerous for them to undergo the operation of vaccination.

Article 14. Children who, owing to ill-health, were exempted from vaccination during their first year of life, must be submitted for vaccination during their second year.

In cases where there may be doubt as to whether a child can be safely vaccinated, the official vaccinator must decide upon the case after having first himself examined the child.

Article 15. Children who have been vaccinated for the first time without showing favorable results, must be again vaccinated at the latest within the ensuing year, and this repeated vaccination must be performed by the official vaccinator.

Article 16. After the age above referred to every individual must offer himself for revaccination whenever the sanitary authority considers that, owing to the existence of special danger of epidemic, such revaccination is necessary.

Article 17. No child can be admitted into a public or private school, or to public examinations, or into any educational or benevolent institution, public or private,

or into any factory or workshop of any kind, if, being eleven years of age or older, he cannot produce an authentic certificate from the communal authority to the effect that he has been revaccinated since he reached eight years of age.

The directors of schools, institutions, factories, or workshops, or whoever may be at the head of any body of persons having the supervision of children of any age above that of eleven, must be held responsible for the observance of this regulation.

Such persons must also take care that all children between the age of ten and eleven that are likely to remain under their supervision are revaccinated according to the requirements of law.

The persons designated must at every request of the communal authority, show the certificates of revaccination of the children intrusted to them.

Article 18. In every commune there shall be annually two gratuitous public vaccinations, one in each solar half-year, at such period as shall be considered best to facilitate the largest attendance of children.

There shall be extraordinary gratuitous public vaccinations wherever it is held that such extraordinary vaccinations are necessary for the more complete observance of law, or where, owing to the appearance of cases of small-pox in the commune, there may be danger of the spread of the disease.

Article 19. The communal authority shall in all cases provide the necessary funds to maintain a staff of sanitary officials (physicians and surgeons) sufficient to vaccinate gratuitously all the individuals who are to be vaccinated, whether the obligation to undergo this operation is due to legal requirements or to the ordinances of the communal or superior government authorities.

Article 20. All persons who have been vaccinated shall present themselves or be presented for vaccination to the official vaccinator, between the seventh and tenth days after vaccination, and the official vaccinator shall himself report, for the purpose of registration to the communal authority, the vaccinations which have been performed and their results, whether the operations were performed at the public gratuitous vaccinations or by private medical practitioners.

This report of the official shall set out the Christian and surname of the person vaccinated, the date of birth, and state whether the vaccination satisfied legal requirements, or whether there is need for it to be repeated.

Article 21. The sanitary officials shall, at the end of each half-year, verify whether all the persons born in the preceding half-year have been successfully vaccinated, and in cases where there has been default it is the duty of the sanitary officials to move the communal authority to intervene according to the provisions of the law.

Article 22. The same sanitary official shall communicate to the prefect of the province, during the month of January in each year, a list of all the vaccinations that have been performed, carefully distinguishing between the cases of vaccination and revaccination.

Article 23. Certificates setting out the particulars of vaccinations entered in the registers of the communal authority, shall be granted by that authority gratuitously.

Article 24. These regulations, in so far as they have reference to the preservation of lymph by the provincial authority, the registration of all cases of vaccinations by the communal authority, and the granting gratuitously of certificates by that authority, shall come into force on the 1st day of January, 1892.

In the seventh volume of the REFERENCE HANDBOOK a digest was presented of the legislation of the principal States of the Union with reference to vaccination.

Careful inquiry shows that but few changes have been made in these laws since 1886.

The following comprise the principal modifications:

Maine.—Chapter 213, Laws of 1889. An Act to provide against the danger of the spread of Small-pox from Paper Mills.

Section 1. No owner, agent, or superintendent of any paper mill where domestic or foreign rags are used in the manufacture of paper shall hire or admit any person to work in or about said mill who has not been successfully vaccinated or revaccinated within two years, or to the satisfaction of the local board of health.

Sec. 2. No person shall work in or about any paper mill where rags are used, who has not been successfully vaccinated or revaccinated within two years, or to the satisfaction of the local board of health.

Sec. 3. The owner, agent, and superintendent in every paper mill where rags are used, shall every year, in the months of February and September, make out and deliver to the local board of health a list containing the names, ages, kind of work, and places of residence of all persons employed in or about said mill.

Sec. 4. In the months of March and October, annually, each and every person who is employed in a paper mill, shall be examined by the local board of health as to whether he or she is successfully and sufficiently protected by vaccination, and the local board of health shall in all cases be the judges of the sufficiency of the protection by vaccination.

Sec. 5. Any person who shall violate any of the provisions of this act shall be guilty of a misdemeanor, and upon conviction thereof shall be subject to a fine of not more than fifty dollars.

Sec. 6. It shall be the duty of the local boards of health within their respective jurisdictions, and of the State board of health, to enforce this act as far as comes within their power, and when said State board of health knows or has reason to believe that any penalty or forfeiture has been incurred by reason of neglect to comply with said act, it shall, at its discretion, give notice thereof, in writing, to the county attorney of the county in which said penalty or forfeiture has occurred, and upon receipt of such notice the county attorney shall prosecute the defaulting person or persons.

Approved February 23, 1889.

Florida.—As a result of a recent invasion of yellow fever, Florida established a State Board of Health in 1889, and entrusted the board with the general sanitary administration of the State. In the same year the board adopted certain regulations in regard to vaccination as a part of the sanitary code. They are as follows:

Section 11. It is hereby made the duty of the Common Council, Board of Aldermen, or other officers of a chartered city or town in this State, to provide for the vaccination and revaccination of the citizens residing in their several cities and towns. And it is also made the duty of every parent, guardian, or other person charged with the care of, or responsibility for, any child, to see that said child is vaccinated, and to have said child or children vaccinated as often as the health authorities of a city or town, or county board of health in the State may direct: *Provided*, That the requirements of this section need not be enforced in sparsely settled communities in this State except in a threatened epidemic from small-pox. *And provided further*, In any case, in the judgment of a reputable physician expressed in writing, such vaccination would be dangerous to the health of the person required to be vaccinated, such vaccination will not be required to be made. Fresh bovine virus only should be used in vaccinating in this State.

Sec. 12. After October 1, 1889, superintendents of all institutions of learning, and all school boards and principals of schools in this State, in incorporated cities and towns of over two thousand inhabitants, are forbidden to admit as a pupil any child or person who cannot produce satisfactory evidence of having been successfully vaccinated.

Sec. 13. No owner or manager of any manufactory in this State shall admit for employment any person who cannot produce satisfactory evidence of having been successfully vaccinated.

In *Vermont*, where a State Board of Health was first established in 1886, the following law relative to vaccination was enacted in November, 1892, being Section 5 of "An Act defining the duties and powers of State and Local Boards of Health, Health Officers, and others."

Section 5. It shall be the duty of every local board of health to report to the secretary of the State board of

health every case of small-pox, varioloid, Asiatic cholera, typhus fever, or yellow fever, occurring within its jurisdiction; to provide, whenever it is deemed necessary by the State board of health, a suitable supply of vaccine virus of a quality and from a source approved by said State board of health; and during the existence of an actual outbreak of small-pox in any town or city, the local board of health shall at all times provide thorough and safe vaccination for all persons within its jurisdiction who may need the same.

California.—The following recent legislation in California became operative in 1889:

An Act to encourage and provide for a general vaccination in the State of California.

Section 1. The trustees of the several common school districts in this State, and boards of common school government in the several cities and towns, are directed to exclude from the benefits of the common schools therein any child or any person who has not been vaccinated, until such time when said child or person shall be successfully vaccinated; *provided*, that any practising and licensed physician may certify that the child or person has used due diligence and cannot be vaccinated so as to produce a successful vaccination, whereupon such child or person shall be excepted from the operation of this Act.

Sec. 2. The trustees or local boards, annually, or at such special times to be stated by the State Board of Health, must give at least ten days' warning by posting a notice in two or more public or conspicuous places within their jurisdiction, that provision has been made for the vaccination of any child of suitable age who may desire to attend the common schools, and whose parents or guardians are pecuniarily or otherwise unable to procure vaccination for such child.

Sec. 3. The said trustees or board must, within sixty days after the passage of this Act, and every year thereafter, ascertain the number of children or persons in their respective school districts, or subdivision of the city school government, being of an age suitable to attend common schools, who have not been already vaccinated, and make a list of the names of all such children or persons. It also shall be the duty of said trustees or board to provide, for the vaccination of all such children or persons in their respective school districts, a good and reliable vaccine virus wherewith to vaccinate such children or persons who have not been vaccinated. And when so vaccinated to give a certificate of vaccination, which certificate shall be evidence thereof for the purpose of complying with Section 1.

Sec. 4. The necessary expenses incurred by the provisions of this Act shall be paid out of the common school moneys apportioned to the district, city, or town. And if there be not sufficient money, the trustees must notify the board of supervisors of the amount of money necessary, and the board must, at the time of levying the county tax, levy a tax upon the taxable property in the district sufficient to raise the amount needed. The rate of taxation is ascertained by deducting fifteen per cent. for delinquencies from the assessment, and the rate must be based upon the remainder. The tax so levied must be computed and entered upon the assessment roll by the county auditor, and collected at the same time and in the same manner as State and county taxes, and when collected shall be paid into the county treasury for the use of the district.

Sec. 5. The trustees of the several school districts of this State are hereby required to include in their annual report, and report to the secretary of the State Board of Health, the number in their several districts, between the ages of five and seventeen years, who are vaccinated and the number unvaccinated.

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VETERINARY SCIENCE IN ITS RELATIONS TO PUBLIC HEALTH.—Modern medicine involves something more than visiting the bedside of a sick person, diagnosing the disease, writing a prescription for the relief of the patient, and leaving a few general orders regarding the administering of medicine and care of the unfortunate one. How to prevent disease is a question fully as important, if not more important, than how to cure, or attempt to cure, an illness; and every physician should pay at least some attention to preventive medicine or sanitary science; and in a consideration of this subject the communicable diseases of our domestic animals, communicable from them to man, are well worthy of the investigation that the danger from them demands. In the writer's opinion every State board of health, and the health boards of our larger cities, should have as one of its members a skilled veterinarian, or, if not as a member, it should at least have one, or if necessary more, as employees, whose duty it should be to investigate, and as far as possible suppress, all cases of infectious disease among animals common to them and mankind.

At present, in nearly all of our cities and towns there is, as a rule, one or more members of the medical profession upon the board of health, and if the services of a competent veterinary surgeon are not readily accessible, it is highly important that the medical officer should have a knowledge of the diseases communicable from animals to man, with an idea of their diagnosis, post-mortem appearance, and the steps to take for their suppression. The more important of the infectious maladies of animals, common to them and man, include actinomycosis, tuberculosis, glanders and farcy, rabies, and

anthrax, as well as vaccinia, although, as far as its danger is concerned, the latter affection is of little significance. The three first-mentioned disorders resemble each other in many ways, and may be classified as a group having many characteristics in common, known as the "infective granulomata."

The "infective granulomata" include beside actinomycosis, tuberculosis, and glanders and farcy, syphilis and leprosy; it is plain therefore that of the five diseases comprising this group, three, or a majority, are common to animals and man—one of them, glanders, being an essentially equine affection, communicable from the horse and ass to others of their own species, and from them to the human subject.

Anthrax and rabies, although not so constantly met with as the infective granulomata, may be very dangerous and cause many fatalities when they do occur.

In a consideration of these diseases the first group will be briefly described in the order already written, after which rabies and anthrax will have some of their characteristics specified.

Actinomycosis.—It is only within a few years that this disorder has been recognized as a distinct disease; Bollinger, a European veterinarian, first described it as occurring in cattle in 1877, and called it actinomycosis, on account of a fungus, the actinomyces, found to inhabit this lesion; a uniform conception of the nature of the disease was then formed by the veterinarians of all lands, and the definition and name, as given to it by Bollinger, was generally adopted.

Ponfick, in 1879, was the first to describe actinomycosis in man, although the disease had been observed by Israel, and described by him as chronic pyæmia, one year previous. And as early as 1845 Langenbeck also described a case that was unquestionably actinomycosis.

Prior to Bollinger's investigations, different authorities expressed most diverse opinions concerning it, and in cattle the affection was designated as "osteo-sarcoma," "cancer," "scrofula," "tuberculosis," "osteo-porosis," "fungoid stomatitis," "sarcomatitis," and the like, the name depending upon the location and general appearance of the growth in many instances. Some authors looked upon it as a variety of glanders peculiar to the ox tribe.

This malady, when it occurs among bovines, is commonly spoken of as "swelled head," or "big jaw," when it attacks the jaw bones; it is also termed "wooden tongue," when the tongue is affected, as it renders it hard and gives rise to a woodeny condition of that organ. Actinomycosis is most commonly seen in cattle; it may also occur in swine; cases are recorded where it has been observed in man, and in a very few rare instances the horse has been known to have it.

It has been classed with the infective granulomata, as it results in the formation of granulation tissue; this is accompanied with the formation of fibrous tissue and suppuration.

Actinomycosis is a progressive inflammatory affection, set up by a certain fungus, the *actinomyces;* this fungus belongs to the *hyphomycetes,* or moulds. It has been observed in the animals just mentioned as the result of natural infection, and has also been produced in cattle, rabbits, and other small animals by inoculation experiments. The parasite which causes the disorder is a peculiar fungus: microscopically it first appears as a tufted rosette of radiating, pyriform, or club-shaped structures; these are either single, or divided by dissepiments, and are of considerable bulk. These club-shaped structures are possibly the conidia (spores). The fungus (still microscopically) appears as a peculiar gland-like body, with the outward form of a mulberry; this appearance is produced by the aggregation of the club-shaped conidia; these spring in all directions from a matted tuft, which may be called the mycelia, and are thus crowded into a compact mass.

When the actinomyces settles in a tissue it at once sets up an inflammation in its neighborhood. While the spore is developing its mycelium and bunch of conidia, a nodular inflammatory focus is formed around it, which in its structure exactly resembles a tuberculous nodule, that is, it contains round, epithelioid, and giant cells. Recent nodules consist chiefly of round cells; older ones, at the part in contact with the fungus core, have the epithelium-like and giant cells present. The fungus core is generally yellowish in tint, and later in the process is often calcified.

When the nodules increase greatly in number and become confluent, the internodular inflammation also extending, large areas of inflammatory swelling are formed, and in many cases, especially in cattle, scar-like bands of fibrous tissue may be formed in the spaces between the nodules. The nodules themselves usually break down and suppurate, or if the tendency toward further development be strong enough, instead of suppuration large nodular patches of new tissue may be formed. These may grow for weeks or months, until they become large tumors. The tumor is made up partly of coarse fibrous tissue, partly of granulations, with the intermediate stages. It always contains small pus-cavities and other excavations, in which the fungus cores are found as small white or yellow, greasy-appearing masses lying among the purulent detritus. The small white or yellow specks are found upon microscopic examination to be clumps of the actinomyces. On the other hand, if the tendency to disintegration and suppuration prove the stronger, large sacculated cavities are formed, communicating with each other by fistulous tracts, some of which may open externally, pus being discharged from them which contains the little masses (fungus cores) already mentioned, which consist of the fungi in clumps. The walls of these sacs are for the most part lined with granulations containing colonies of the fungus.

In the case of cattle, the disease most frequently attacks the lower jaw, then the upper jaw, tongue, pharynx, larynx, œsophagus, stomach, and intestinal wall. It may also invade the skin, lungs, subcutaneous and intermuscular connective tissue. In cases observed in the human animal the disease has generally attacked the soft parts of the neck, the thorax near the spine, the mediastinal tissue, and the lungs. In one case the infective material gained access to the blood-current and gave rise to metastatic foci.

These inflammatory growths seldom reach any great size in man, being apt rather to break down early; but in cattle the tumors, especially when located upon the jaw-bone, may attain considerable dimensions, being frequently as large as the top of a hat.

When this process invades bone it leads to destructive caries. This is notably the case with regard to the vertebræ in man, or the jaw-bones in cattle. In fact, in all affected regions the destruction of tissue is considerable.

As regards the genesis of this disease, it seems very probable that the mouth is usually the starting-point of the infection. The specific fungus has been found in the crypts around the tonsils, hollow teeth, and similar situations in the buccal cavity of healthy individuals. The infection probably then follows wounds of the mouth, the extraction of teeth, or any injury that gives the spores of the fungus a chance to enter the living tissues, where it finds a suitable habitat for its development.

Thus, in cattle, if an animal has a scratch or cut on the tongue, and the fungus spores gain access to it, the result may be actinomycosis of the tongue, or as the farmers in England call it, "wooden tongue." Actinomycosis of the jaw in cattle occurs not infrequently, and here the spores of the fungus are supposed to gain access to the interior of the bone through the alveolus of a tooth, when a temporary is shed to make room for a permanent molar.

When actinomycosis occurs in the lung it is believed to be due, as a rule, to inhaling the spores with the inspired air.

Metastasis is not common, although it may occur. As a rule the disease is marked, clinically speaking, by its chronic course and local malignancy.

Treatment of cattle suffering from actinomycosis may avail in some forms of the disease. For example, in

cases of "wooden tongue," when the nodule first appears, it may be cut out and the wound painted with tincture of iodine, with a fair prospect of satisfactory results. The iodide of potash treatment is also said to be of considerable value, and experiments with it have recently been tried by the U. S. Bureau of Animal Industry in order to ascertain its efficacy in treating bovine actinomycosis, and the results in many cases have been very successful.

In cases where the jaw is attacked, the best course is to fatten the animal as rapidly as possible for beef, as the disease is usually local, and when this is the fact it is not likely that the flesh is dangerous as an article of food. This view is borne out by the fact that bovine actinomycosis is by no means a rare occurrence in this country, while in the human being it is found to be very infrequent—so much so that it is almost never met with. The animal suffering from this trouble should be fattened as early as possible, as when the tumor attains a large size it interferes with eating; finally it breaks in places and continually discharges, the creature losing flesh and wasting away.

In actinomycosis of the jaw a swelling appears, small at first, growing slowly and continually, until it becomes of considerable size; it may in time ulcerate in spots, and these ulcers will be found to be the openings of fistulæ leading into the bone substance, from which there is a constant discharge of thin purulent material, containing little flocculi, these being clumps of the fungus. The tumor is hard and painful, and when the sores appear upon it, disgusting to the sight. This disease cannot be particularly infectious, as one or two animals in a herd may have it and yet the others remain perfectly healthy; although it is usually fatal to men or animals unfortunate enough to contract it.

The actinomyces germs are probably taken into the system through the mouth, being contained in the food, as the parasite has been found in chaff and husks of grain, in siftings from grain, in corn-stalks, and the like. As it has been found also frequently between the teeth, in hollow teeth, and in nooks and crannies in the mouths of healthy animals and men, it would seem that the fungus cannot obtain a foothold where the mucous membrane is healthy, but only where some abrasion of it exists.

Actinomycosis seems to occur frequently in the tongue among cattle in the low-lying fen districts of England; while in the United States it is met with chiefly in the West, and here the jaw, usually the lower one, is the point most commonly invaded.

That it is possible for actinomycosis to be transmitted from animals to man is proved by the following case: An Austrian veterinary surgeon upon the Russian frontier, who was employed to examine cattle by the Austrian government, was in the habit of holding bits of paper connected with his work in his mouth while he examined the animals, some of which had actinomycosis. In some way, by handling first the cattle and then the papers, he became infected with the disease, the tongue being the organ involved. He recognized the trouble early, however, had the nodule removed and the wound suitably dressed, and he made a complete recovery.

Another instance of its infectiousness is illustrated by the following case: A horse having a wound on the stifle, was placed in an empty shed, which had formerly been occupied by some cattle, with the result that actinomyces gained access to and developed in the injury.

TUBERCULOSIS.—Tuberculosis among the domesticated animals is seen very much more frequently among bovines than any other species, and occurs in the milch-cow in more instances than in any others of the family. It is in this country, from a sanitary point of view, of more importance than any other malady communicable from the lower animals to man, because so little has been attempted toward preventing its ravages by legislation. Tuberculosis in cattle is probably as dangerous to the human family as glanders among equines would be if no laws had ever been enacted providing for the slaughter of glandered horses; and it is more dangerous than the occasional outbreaks of rabies among dogs that occur from time to time in various localities; yet the danger to the human race from this source has never been fully realized, as the disease is so insidious in its attack, and so gradual in its development, that it is seldom that the relation between cause and effect is traced out here, as it is in a case of glanders in a man known to have had the care of a diseased horse, or of rabies in a person known to have been bitten by a mad dog.

Bovine tuberculosis is an important affection from two points of view: first, from that of the sanitarian, who wishes to prevent, as far as possible, the ravages of a most destructive malady among the human race; secondly, from that of the farmer, who desires to keep from his herd a troublesome and dangerous infectious disease. Hence, in some of the few States where legislation for its suppression among cattle has been attempted, the work has been placed in charge of the State Board of Health, while in others it has been turned over to the State Board of Agriculture, or to a special cattle commission.

A tubercle is simply a nodule, and the name tuberculosis conveys to the mind at once the idea of a disease whose characteristic feature is the formation of nodular growths in various organs of the body. Of course, it does not follow that every nodular growth found in the organism implies tuberculosis, as there are other diseases in which nodules are found; for example, in glanders nodules may be present in the lungs or possibly in other organs, which are spoken of as the nodules, or tubercles, of glanders. Therefore two adjectives are used in connection with nodular diseases: the term *tuberculous* is applied to the lesions of *tuberculosis*, and *tubercular* is used in speaking of nodules that resemble tubercles when the malady *is not tuberculosis*. In all the infective granulomata there are *tubercular* appearances, but these are only *tuberculous* when the disease is *tuberculosis*. There may be in some other disorders tubercular appearances, to the naked eye at all events, which are due to some other cause.

Virchow describes a tubercle, when newly formed, as a small gray, translucent nodule, not exceeding a millet seed in size, mainly composed of cells, and developed from connective tissue. The cellular elements are essentially similar to those of lymphatic glands; they are round cells of various sizes, some of them like white blood-cells, some larger, and some smaller. These cells contain nuclei, single in some cases, in others there may be two or a number, these poly-nucleated cells being the giant cells. Some of the cells may become flattened, giving them an epithelioid appearance. Between the cells are found fibrous filaments arranged in a network, and sometimes vessels also. The latter are never new-formed, but existed before the tubercle was developed, and lie within it simply because it has grown around them. These nodules may occur singly or in numbers; or they may be grouped in confluent masses. In the latter case the internodular tissue does not remain unchanged, but seems to be made up of imperfect granulation-tissue, giving it the appearance of a compact, uniformly diseased mass, rather than normal tissue containing nodular deposits. As a nodule becomes older the centre becomes soft and cheesy. It is then yellowish-white and opaque, under the microscope it appears as a granular friable mass at the centre, while the outer portions retain the cellular constitution; these cells also appearing to spread out into the normal surrounding tissue. This caseation of the centre of the nodule is due to the growth increasing to such an extent as to press on the blood-vessels, shutting off the supply of food to the central portion, causing the cells to die and break down; thus the centre of the tubercle becomes softened and cheesy. A number of tubercles may become confluent, and then as the centre of the mass breaks down it leads to the formation of a large cheesy body, and this may be spoken of as a tuberculous abscess. Very rarely the tuberculous nodules may become fibrous instead of cheesy. In later stages still, lime salts may become deposited in the cheesy mass; then it becomes hard and a knife drawn through it grits, as it would if drawn through particles of coarse sand in

the substance of the nodule. In cattle tubercles are rarely found in large numbers of a miliary type; the tendency is to form large nodules, or masses, and also to become infiltrated with lime salts, and in cattle kept under good hygienic conditions there is also a tendency for the disease to develop slowly, taking on a more or less chronic type, the animal often living for years in a diseased condition.

In cattle there is also a tendency to form bunches of grape-like masses upon the serous membranes of the thoracic and abdominal cavities; these pearly nodules are the "Perl-sucht" of the Germans, and among English butchers are known as "grapes."

Tuberculosis was formerly separated into several diseases, which were described as different affections, but modern discoveries have shown that some of the maladies which were described separately are in reality tuberculous. For example, scrofula, lupus, and the like are now all known to be tuberculous. Cattle may have tuberculosis in about all the forms known in man, such as *phthisis pulmonalis, tabes mesenterica,* tuberculous arthritis, tuberculous meningitis, scrofula, lupus, etc. It may be general or local, but as a rule is met with most frequently in the lungs among bovines and least frequently (almost never) as lupus. Tuberculous arthritis, and tuberculous meningitis, while not common, are occasionally met with. The identity of tuberculosis in man and animals was long questioned, and among the medical profession its infectiousness was not generally believed in, until Koch's work on the etiology of the disease settled the matter for all time; and at this place a consideration of the etiology of tuberculosis is appropriate.

Etiology of Tuberculosis.— Until within a few years but little or nothing was known of the cause of tuberculosis; all kinds of vague ideas were held as to its origin, but most of them were very wide of the mark. Within twenty-five years it was shown, by some continental veterinarians, that the disease could be artificially induced by feeding tuberculous material from infected organs, and milk from tuberculous cows, to calves, pigs, and other small animals, and that it could be produced in rabbits and guinea-pigs by inoculating them with tuberculous products.

Several years before the real cause of this disease was known, Professor Walley, an English veterinarian, speaking of it, said: "In whatever way I consider tubercle as tubercle, my mind always reverts to the same conclusion, viz., that tubercle is as much a specific disease, whether inherited or acquired, as glanders, syphilis, or any other affection of the kind with which we are acquainted."

Many veterinarians for a number of years have known tuberculosis to be infectious among cattle; but the idea that it was an infectious disease was not generally accepted by the medical profession until within the last eleven years, for various reasons, one of which was that all observers did not acknowledge the identity of tuberculosis in man and animals.

Finally, all disputes as to the etiology of tuberculosis, and the question as to whether the disease was identical in the human and lower animals, was settled by the great discovery of Dr. Robert Koch, of the Imperial Board of Health, in Germany. At a meeting of the Berlin Physiological Society, held on March 24, 1882, Dr. Koch communicated some of the results of his researches on tuberculosis, which constituted a distinct advance in the knowledge of its cause. He announced that the tuberculous virus is a special germ, the *bacillus* of *tuberculosis.* Its length is about the third of the diameter of a red blood-cell, and its length is about five or six times its breadth as a rule, although it may be a little more or less. Individual bacilli may contain bright clear spores, or vacuoles. The bacilli are found chiefly in new tubercles, more sparingly in older ones; some of them lie within the cells, and especially within the giant cells, others lie outside. They are generally single and scattered, or may be found in groups and clusters. Koch discovered the bacillus without staining it, and must have had a wonderfully sharp and well-trained eye to do so, as an ordinary observer would not be able to see it unstained even if he knew it were in the field of the microscope. Other German scientists have experimented with staining it in various ways, until now there is a certain definitive way of staining the bacillus of tuberculosis, so that it cannot be confounded with any other; the only other bacillus having the same staining reaction is the lepra bacillus, which is shorter and only found in leprosy.

Koch has shown that the tubercle bacillus can be cultivated upon sterilized blood-serum (it can also be grown upon glycerine agar); it grows only in a constant temperature apparatus not below 30° C. or over 41° C.; it is therefore very doubtful if it can multiply naturally outside of the animal body. He also demonstrated that bacilli thus bred may then be introduced into the bodies of various animals, such as rabbits, rats, dogs, and guinea-pigs, and tuberculosis is thereupon induced; that is, they are attacked by a disease characterized by a progressive formation of cellular nodules. These nodules always contain the characteristic bacilli. In guinea-pigs the first appearance of the disease is manifested ten days after inoculation.

Tuberculosis is the same disease in both man and the lower animals, as the specific bacilli are found in the nodules of all, having the same general shape and size, and peculiar staining reaction. Scrofula and lupus, formerly not considered to be identical with tuberculosis, are now known to be, as the characteristic bacillus is always present in these affections, as it is in what has always been called tuberculosis. In considering the causes of a disease they may be divided into two classes, the exciting cause, and the predisposing causes.

The exciting cause of tuberculosis is the specific bacillus which occasions the disease. Clinical experience would seem to indicate that the tubercle bacillus is no ordinary bacterium, such as may enter and affect any organism without distinction; it would seem rather as if infection occurred only where a definite predisposition exists, or where a considerable quantity of virus is introduced, in some cases constantly or at frequently recurring intervals. This predisposition may be local or general. A local predisposition may depend mainly on some antecedent inflammatory change, for example a cold followed by consumption. A general predisposition is attributed especially to scrofulous subjects; this tendency to become scrofulous or tuberculous used to be spoken of as a *scrofulous* or *cachectic diathesis.* These terms were applied to persons whose tissues exhibit a certain frailty or susceptibility to injury, that makes them particularly liable to chronic inflammatory disorders. Often the term "scrofulous" is applied to persons or animals actually suffering with tuberculosis, as well as to those which are only predisposed to it.

Beside the bacillus as the exciting cause of tuberculosis, there are certain predisposing causes to be taken into consideration. The following list is similar to one found in Walley's "Four Bovine Scourges," but is modified a trifle in order to have it in accordance with the latest knowledge on the subject.

Predisposing Causes of Tuberculosis.—1, Species of animal; 2, hereditary predisposition; 3, congenital; 4, breeding in and in; 5, breed; 6, early, late, and overbreeding; 7, physical conformation; 8, climate and locality; 9, debility produced by lactation, sickness, and bad food; 10, bad hygienic conditions.

1. *Species of Animal.*—The bovine tribe is pre-eminently disposed, equally so with man, to acquire tuberculosis. The rabbit is very subject to it, and in some rabbit warrens in England these little animals have been almost annihilated by this disease. Guinea-pigs also develop it very easily when used for inoculation experiments. Of the farm animals the pig is the most susceptible next to the cow, but as this animal is generally killed at an early age the tubercles generally escape observation, as these animals are usually so slightly diseased that their general health is not impaired. Tubercle is rarely seen in the sheep, cat, or dog, and more rarely in the goat. It is so rare in the horse as to be almost unknown in this species, although there are a very few cases

of the malady on record in the equine. It not infrequently occurs in fowls, and it is said that it may also attack game birds. In zoölogical gardens in climates similar to the United States, Northern Europe, or England, it often causes great havoc among animals from tropical countries; it is here very common among monkeys, antelope, and deer, and has also been observed in birds and snakes, as well as occasionally in the carnivora; it would therefore seem to be common to many animals beside man.

2. *Hereditary Predisposition.*—Persons or animals born of a parent or parents affected with tuberculosis, have what is known as an hereditary predisposition to the disease. That is, they have a tendency to acquire tuberculosis much more readily and easily than the offspring of strong, rugged parents free from this malady; if exposed to infection their tissues have not the same power of resisting the virus. Animals with this predisposition (including the human animal) were formerly said to have a "scrofulous," or "cachectic diathesis."

3. *Congenital.*—Congenital tuberculosis is very rare, all the weight of evidence going to show that it almost never occurs. Professor Johne, of Dresden, records a case in a newly born calf. Other veterinarians have recorded cases, but in some instances the young animals were not killed until they were several weeks old, and then they were but slightly diseased, so that it is possible that in some of the so-called congenital cases the disease was acquired after birth. As a rule, it seems to be the will of a great and wise Creator that the offspring of tuberculous parents shall at least have an opportunity to start in life free from this scourge, and that in almost every instance it is acquired after birth.

4. *Breeding In and In.*—This may be classed as another potent predisposing cause, when carried to extremes, as it tends to weaken the constitution of the progeny.

5. *Breed.*—Breed plays an important part in the production of tuberculosis among cattle. Those most subject to it are the Jerseys and Guernseys; certain strains of the Ayrshire are prone to it, while other families appear to be very hardy. Herefords are said to be not particularly predisposed; it is not common among Devons, but does occasionally occur among them. Some families of Shorthorns are very subject to tubercle, while other strains of the same breed are remarkably free from it; in this breed hereditary predisposition plays an important part. Holsteins are, as a rule, hardy cattle, but are by no means exempt. In short no bovine is exempt from this disease, although some resist infection much more than others. The hardy New England stock, "natives," as they are called, are less liable to tubercle than pure breds, and those breeds coming from warm, even climates are in the changeable, rigorous climate of the Northern United States and Canada, with its great extremes of temperature, more subject to tubercle than breeds originating and kept for several generations in a climate resembling it.

6. *Early, Late, and Over-breeding.*—Cows which are bred from at a very advanced age, heifers which calve when very far short of maturity, and cows bred from year after year, giving at the same time, perhaps, large quantities of milk, or butter-forming material, have their systems so depleted that their young have not the strength and vitality that they would under more favorable conditions, and consequently these calves have a greater susceptibility to tuberculosis than they otherwise would. These same depleting influences also cause the mothers to be in a condition more favorable to the development of this disease.

7. *Physical Conformation.*—In man and cattle physical conformation plays an important part in the tendency to acquire tuberculosis. Cattle with narrow chests, light barrels, and disproportionately long legs, are undoubtedly predisposed, but at the same time it must be borne in mind that these peculiarities in themselves are often evidences of a tuberculous diathesis.

8. *Climate and Locality.*—Although this disease is found over the entire globe, yet it is more destructive in some localities than in others. In Mexico it is said to be very prevalent, thirty-four per cent. of the cattle killed for food there are said to have it. (*Vide* Fleming's "Sanitary Science and Police," Vol. ii., page 368.)

A moist, changeable climate is more favorable to its development in animals and man than where the air is dry and rare and the temperature less variable. Cattle in the dairies in the neighborhood of large towns and cities are to a much greater extent the victims of tuberculosis than those in a distinctly farming community. In the vicinity of large cities infection from diseased to healthy cows plays an important part in its spread, there being a constant buying and selling among milkmen; and once it obtains a strong foothold in a herd it may take some time to eradicate it.

In the dairies surrounding large cities, bad hygienic surroundings also play an important part in its development.

9. *Debility from Various Causes.*—One of the most fertile causes of a low tone of the system among cows is the depleting influences of lactation; animals giving immense quantities of milk are much more liable to tuberculosis than other cattle, because it is a constant strain upon the general health of the creature. The cow in a state of nature gives only enough milk for her calf, and in a few months becomes dry again as soon as her young can shift for itself; but man has converted her into a mere milking machine, giving enormous quantities of milk for the greater part of the year, and this is necessarily a great tax on the constitution, rendering her much more susceptible to diseases of various kinds.

Sickness of any description is another predisposing cause, as an animal recovering from an exhausting illness, if exposed to the infection of tuberculosis, is much more likely to contract it than if in a condition of perfect health.

Another predisposing cause of tuberculosis among cattle is bad food; an animal fed upon an inferior, indigestible quality of food, perhaps deficient in quantity as well, has the system reduced, and is in a condition of greater receptivity than one fed upon a sufficiency of nutritious, healthful material. Bad food might be classed under "bad hygienic conditions" as well as under "debilitating influences."

10. *Bad Hygienic Conditions are also Predisposing Influences to Tuberculosis.*—Animals housed in hot stables, kept hot by the heat of their own bodies, and with no change of the atmosphere, for fear of allowing cold air to enter, are much more susceptible to this disease than where there is an abundant supply of fresh air; it also gains headway more rapidly in a dark stable. Cattle should be maintained in light, well-ventilated, high-studded stables, and if they are to be warmed in winter the heat must come from some other source than the warmth of the animal body. A stable with a large cubic air-space is not sufficient, but there must be a constant substitution of fresh for contaminated air.

The Dissemination and Propagation of Tuberculosis.—Tuberculosis is ordinarily acquired in three ways: 1, By inhalation; 2, by ingestion; 3, by inoculation.

Tuberculosis acquired by inhalation is the form seen in the great majority of cases both in man and cattle, the tubercle bacilli gaining entrance to the lungs in the inspired air. Under these circumstances the lungs are probably primarily affected, and the disease spreads from here to other organs. Here the first symptom is the cough, and a man or other animal suffering from phthisis is constantly coughing up and expectorating (at least, the man expectorates; animals simply cough out) morbid products from the lungs; this sputum contains numbers of tubercle bacilli, and when it dries and becomes part of the dust floating in the atmosphere, the bacilli also float with the dust and may gain access to the lungs of healthy animals. Now, if a person or animal is just recovering from a severe cold and has a little ulcerated spot in one lung, the bacilli may gain a foothold there and grow and produce the disease, spreading from the original point to other parts of the lungs and to other organs. Or, if large numbers are present in the air of a

room, a person constantly inhaling them may become infected, even though naturally quite healthy, being finally overcome by numbers. The bacilli of tubercle retain their vitality for a long time; Koch has found that after several months in a dry room they still were capable of producing the disease. Dr. A. K. Stone, of Boston, Mass., has demonstrated that dried tubercle bacilli retain some of their virulence for at least three years (*American Journal of the Medical Sciences*, March, 1891).

Nearly everyone has doubtless inhaled these bacilli; but when present in small numbers, and with the pulmonary mucous membrane healthy, the ciliated epithelium of the air-passages returns them to the throat, and they are expectorated. Then the colony is so slow in growing at first that it may have a difficult time in fixing itself permanently.

Phthisical patients in expectorating are constantly giving out germs which may infect other people, and possibly cattle; and *vice versâ*, there is a possibility that a person of a cachectic diathesis working in a stable occupied by tuberculous cows may acquire phthisis from them.

Infection by ingestion means acquiring the disease through the digestive tract by swallowing the virus, and this method of infection is of special interest in a consideration of the malady from a veterinary sanitary standpoint, as it is from the use of the flesh and milk of tuberculous animals that the chief danger lies of infection by this method. Tuberculosis by ingestion may also result from secondary infection, a tuberculous patient swallowing his own sputum. Tuberculosis by ingestion may also be caused in pet dogs with morbid appetites, or in fowls, by swallowing the sputum of a consumptive person.

The use of milk or dairy products from cows suffering from tuberculosis is probably very dangerous—at least it is if the effect upon children is equal to the effect it has upon calves and pigs.

The writer feels as though he could speak authoritatively upon this subject, as he was employed by the Massachusetts Society for Promoting Agriculture, in conjunction with Dr. H. C. Ernst, of the Harvard Medical School, for three years, from January, 1888, to January, 1891, in the study of tuberculosis, with special reference to the infectiousness of the milk from cows suffering with this malady. The Society leased a farm near Boston, as an experiment farm, and here and at the bacteriological laboratory of the medical school the investigation was conducted. At that time but little was known concerning the presence of the tubercle bacillus in milk, but it was thought that a cow must be suffering from a diseased condition of the udder in order to give these bacilli in the lacteal fluid, and also that it was to be found only in the sediment after allowing the milk to settle. It was found that a cow suffering from general tuberculosis can give the bacilli in the milk, even although the udder is healthy, and also that they are quite as likely to occur in the cream as in the sediment. Recent continental observations go to show that the tubercle bacilli from diseased cows may also be present in the butter and cheese made from their milk; this is not surprising, as there is no reason to suppose that the process of cheese or butter making should remove this germ.

In the investigations conducted under the auspices of the Massachusetts Society for Promoting Agriculture, out of samples of milk examined from 36 cows, 10 gave tubercle bacilli in their milk, or about twenty-eight per cent. Of the ten giving the bacilli in the lacteal secretion, three or four had tuberculous mammitis, but the majority were cases of general tuberculosis with healthy udders. Of the 36 cows, about twenty-five belonged to the Society at one time or another; the others were animals that it was unable to obtain possession of.

Calves and pigs were fed upon the milk of these cows for periods of about six months each; at the end of that time the young animals were killed, and careful post-mortem examinations made; every abnormal part of an organ was saved for microscopic examination, and nothing was called tuberculous unless the specific germ was found in the specimens examined. Each calf was fed the milk from a certain cow (except in a few instances where the milk of two cows nearly dry was mixed, in order that the calf should have enough food), and had its own particular pail which was scalded out every day. The calves were kept in a separate building from the cows, each calf in its own pen; so the only way in which it could become infected was through the medium of the milk brought to it.

The pigs were not the subjects of special experiment, but were simply given the surplus milk from the various cows. Every calf dropped by a diseased cow on the place was killed when but a few days old, and the calves bought for feeding experiments were always carefully selected as the offspring of healthy mothers, as far as it could be ascertained.

Twenty-five calves and twelve pigs were used in these feeding tests, and when they were killed the post-mortem examination showed that about forty per cent. of each were tuberculous. Most of them were at the time of slaughter in good health to all external appearances, and the autopsy revealed very few morbid changes, perhaps two or three little nodules no larger than a very big grape-seed in the liver; in one calf only a slight alteration in the appearance of one kidney was noted, but under the microscope these nodules possessed the usual appearance of tubercles, and the characteristic bacillus was found, showing that the disease was present, and only awaited a favorable opportunity to develop itself still farther. In the case of heifers the depleting influence of lactation often causes the disease to develop rapidly.

Rabbits and guinea-pigs inoculated with milk or cream containing the bacilli of tuberculosis, by means of subcutaneous injections of it upon the abdomen, develop the disease and die of it in a few weeks, unless killed for purposes of autopsy before allowing them to die of themselves. In a few instances these little animals developed tuberculosis, after being inoculated, when no bacilli were found by microscopic examination of the milk; this shows that the bacilli were present in small numbers, but none were in the slides examined. This is not surprising, considering that only a few drops from a sample of milk or cream can be examined, and the extent to which these germs are diluted by the fluid containing them; the only wonder is that they were found as many times as they were.

In fact, in an examination of milk for tubercle bacilli the easiest and surest test is by inoculation experiments upon these little animals, rather than by microscopic examination, which entails a great deal of work and the expenditure of much valuable time.

Samples of milk were examined from the first and last parts of the milking, with the result that the bacilli could very well occur in either; it was also found as frequently in the cream as in the sediment, and it was ascertained that a cow giving them in the milk does so with a considerable degree of constancy.

These results are borne out by the researches of Bollinger, Bang, and other continental scientists, as well as by Dr. Leonard Pearson, of the Veterinary Department of the University of Pennsylvania.

The danger from the use of the flesh of tuberculous animals killed for food has been less studied than the question of milk, but it is pretty certain that the meat of these creatures is unfit for human consumption unless thoroughly cooked. The danger from the use of the meat of these animals is, however, very much less than from milk and dairy products, as it is generally customary to eat thelatter uncooked, while the former is usually subjected to enough heat to kill the germs.

In abattoirs in Europe, and also at the Brighton abattoir, near Boston, veterinary inspectors are appointed whose duty it is to condemn all carcasses which are affected with tuberculosis to any great extent, although if the disease is localized in a part of one organ the meat is not then considered dangerous.

Dairy inspection is but a matter of time, and is sure to come. In Massachusetts the law requires that all milk sold must contain thirteen per cent. of total solids, yet

no regard is paid to the health or sanitary surroundings of the cows.

During the past year the New York State Board of Health has made a good beginning in this direction, examining dairy herds and killing all tuberculous cows found, and destroying the carcasses. The only way in which milk can be rendered safe when nothing is known of the source from whence it comes, is to sterilize it by steam heat; this should always be done with infants' milk in summer, as it destroys various injurious germs which may cause cholera infantum and similar disorders.

Infection by Inoculation.—Infection may occur also from inoculation when the virus enters the body through the skin, and may be either accidental or intentional. It is intentional when tried experimentally upon animals, and accidental if the virus enters the system through a scratch or cut on the skin. Accidental inoculation might occur to a person who cut or scratched his hand while making an autopsy upon a tuberculous animal, or while performing an operation upon a tuberculous subject. When the disease is induced by inoculation it begins with a nodule at the point of entrance, but if it is the result of ingestion the bacilli may enter the circulation and first attack some organ that has a lesser resisting power than other organs.

Tubercle bacilli may be excreted in small numbers in urine or fæces, but this is a less fertile source of infection than sputum or contaminated food.

The transmission from man to man, or from bovine to bovine, is chiefly due to the inhalation of dust from the desiccated sputum, but at the same time it must not be forgotten that tuberculous food products are dangerous, and have probably caused many cases of consumption that have never been laid to their door.

Diagnosis of Bovine Tuberculosis.—This disease is so insidious in its attack, and so gradual in its development, that in its early stages it is very difficult of diagnosis; but as it progresses, in time almost anyone can tell what the trouble with the animal is, if he has any knowledge of cattle at all. In advanced stages of the disease the emaciation of the patient, the great weakness and lassitude, the frequent distressing cough, the quickened respiration, and appearance of general unthriftness, tells the merest novice at a glance the nature of the disorder.

But this is only after the trouble has existed for some time; a cow may be tuberculous for years if she is under good hygienic conditions, the malady frequently having a tendency to assume a chronic character in cattle; she will give a fair quantity of milk, and her general appearance will be thrifty to an inexperienced eye, or for that matter, perhaps to even an experienced one; she will calve regularly, and perhaps in the course of time die of some other sickness, or be killed for beef because her days of usefulness are ended at the milk pail; when the butcher, to his surprise, may have to throw away her carcass, if he be a conscientious one, or, as is more frequently the case, her flesh will be sold for food, a fitting climax to her death-dealing career.

As an example of this the cows kept at the experiment farm, by the Massachusetts Society for Promoting Agriculture, will serve. Some of them were kept for two years, remaining in much the same condition during that time as when first purchased, and in a few instances even improving in health; in fact, there were two that may be said to have actually recovered by simply being placed under the best of hygienic conditions, and not forced by feeding to a large yield of milk.

It is an exceedingly difficult thing, then, to diagnose a case of tuberculosis in a cow, when it is in its incipiency or when it assumes a chronic form, advancing in its development very slowly. In dealing with tuberculosis in a lot of cattle, if no well-marked cases are present, it is often of great value to know the previous history of the herd; if one is told that animals have previously been killed in it for this affection, he is naturally led to consider certain creatures suspicious that he might not suspect if he knew the herd had always been healthy. It is not necessary that a cow should have *phthisis pulmonalis* in order to be tuberculous, for she may have tuberculous arthritis, scrofula, *tabes mesenterica*, or tuberculosis of other organs, and at the same time the lungs may be free, or comparatively free, from the disease. In examining a cow, then, besides examining the lungs and noticing whether there is a persistent cough, notice also whether the external lymphatic glands are enlarged and hard; observe whether she is free from lameness; find out if she is at times constipated and at others affected with diarrhœa (as they are in *tabes*); learn, if possible, whether she is a nymphomaniac (commonly called by farmers a "buller"); ascertain if abortion is a frequent occurrence in the herd, although this is of little value, as there is an infectious form of bovine abortion that has nothing to do with tuberculosis; and examine the udder and see if it is nodulated, or what is commonly called "gargety." Any or all of these symptoms may aid in making a correct diagnosis, especially if it is possible to obtain a reliable history of the previous health of the herd, which it is not always an easy thing to do.

In making a physical examination of the lungs of a bovine, percussion is not of much value, owing to the thickness of the hide and of the thoracic walls, and to the large area covered by the scapula. Auscultation is of a good deal of value, and in order to become expert at it the best way to do is to auscultate the lungs of a large number of healthy cattle, until a thorough knowledge of the normal lung sounds is obtained, when it will become much easier to discern any departure from these in examining a diseased animal. If a large area back of the shoulder is solid, there will be a loss of respiratory murmur; if the area is superficial, a tubular sound may be heard; and if there are small diffuse tubercles through the lungs, there may be a partial obstruction to the lumen of some of the bronchi causing piping sounds. If there are tuberculous deposits upon the pleura, pleuritic friction sounds may be heard.

There are other diseases of cattle that may produce lung sounds similar to tuberculosis, and which are often difficult to differentiate; for example, in bronchitis or broncho-pneumonia there may be mucus in the bronchi that will produce piping sounds very difficult to tell from the piping heard in some cases of tuberculosis. Patches of pneumonia may cause loss of respiratory murmur and dulness on percussion. Parasitic bronchitis, caused in young cattle by the *strongylus micrurus*, is a cause of a frequent distressing cough and much bronchial irritation that might deceive the inexperienced. Ordinary pleurisy may cause friction sounds, that may become permanent if adhesions are formed; and pulmonary emphysema, common in old cattle, may lead to exaggerated respiratory murmurs.

The clinical thermometer, as an aid to diagnosis, is of so little value that it is simply a waste of time to take a cow's temperature in an examination for tuberculosis; there is rarely any fever, unless some degree of sepsis be present from an abscess in the lung containing all sorts of bacteria, besides the tubercle bacillus. The normal temperature of the cow ranges from 101° to 102° F., and in advanced pregnancy may be nearly 103° F., and in old depleted subjects may not be more than 100° F. The temperature of animals is taken per rectum, or occasionally per vaginam.

The microscope will occasionally be found of great value in the hands of the scientist in diagnosing bovine tuberculosis, by cutting out enlarged glands and examining them; or the examination of milk or various secretions revealing the presence of the specific germ, the *bacillus tuberculosis*, will settle the question beyond all doubt.

A possible, but not always convenient, way of diagnosing pulmonary tuberculosis in the ox tribe, is to cut a slit in the trachea and pass down it, as far as possible into the lung, a long wire with a bit of sterilized sponge or sterilized absorbent cotton on the end, withdrawing it, and smearing any pulmonary secretion upon it on a cover glass, dry, and stain; if any tubercle bacilli are found it is a sure confirmation of the diagnosis in a suspicious case.

Occasionally a scrofulous cow may have a tuberculous

gland back of the pharynx, or in closer proximity to the larynx, which will cause more or less obstruction to the entrance of air to the trachea, resulting in her emitting a roaring sound when breathing; this sound may be constant, or there may be intervals of relief, but no hesitation need be felt in making a diagnosis in such cases, as any other cause of the difficulty is so rare that it is safer to lay aside the possibility of its being something else than to run the chances of letting a tuberculous animal escape.

Another method of diagnosis that has not been sufficiently investigated to warrant its being taken up in field work as yet, but which is spoken of highly where it has been tried as a matter of experiment, is subcutaneous injections of Koch's tuberculin. It is said that if a cow suffering from any form of tuberculosis, no matter how slight, receive a subcutaneous injection of Koch's tuberculin of from 0.2 to 0.3 c.c., depending upon her size and age, in the scapula region or side of the neck, there will be a marked reaction of a febrile character following in the course of ten or twelve hours, the temperature rising in from twelve to fifteen hours as high as 106° F. to 107° F., then gradually falling very slowly until it reaches the normal again, in from twelve to twenty-four hours more. When this method is pursued the animals are inoculated in the evening after milking, and the temperatures are then taken at the time, and every three hours thereafter for the next twenty-four hours. Every tuberculous creature, no matter how slightly diseased, should react, and it is very seldom that any but an affected animal reacts; but it is said that in rare cases a cow with a maximum of disease, inoculated with a minimum of the tuberculin, will not react; but, as has already been said, this method of diagnosis needs to be further experimented with before it can be said positively to be adapted to the sanitary inspection of herds. If it proves a success it will furnish a simple and ready means for the diagnosis of tuberculosis, with a view to its eradication among cattle, although even then it can be urged that many animals would react to it that had not become either a danger to other cattle or to the public health.

Post-mortem Appearances of Cattle Suffering with Tuberculosis.—The post-mortem appearances found in a cow that has died with, or been killed on account of, tuberculosis, depend upon the organ or organs diseased. Tuberculosis may be localized in a single organ, or it may be general and affect nearly all of the thoracic and abdominal viscera.

The general appearance of tubercle in the different organs is much the same, as already described; when they occur in the lungs they may at first be miliary, but they grow and form whitish nodules the size of a pea or larger, and as they grow they may become confluent, forming masses, and finally invade so much of the lung tissue that that viscus, instead of weighing three or four pounds as it normally would, may weigh from fifteen to twenty. As the centre of a tubercle becomes deprived of its blood-supply by the growth of its periphery, it becomes broken down and "cheesy;" later, if lime salts are deposited there, it becomes calcareous. A number of tubercles in the lung coalescing and becoming cheesy, may form a large abscess, possibly capable of holding several quarts; this abscess may break into a bronchus, and its contents be discharged through the mouth, leaving a vomica. The formation of tubercles does not vary much throughout the body; there is the nodule of variable size composed of granulation tissue, if looked at under the microscope, the outer cells flattened by pressure resembling epithelium, and also containing the giant cell; besides this the tubercle bacillus *must* be present to complete the diagnosis.

In the thoracic cavity, beside the lungs, tubercles may develop upon the pleura, especially the parietal layer, at its inferior part particularly, forming large masses resembling clusters of grapes, the "*Perl-sucht*" of the Germans, and "grapes" of the English butchers. These may be in various stages of development, from a newly formed one to a cheesy or calcareous nodule. Adhesions may be formed between these clusters and the lungs, cementing the latter firmly to the ribs. Tubercles in the thoracic cavity may also exist in the lymphatic glands in the space between the lungs, also in the outer layer of the pericardium, and very rarely in the layer covering the heart. When a mediastinal lymphatic gland is tuberculous, it at first becomes increased in size; later, miliary tubercles may be seen in it; then the tubercles may become larger and cheesy, and later calcareous, or an abscess may form in it; these glands frequently become enormously enlarged, one normally the size of the end of the thumb often being as large as a full-sized cucumber. This description of a tuberculous lymphatic gland in the mediastinum will do for all, except that others rarely become so enlarged as in the mediastinum, with the exception of an occasional post-pharyngeal abscess. The enlarged lymphatics may be looked for in the submaxillary region, back of the pharynx, in the axilla, in the flanks, in the inguinal region, as well as in various parts of the thorax, abdomen, and rarely the intermuscular connective tissue. The bacilli of tuberculosis may sometimes be found in hypertrophied lymphatic glands before the formation of a miliary tubercle visible to the naked eye. If the bacilli can be found in an organ it decides a case as being tuberculosis. As a rule the bacilli are most plentiful, and consequently most easily found, where the tubercle is developing rapidly, that is, near its periphery, and as the centre becomes cheesy from the cells breaking down, the bacillus disappears, until it is very difficult, or else impossible, to find it.

Enlarged lymphatic glands in the region of the throat may cause difficulty in breathing or swallowing, and when in the thorax in close proximity to the heart, they may cause symptoms of heart disease.

In the abdominal cavity of the cow tuberculosis may attack any organ, but some more frequently than others; the liver is the one most commonly affected, but it may occur in the spleen, mesenteric lymphatics, the walls of the intestines, the ovary (causing barrenness and nymphomania—"bullers," they are called by the farmer)—occasionally the kidney, and not infrequently the peritoneum, may be studded over with nodules.

In the liver, spleen, or kidney the tubercles may appear as spots under the capsule of the organ, varying in size from a pinhead to a walnut; the larger ones may be undergoing destructive changes in their centres. Histologically, their structure is the same as already described.

In addition to the lesions already enumerated, cattle may have tuberculous meningitis, where tuberculous deposits occur in the vascular layer of the membranes of the brain or spinal cord, producing symptoms of delirium or paralysis, more or less complete, depending upon the extent and location of the deposit.

Last, and most dangerous of all, is tuberculous mammitis, or tuberculosis of the udder. In tuberculous mammitis it is very hard to differentiate between it and any other form of inflammation of the udder; the bag has an indurated feeling in one or more quarters, as though chronically inflamed from some cause, and it is impossible to tell it from any other form of irritation where the connective tissue in the gland is simply increased. After frequently seeing the cow and ascertaining that she is really tuberculous, it may then be inferred that the mammitis is tuberculous; or it may be discovered by a microscopic examination of the milk, or by an inoculation test upon guinea-pigs.

When tuberculosis of the udder exists the bag has a nodulated feeling upon palpation; these nodules may in time break down and discharge their contents through the milk-ducts.

On post-mortem examination in tuberculous mammitis there is found to be simply an increase of the connective tissue in the udder, but no tubercles, unless a few cells with bacilli are found upon examination with the microscope; but in tuberculosis of the udder nodules are present bearing the usual characteristics.

Cattle not infrequently have tuberculous arthritis, but lupus is a very rare, almost unknown, occurrence among them.

PROPHYLAXIS OF BOVINE TUBERCULOSIS.—The treatment of tuberculosis may do in man, but with animals it is neither practicable nor wise, and our efforts should be directed toward its prevention rather than its cure. The prevention of tuberculosis in man and animals is one of great sanitary and economic importance, which has only lately attracted the attention of health authorities since Koch's discovery awakened the world to the true nature of the disease. This is not the place to write upon the prevention of the transmission of tuberculosis from man to man, but the importance of averting its communication from animals to man, and from one bovine to another, cannot be too strongly insisted upon; the people should therefore be protected from the use of tuberculous meat and milk by a system of slaughter-house and dairy inspection. The flesh from animals badly diseased should be destroyed, and that from those slightly tuberculous should not be sold except with the understanding that it is to be thoroughly cooked. Milk from diseased cows should at least be sterilized, or better still, affected cows should be killed, both to protect the public health as well as to guard against their giving it to other cattle.

In regard to cattle, Walley, in his "Four Bovine Scourges," furnishes the following recommendations:

1. "All flesh and offal of affected animals, especially in advanced stages of the disease, should be destroyed by fire or otherwise."
2. "All suspected animals should be carefully isolated until pathognomonic signs have been developed."
3. "All actually affected animals should be slaughtered."
4. "All contaminated food, litter, etc., should be disinfected or burnt."
5. "All infected buildings should be disinfected."
6. "No animal whose history is tainted, even in the slightest degree, or in whose system there exists the slightest suspicion of tubercle, should be used for breeding purposes."
7. "Great care should be exercised at the period of birth to avoid any influences which will weaken the tissues in adultism."
8. "Breeding animals should be carefully shielded (as far as practicable) against debilitating influences of any kind."
9. "The system of feeding and general management of our high-class stocks should be regulated on a more rational and conservative basis than that on which it at present rests."

These rules, although written a number of years before the discovery of the tubercle bacillus, are in the main very good, and no exception can be taken to them. With the present knowledge of the matter it can be added, if the herd is healthy, keep the infection out by not allowing any tuberculous animals on the place. Neither should a consumptive attendant be employed, who might infect the cattle by constantly expectorating around the barn and upon their food.

If tuberculosis exists in a herd the diseased animals should be removed and destroyed, and their places disinfected before replacing them with new animals. Suspected animals should be removed from the herd and isolated in a separate building, until it can be decided whether they are or are not diseased.

Furthermore, the herd should be kept under the best hygienic conditions. Plenty of fresh air and sunlight, and not too warm a stable, will keep them in a condition in which they will be but little likely to contract the disease, and if an animal occasionally has it, if immediately removed from the herd and destroyed, there is little likelihood of others contracting the ailment.

The percentage of tuberculosis in cattle in the United States is very low. In an average dairy country it is not more than ½ to 1½ per cent., but in individual herds it may be very high, perhaps fifty per cent. of a herd of sixty or seventy cows being tuberculous; possibly this herd furnishing a milk route exclusively, the milk being sold perhaps in sealed glass jars at a price slightly above the usual rate, because it is "Jersey milk" from "Clover Dell Farm," or something of the kind. Hence the need of legislation of some kind as well as action by local health boards. In securing State legislation the disease has been looked upon from two standpoints, one as a matter of public health calling for action on the part of the State Board of Health, the other view being to look upon it as a matter of agricultural importance, considering the malady as one of the infectious animal diseases to be taken in hand by the State Board of Agriculture or by a State cattle commission. It makes little difference what board has the work in charge so long as it is well done.

The laws of two States are herewith appended as samples of legislation: that of New York, because it views the matter chiefly from the standpoint of public health, and that of Rhode Island on account of the preponderance which it gives to agricultural interests.

Any tuberculosis law should be worded in a way to allow for mistakes in diagnosis, as the best experts will make mistakes in diagnosing bovine tuberculosis; that is, it should provide for the slaughter of cattle having tuberculosis, or *suspected* of having tuberculosis, thus leaving a loop-hole in case a mistake is made; and also allowing animals to be killed when any doubt exists as to the nature of the malady, as it is safer to occasionally kill a creature that may be suffering from some other disease than to allow a tuberculous animal to escape.

LAWS OF NEW YORK.—By Authority. [Every law, unless a different time shall be prescribed therein, shall commence and take effect throughout the State, on and not before the twentieth day after the day of its final passage, as certified by the Secretary of State. Sec. 12, title 4, chap. 7, part 1, Revised Statutes.]

Chap. 487. An Act in relation to tuberculosis in milch-cows and other cattle, and infectious and contagious diseases of cattle. Approved by the Governor May 5, 1892. Passed, three-fifths being present.

The People of the State of New York, represented in the Senate and Assembly, do enact as follows:

Section 1. That the State Board of Health shall use all reasonable means for ascertaining the existence and cause of disease in, or danger to health from, milch-cows and other cattle in the State of New York, and for averting the same, and preventing all injury from tuberculosis in milch-cows or other cattle in any part of the State; and shall promptly cause all proper information in possession of said Board of Health, respecting any such disease among cattle in any part of the State, to be sent to the local Board of Health of the city, village, or town nearest to the herd, cows, or other cattle affected by any such disease, and shall add thereto such useful suggestions as to the removal of all sources of danger therefrom, or the destruction of said cattle, as the experience of the said board may at any time supply. And it is made the duty of the health authorities throughout the State to supply the like information and suggestions to the State Board of Health respecting the existence of any infectious or contagious disease in milch-cows or other cattle in any part of the State.

Sec. 2. The State Board of Health shall have power to employ such and so many medical and veterinary practitioners and other persons as it may from time to time deem necessary, to assist in the inspection, in the isolation, destruction, or disposition of milch-cows or other cattle affected with tuberculosis or any infectious or contagious disease in any portion of the State, to prescribe rules and regulations for such inspectors and employees, and to fix their compensation.

Sec. 3. Whenever tuberculosis shall be found among milch-cows or other cattle in any part of the State, it shall be the duty of the State Board of Health to take measures to suppress said disease promptly, to prevent the same from spreading, and the said State Board of Health shall have authority to order all persons to take such precautions against the spread of such disease as in the judgment of the said State Board of Health may be necessary or expedient; and further, to call upon all sheriffs, deputy sheriffs, and officers of the peace in the neighborhood where such disease extends among milch-cows or other cattle, to carry out and enforce the orders

of said Board of Health respecting the same, and to observe and carry out the rules and orders and instructions which they may receive from the said Board of Health in the premises; and further, to prescribe regulations for the destruction of animals affected with tuberculosis, or any contagious or infectious disease, and for the proper disposition of their hides and carcasses, and of all objects which might convey infection or contagion; provided, that no animal shall be destroyed unless first examined by a medical or veterinary practitioner in the employ of the State Board of Health aforesaid; and further, to prescribe rules and regulations for the disinfection of premises, buildings, boats, railroad cars, stables, and all objects from or by which infection or contagion may take place or be conveyed, and to alter and modify from time to time all such rules, regulations, orders, and instructions as the said State Board of Health may deem expedient.

Sec. 4. Whenever in the judgment of the said State Board of Health it may become necessary to prevent the spread of tuberculosis, or any infectious or contagious disease of domestic animals, or the public welfare shall be promoted thereby, the said Board of Health may cause to be slaughtered, and has authority to kill, or order to be killed, any animal or animals which by contact or cohabitation with diseased animals, or by exposure to infection or contagion therefrom, the said State Board of Health may consider and determine, may be liable to contract or communicate the disease sought to be suppressed, and to prevent all danger therefrom.

Sec. 5. Any person or persons refusing to obey the orders, rules, or regulations of the said Board of Health adopted in pursuance of the provisions of this act and the authority by this act given to the said State Board of Health, or transgressing the rules, orders, and regulations of the said State Board of Health adopted for the removal of the sources of danger from tuberculosis in milch-cows or other cattle, or any infectious or contagious disease in domestic animals in any part of the State, shall be guilty of a misdemeanor, and shall also be liable to pay a fine of one hundred dollars, which fine the State Board of Health is hereby authorized to sue for and collect in its name in any court of this State.

Sec. 6. All expenses incurred by the State Board of Health in carrying out the provisions of this act, and in performing the duties hereby devolved upon it, shall be audited by the Comptroller as other expenses of the said State Board of Health, and the sum of five thousand dollars, or so much thereof as may be necessary, is herewith appropriated out of any money in the treasury not otherwise appropriated for carrying out the provisions of this act.

Sec. 7. The actual value at the time they are killed, of any animals slaughtered, under the provisions of this law, to be ascertained and determined as hereinafter provided, may be paid to the owners of such cattle under and pursuant to any resolution of the said State Board of Health providing for such payment, and the Board of Claims shall have exclusive jurisdiction to hear, audit, and determine all claims which shall arise under the provisions of this act, and to allow thereon such sums as should be paid by the State; provided, however, that no compensation shall be made under the provisions of this act or otherwise to any person who shall wilfully have concealed the existence of disease among his animals, or upon his premises, or who shall in any way, directly or indirectly, by act or wilful neglect, have contributed to the spread of disease sought to be suppressed or prevented; and provided, further, that such claims shall not have accrued more than two years prior to the filing of the said claims.

Sec. 8. This act shall take effect immediately.

STATE OF NEW YORK, } ss.:
Office of the Secretary of State, }

I have compared the preceding with the original law on file in this office, and do hereby certify that the same is a correct transcript therefrom and of the whole of said original law.

FRANK RICE,
Secretary of State.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS.—Chap. 1082. An Act in Amendment of Chap. 507, Chap. 627, Chap. 643, and Chap. 1025, of the Public Laws.

It is enacted by the General Assembly as follows:

Section 8. The board may appoint one cattle commissioner in each county of the State, whose duty it shall be to visit and inquire into the condition of any domestic animal in their respective counties whenever there is reason to suspect that any such animal is affected with tuberculosis, or other contagious, infectious, or communicable disease.

Sec. 9. The board may employ veterinary surgeons.

Sec. 10. Whenever any animal shall be suspected by either of the cattle commissioners to be affected with tuberculosis, the commissioner of the county where the animal is found shall immediately notify the secretary of the State Board of Agriculture, who shall promptly fix a day when the appraisers, duly appointed as hereinafter provided, shall visit the suspected animal with the veterinary surgeon; and upon confirmation of the disease, and after appraisement of the value as hereinafter provided, the affected animal shall be killed, and the carcass disposed of in such a manner as will not be detrimental to the public health.

Sec. 11. For the purposes aforesaid, the board may appoint some suitable person as appraiser, whose duty it shall be to act with one of the cattle commissioners in each county, which two persons shall constitute the board of appraisers for the county. In case of disagreement between the two appraisers, the veterinary surgeon shall act as a third appraiser, and the estimate of value of either two of them shall be final, provided that not more than $50 shall be allowed for any single native animal, nor more than $75 for any single grade animal, nor more than $100 for any single registered animal. And written notice of the amount of the appraisal, signed by the board of appraisers, shall be immediately given to the owner or claimant of said animal; and provided further that any party aggrieved by any award made under the provisions of this section may appeal therefrom to said board within five days after the receipt of said notice.

Sec. 12. The board of appraisers, by and with the advice of the veterinary surgeon, is hereby authorized to quarantine any animal or animals supposed to be affected with a contagious, infectious, or communicable disease, and one-third of the cost of such quarantining shall be assumed and paid by the State, except as otherwise provided in Section 21 of this act.

Sec. 13. The State shall pay to the owner of any animal killed under the provisions of Section 10 of this act, one-half of its appraised value; but if upon a post-mortem examination it shall be found that the slaughtered animal was not affected with tuberculosis, then the animal so killed shall be paid for at its full appraised value, provided that the State shall not pay for any diseased animal so killed if the animal has not been in the possession of its present owner three months previous to the day of the slaughter.

Sec. 14. When any person shall be shown to have knowingly brought into this State an animal suffering, or suspected to be suffering, with tuberculosis, or to have concealed the existence of such disease in any animal owned by him, such person shall not be entitled to any compensation for the animal slaughtered under this act, and shall be deemed guilty of a misdemeanor, and upon conviction shall be fined for such offence not exceeding one hundred dollars.

Sec. 16. No person having the care or custody of any animal having any one of the diseases mentioned in the preceding sections, shall, knowing the same to have any such disease, sell or exchange, or permit the removal, use or driving of the same upon any public highway, or the exposure of the same to contact with any other healthy animal of the same kind, except by permission of some member or agent of the State Board of Agriculture. Any person so doing shall be deemed guilty of a misdemeanor, and on being convicted, shall be fined not exceeding one hundred dollars.

Sec. 17. The State Board of Agriculture, or its duly authorized representatives, having reason to suspect the existence of any of the diseases mentioned in this act upon any grounds or premises, are hereby authorized and empowered to enter upon such grounds or premises for the enforcement of the provisions of this act

Sec. 18. The governor is hereby authorized to accept on behalf of the State the rules and regulations prepared by the Commissioner of Agriculture under and in pursuance of section 3 of an act of Congress, approved May 29, 1884, entitled: "An act for the establishment of a bureau of animal industry, to prevent the exportation of diseased cattle, and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," and to co-operate with the authorities of the United States in the provisions of said act.

Sec. 19. The inspectors of the bureau of animal industry of the United States, in co-operation with the State Board of Agriculture, shall have the right of inspection, quarantine, and condemnation of animals affected with any contagious, infectious, or communicable disease, or suspected to be so affected, or that have been exposed to any such disease, and for these purposes are hereby authorized and empowered to enter upon any grounds or premises. Said inspectors, in co-operation with the State Board of Agriculture, shall have the power to call on sheriffs, constables, and peace officers to assist them in the discharge of their duties in carrying out the provisions of the act of Congress approved May 29, 1884, establishing the bureau of animal industry; and it is hereby made the duty of sheriffs, constables, and peace officers to assist said inspectors when so requested; and said inspectors shall have the same power and protection as peace officers while engaged in the discharge of their duties.

Sec. 20. The State shall not be liable for any damages or expenses incurred under sections 18 and 19 of this act.

Sec. 21. Any person or persons who shall wilfully or intentionally interfere with any officer or officers, duly authorized to carry out the provisions of this act, or who shall wilfully or intentionally violate the provisions of the quarantine authorized by section 13 of this act, shall be deemed guilty of a misdemeanor, and upon conviction shall be liable to imprisonment not exceeding three months, or a fine not exceeding one hundred dollars, or both, at the discretion of the court.

Sec. 22. The State Board of Agriculture is hereby authorized to fix the compensation of the cattle commissioners, appraisers, and veterinary surgeons, to prescribe their duties and to remove them when deemed expedient so to do.

Sec. 23. The Secretary of the State Board of Agriculture shall make a monthly report to the governor of the obligations of the State Board of Agriculture; and the State Auditor is hereby directed to draw his orders on the general treasurer for the payment of the same upon vouchers approved by the governor.

Sec. 24. The sum of $15,000, or so much thereof as may be authorized, is hereby annually appropriated for the purpose of carrying out the several provisions of this act, including all salaries and expenses created under the authority hereof.

Sec. 25. All prosecutions for offences against the provisions of this Chapter shall be commenced within sixty days after the same shall have been committed, and not afterward.

Sec. 26. Chap. 507, Chap. 627, Chap. 643, and Chap. 1,025 of the Public Laws, and all acts and parts of acts inconsistent herewith, are hereby repealed, and this act shall take effect immediately upon its passage.

GLANDERS AND FARCY.—Glanders and farcy is the third form of the infective granulomata common to man and animals; it may be defined as a disease peculiar to solipeds, and transmissible from them to man and other animals.

It is very widely diffused and has been known from the earliest antiquity; it would appear, however, that some countries are more severely visited than others, and they are those where horses are most artificially maintained, and in which the laws of health are most imperfectly maintained or altogether ignored.

Liguistin, a French veterinarian, says that glanders was unknown in Mexico until the time of the Mexican war, in 1847, when the United States Army brought it to Vera Cruz; it is still rare, however, in its new home. It is very rare or unknown in Australia and India, is not infrequent at the Cape of Good Hope, and occurs in China. Great Britain and the Continent of Europe are much ravaged by it, and it occasions a great deal of mischief all over the United States.

The designations "Glanders" and "Farcy" are employed to distinguish two forms of one disease, that is, they seem to be two different diseases, but are in reality identical, however dissimilar in their external manifestations.

The term glanders is applied to the disease when the nasal or respiratory mucous membrane and adjacent lymphatic glands, as well as the lungs and other organs, are involved; and farcy, when the malady is localized in the skin and subcutaneous connective tissue, and secondarily in the lymphatic vessels and glands.

These two forms of affection may be observed in the same animal singly, simultaneously, or successively; and the virus of glanders may produce farcy by transmission from a diseased to a healthy animal, or farcy may in the same way produce glanders. Hence the name skin glanders (*Hautrotz*) given by the Germans to farcy is perfectly applicable.

Experimentation has shown that the morbid products of glanders and farcy, no matter from what organ or surface they are taken, give rise indifferently to one or the other form; and that the principal seat of the lesions of acute glanders, developed by inoculation, does not at all depend upon the source from which the inoculating material was derived; inoculation with the matter obtained from a glanderous pulmonary abscess may produce infection in which the principal, and sometimes only apparent, lesion is located in the nasal mucous membrane, and *vice versâ*. Again, material derived from a cutaneous abscess of acute farcy may occasion acute glanders, in which perhaps the most marked alterations will be found in the lungs or nasal passages, and *vice versâ*.

These facts prove glanders and farcy to be one and the same disease, no matter what organ, organs, or tissues appear to be more particularly affected.

Although glanders and farcy has been known to be a contagious disease for years, yet before the germ theory was thoroughly understood it was believed that under favorable conditions the malady might arise spontaneously in a horse, and that then he might transmit it to others. This was thought to be the case because it is sometimes impossible to trace an outbreak to its source, and this was an easy explanation for it; but now the belief is generally accepted that every germ must be the offspring of a pre-existing one, and that in order to have glanders develop in a horse, the specific virus must have gained an entrance to his system, even if the time at which he was exposed to infection is not known.

The causes of glanders, as of all communicable disorders, can be divided into the exciting cause and the predisposing causes.

The exciting cause of glanders has been discovered, within a few years, to be a bacillus, about the size of the tubercle bacillus, perhaps a trifle shorter and thicker. It has been studied chiefly by two German scientists, Loeffler and Shütz. It grows in a constant-temperature apparatus at 39° C. or 40° C. on sterilized blood-serum, or agar-agar; it also grows on sterilized cooked potato, on which it has a characteristic growth, forming brownish, gelatinous colonies.

After being carried on in pure cultivations for several generations it was found to still possess the power of producing the disease when inoculated into horses, rabbits, guinea-pigs, and field-mice.

It is hard to stain in sections, and has no characteristic stain like the tubercle bacillus, but in cover-glass preparations of cultures, the discharge from chancres or

pus from abscesses, it is readily stained by solutions of methylin blue.

The predisposing causes of glanders and farcy are similar to the predisposing causes in other diseases, that is, anything that depletes the system, renders it more liable to acquire disease; hence hard work, poor food, and bad hygienic surroundings are predisposing causes, as well as greater susceptibility on the part of some animals than others for some unknown reason, and also the free intermingling of animals, throwing them open to contagion. Glanders is almost certain to break out among army horses during a campaign. Here the privations, hardship, and work act as predisposing causes, and the diseased and healthy intermingle freely together, drink at the same troughs, and a healthy horse may be quartered to-night where a glandered one was last night. Invariably this disease causes great havoc among military horses during a war; it was rife among the horses used in the Crimea in 1854–56; in the war between France and Italy; in that against Austria; and in the Franco-German war in 1870. In the latter case the German cavalry took the field with magnificent horses that had been picked out carefully with especial reference to having them sound and healthy, yet it is said that not a single regiment returned without some of its horses being infected, and they spread it in Germany and Northern France to such an extent that, even to this day, it is said to be much more common on the Rhenish frontier than formerly.

In crowded, badly ventilated stables in large cities glanders spreads to a great extent if it once gets a foothold, especially if the work is hard, food poor, and the animals exposed to all kinds of weather. It is a question whether the beautiful public watering-troughs set up by benevolent hippo-philanthropists and noble humane societies may not assist in disseminating this disease if it is prevalent in a locality, healthy horses drinking after affected ones and becoming contaminated in this way.

Symptoms of Glanders and Farcy.—Clinically, glanders and farcy may be divided into four divisions: 1, Chronic glanders; 2, acute glanders; 3, chronic farcy; 4, acute farcy; and in studying the symptoms each form will have to be considered separately. This disease seems to take on an acute or chronic form depending upon the virulence of the virus, and the condition of the animal attacked, or its breed.

"Low-bred lymphatic horses being more apt to have the chronic form, while well-bred horses are more subject to the acute, although, as a rule, the chronic form is most common, but it may assume an acute character at any time.

"Chronic glanders may continue for months, and even for years, and the animals may exhibit but little constitutional disturbance, and yet be a source of constant danger to others with which they come in contact.

"The symptoms are local and general; the first are essential and constant, as well as contingent and accessory; the latter consists of more or less fever according to the duration of the disease and influencing circumstances.

"The essential characteristic local lesions are the nasal discharge, the ulceration of the pituitary membrane, and the enlargement of the submaxillary lymphatic glands. The disease usually commences with the symptoms of an ordinary acute or chronic catarrh from one or both nostrils, though it is said to be generally from one. The discharge, at first transparent and watery, later becomes opaque and sticky, collecting around the margin of the nostril, or being blown out in thick, lumpy masses.

"The discharge usually comes from the nostril in which the ulcers hereafter to be described are situated; when from both nostrils the ulceration is to be looked for in both of them. The older French veterinarians describe a form of the malady which they call 'Dry Glanders' (*morve sèche*), because there is no nasal discharge. It is extremely rare, however, that there is no discharge at all, a little serous slightly opaque fluid always flowing from the lower commissure of the nostril. In most instances at the commencement of chronic glanders the discharge from the nose is very slight, being produced by the ulcers that are just beginning to form · but if there be much inflammation of the mucous membrane, as there often is, then the discharge will be more copious, though less characteristic.

"The character of the discharge in chronic glanders, after the disease has existed for some time, is characteristic and not to be lost sight of as a symptom.

"It is glutinous, adhering to the skin around the opening of the nostril, forming soft, greasy-feeling crusts of a dark-brown color, which adhere to the fingers when touched; particles of straw, hay, hayseed, and the like are apt to adhere to the skin and hair, being held by this sticky discharge. At first it is chiefly albuminous, but it afterward becomes purulent, and then assumes a peculiar slightly greenish tint, which has been looked upon as a marked feature.

"If the disease has a tendency to assume an acute type, the ulcerations may cause slight hemorrhages, which cause the discharge to be streaked with blood, or else assume a rusty tint. As a rule the discharge has no odor, or it may have a slight sickish smell; it only has much fœtor when it accummulates in the sinuses of the head for some time, and is then due to putrefactive changes.

"The ulcers on the mucous membrane of the septum nasi or air-passages may be of two kinds: a true chancre, or simply a destruction in spots of the epithelium covering the mucous membrane.

"Only a small portion of the mucous membrane of the septum can be seen even when a careful examination is made, but sometimes the ulcers can be felt with the end of the finger above the reach of the eye, or they may be so far up as to be impossible of detection; in this case the character of the discharge and the enlarged submaxillary lymphatic glands have to serve as a guide in forming an opinion, with, in some instances, a knowledge of the history of the case.

"In chronic glanders the chancres are few in number, principally on the turbinated bones, and hard to find; it is possible, however, for them to be in plain view in both nostrils. What are to be chancres later first appear as small resisting points or 'nodosities,' varying in size from a millet-seed to a small pea; to the touch of the finger they feel like a small foreign body firmly fixed in the membrane; to the eye they appear as little round bodies of a yellowish color, surrounded by a pale, shining margin, or the margin may look red and inflamed the more nearly the disease approaches an acute type. They develop rapidly, often attaining their maximum size in a day. After three or four days the centre of the nodule becomes white and opaque, then breaking down, casting off the epithelium, allowing a drop of pus to escape, leaving a small concave depression; this is the first appearance of the glanders chancre, and constitutes confirmed glanders. At first this ulcer is somewhat circular, with a sharply defined border, finely notched around its margin, and roughened at the bottom.

"It is of a dull, leaden-gray color, occasionally streaked with blood-colored lines, or if the malady approaches the acute form it becomes bright red or violet-colored; invariably its margin is firm, hard, and slightly elevated, continuous with the fibroid base on which it rests. The chancre once formed may continue to ulcerate and extend, and may coalesce with others, forming a large irregularly shaped ulcerating surface; in proportion as the ulcer enlarges the induration of the mucous tissue becomes more extensive. The chancre may continue to suppurate, and the matter from it is often considerable in quantity compared with the size of the sore; not infrequently it coagulates and forms a yellow, but slightly attached crust over the ulcer. Occasionally the chancre may have a tendency to heal, it then contracts and fills up with granulations, which become covered with epithelium, the process forming a circular or stellate scar, its white color contrasting sharply with the natural color of the mucous membrane of the nose.

"In a stable of horses it is not rare to find one or more

with a small cicatrix or erosion in one nostril; these marks are perhaps due to a prick or scratch from a stub or similar foreign body, and should not be mistaken for chronic glanders chancres healed over.

"The healing process described above is probably the result of a check in the progress of the disease, and is an attempt of nature to restore the parts to a normal condition.

"But although the chancres in chronic glanders may sometimes heal, it by no means indicates perfect recovery, for the tubercles of glanders still remain in the lungs and are never absorbed, the body retains the virulent properties of the disease, which, although latent, will again become manifest at a future period by a second crop of chancres. In addition to the chancres in long-standing cases, there are frequently seen irregularly shaped erosions from which the epithelium has disappeared, as though it had been scraped off; they are usually observed upon the middle portion of the septum nasi, which is in this situation of a dull red color, has lost its shining appearance, and at times is covered with a purulent matter that is easily rubbed off. The third characteristic symptom of glanders consists in the enlargement of the submaxillary lymphatic glands, as the result of the action of the glanders poison upon them; this condition is always associated with the chancres in the nose, and the glands may be enlarged on one or both sides, depending on whether one or both nostrils contain the ulcers (hence the name of 'glanders,' given to the disease by the old farriers), the swollen gland being upon the same side as the nostril containing the ulcers. The gland is generally hard, nodulated, painless on pressure after the first few days, as a rule is rather immovable, adhering somewhat closely to the skin and structures over the jawbone. It is apt to be irregular in shape, usually oval, stretching from before backward, although it may be round and varying in size from a chestnut to a small apple, and generally has no tendency to soften and suppurate. Chronic glanders is sometimes accompanied or preceded by rheumatoid affections of the joints or sheaths of tendons, causing tumefaction of these and lameness, brittleness of bones, swelling of dependent parts, nose-bleed, cough, irregular respiration, and swelling of the sinuses of one side of the head, and the separate or collective presence of these symptoms may aid in diagnosing the disease when it is otherwise only suspected.

"The general symptoms accompanying these changes are, in the majority of cases, obscure at first; there may be observed a certain amount of fever, debility, and unthriftiness, with diminished appetite and loss of weight. When the appearances previously described commence to manifest themselves, there is a striking recovery apparently, the appetite is regained, the animal becomes lively, improves in condition and general appearance, as if a crisis had been passed and recovery was assured.

"This deceptive state may continue for some months, and it is only in those cases in which the disease is localized in the lungs from the commencement, and generally when the malady is of long standing, that the animal continues to look ill, and the above-enumerated general symptoms persist.

"Usually, notwithstanding the apparent healthiness, or check of the disease, it goes on extending its ravages, and at more or less distant intervals is complicated by exacerbations, which promptly increase the lesions. Some of the exacerbations are at times so severe that the animal may die of acute glanders in a few days; indeed, the malady nearly always terminates in this manner, as its progress is generally all the more rapid the older it is, as though the acute type had suddenly appeared. Then come the frequent cough, difficult breathing, swelling of the extremities and dependent parts in general, or farcy tumors or ulcers appear in different regions; and finally death follows from marasmus, or rapid formation of glanderous abscesses, accompanied by intense fever or pyæmia" (Fleming's "Veterinary Science and Police").

Although the classical symptoms of glanders are the chancre, discharge from the nose, and enlarged submaxillary glands, yet it is not infrequent for one or more of these symptoms to be absent, and there may be cases where glanders tubercles exist in the lungs without any external manifestation of the disease being present; the horse after death is found to have the lungs full of glanders nodules in various stages of development, from the new translucent nodule to the calcareous one, with intermediate forms in different states of caseation. This form is called internal or pulmonary glanders. The nodules may also be found in the liver, spleen, bronchial and mesenteric glands, and similar locations. These cases are the most dangerous, as such horses are capable of transmitting the disease to others, yet during life they show no symptoms by which even veterinary experts can make a diagnosis, unless an animal may be suspected for some reason in a stable where glanders exists.

Acute Glanders.—Glanders may assume an acute form at the outset, or chronic glanders may terminate by assuming an acute character. Here, as in chronic glanders, the symptoms are general and local. The general symptoms are loss of, or capricious appetite, a staring, unthrifty-looking coat, and high fever; the temperature is said to have reached 109° F., according to Trasbot, a French observer; at all events it reaches 106° to 107° F. (the normal temperature of the horse is 100° F.); the fever lasts several days and there is rapid emaciation.

The animal sweats on the slightest exertion, the subsequent lassitude is very marked, and there are shiverings and tremblings, and perhaps sudden lameness without any appreciable cause. The urine is increased in quantity and of a low specific gravity, and it is said may contain albumin; the breathing is hurried and irregular, occasionally being as high as forty or fifty respirations to the minute, and may be accompanied by a snoring sound, and dyspnœa almost amounting to suffocation. The pulse is small and quick, and the artery soft and flaccid. The visible mucous membranes are highly congested, of a yellowish hue at first, later becoming darker-colored until almost purple, when suffocation is imminent. The nasal mucous membrane is highly congested, appears thickened, and there may be hæmorrhage from it.

After a few days the fever subsides, and as it disappears the local and essential lesions commence to manifest themselves, their appearance being coincident with the decrease in fever, although the temperature does not become normal but remains at about 102° F.

The glanders nodosities then appear upon the pituitary membrane resembling those described as belonging to chronic glanders, except that in the acute form there is a red zone around the nodule. In a few days these points break down, leaving a granulating ulcer of a reddish-violet hue, having a ragged salient border, and a tendency to bleed easily when touched. The chancres are numerous, irregular in shape, and rapidly invade the membrane, often becoming confluent, forming great ulcerating sores of various sizes and outlines, which may penetrate to the cartilage, and even lead to necrosis of it, sometimes even causing perforation of the septum if the animal lives long enough; the ulcerative process may also extend to the larynx and trachea. Following the formation of the ulcers comes the characteristic discharge, thin and watery at first, later becoming thick and sticky, or streaked with blood.

Then, as a result of the passage of the virus through the lymph-vessels, the submaxillary lymphatic glands enlarge, being soft and painful at first, later becoming hard and adherent and free from pain.

Farcy in an acute form (Fleming) nearly always complicates acute glanders, just preceding it, accompanying it, or following it; in addition, lymphatic vessels in different parts of the body become inflamed, depending parts become œdematous, even the head around the nose. Respiration may be harsh and difficult from the ulceration of the larynx.

The fever, which had almost disappeared when the eruption broke out, returns; the lungs may be inflamed from a lobular pneumonia or from the formation of nodules; new ulcers are continually forming on the skin and on the septum nasi, and suppurate freely; emaciation is very

rapid, and a profuse diarrhœa may appear toward the end.

In acute glanders death occurs from eight to fifteen days after the appearance of the fever, and is due either to exhaustion, to asphyxia when the larynx is severely involved (in which case it may occur earlier), or in consequence of the amount of lung involved in the process.

Chronic Farcy.—Farcy, like glanders, can be divided into two forms—the chronic and the acute—and may exist by itself or be associated with glanders.

Chronic farcy is considered the least serious form of glanders; though it is, Fleming asserts, the most frequent. This is not the writer's experience. As far as he has been able to observe in this country, farcy is rare in comparison with glanders, and usually the cases of farcy he has seen have been associated with glanders.

As in the other forms of the disorder there are local specific lesions, and also the general symptoms.

The local lesions consist in the appearance of superficial indolent tumors, especially along the course of the lymphatic vessels on the inside of the hind- or fore-leg, called "farcy buds." These soon ulcerate and become chancres, constituting the specific feature of the malady. These tumors may vary in size from a pea to a small nut, may appear in the skin first, and later extend into the subcutaneous connective tissue, or may appear first in the subcutaneous connective tissue, and later extend to the skin; the small ones are generally in the skin, and the large ones commonly in the subcutaneous connective tissue, invading the skin only when they begin to ulcerate. Either form may occur as isolated lumps, or in groups, or the latter may become confluent over a limited surface. Besides appearing on the inside of the legs these tumors and ulcers may develop anywhere upon the body, although they generally appear where the skin is thinnest and most vascular, next to the insides of the legs coming most frequently around the eyes, nostrils, lips, and upon the face, in the jugular space, on the chest, abdomen, shoulders, flanks, and near the root of the tail.

Their number is very variable. First one and then another of the nodules may appear, followed by one or two more, invading the system gradually, or a large number may develop all at once.

Much depends upon the general health of the animal, and the severity of the attack at first; when it appears with first one bud, and then another develops, it may be several weeks, or possibly months, before the horse becomes badly diseased. After the appearance of the nodules under the skin, which at first feel like small, hard points, that may sometimes disappear to appear again in other situations; they finally increase in size, soften at the centre and break down. From this small abscess there flows a little thin, yellow, oily, purulent material, which is very characteristic of the disease, leaving a chancrous ulcer, appearing as a concave excavation of a dirty yellow or grayish color, with an indurated margin and base. It secretes considerable pus, which may coagulate upon the surrounding hair, forming a yellowish crust over the ulcer, which can, however, be easily rubbed off with the finger. The farcy ulcer has no tendency to heal, and may extend by destroying the tissue around its margin; if near together, several chancres may become confluent, forming a large, irregularly shaped sore. No matter how irregular in shape the ulcer may be, it retains certain specific characteristics that are never lacking, and that are diagnostic: the character of the secretion, the peculiar jagged border, the surrounding induration and hard base, as well as the marked depression in the centre of the sore, are to the experienced eye unmistakable evidences of chronic farcy.

Following the development of the farcy buds, within a few days cord-like swellings appear, leading from the ulcers toward the nearest lymphatic glands; these are inflamed lymphatic vessels, and are called "farcy cords." At first there is a diffuse swelling around them, but in three or four days they become well defined, are hard to the touch, and about the size of a goose-quill.

This corded condition of the lymphatic vessels soon changes, and at certain distances along their course little enlargements appear, giving them a beaded appearance; these enlargements soften in the centre, break down and form new chancres; this is the result of the action of the glanders virus upon the lymphatics, the new buds probably forming at valves in the vessel, where the virus has a chance to rest and cause the production of buds, followed by ulcers. The chancres may extend until the cord is transformed into a chain of sores, which may even coalesce, forming a long, linear, ulcerating furrow.

Occasionally these secondary ulcerations may attempt to cicatrize, but when they do form granulation tissue it is soft, spongy, and easily torn. Very rarely the primary buds from which the cords emanate may disappear or cicatrize, in which case the cords, instead of forming secondary buds, may partially subside, or even regain their normal condition. This state of affairs, which is very infrequent, would appear to mark a check in the course of the malady, and lead to the hope that it is about to terminate in recovery, but in too many instances the improvement proves to be only temporary, and the disease again shows itself, sooner or later.

In chronic farcy the lymphatic glands may later become swollen, as the result of the farcy cords carrying the poison from the farcy buds to them. These glands may be in various locations, depending upon the proximity of the farcy buds to them, and have the same characteristics as the submaxillary glands in glanders.

In chronic farcy there may also occur swellings and tumors; the latter are rather rare, consist of swellings on various parts of the animal, varying in size from a hen's egg to a man's fist. At first hard, hot, and painful, they in a few days soften and fluctuate; then, if lanced, they discharge matter resembling that from a farcy bud, and continue to discharge, with little tendency to heal; or the lips of the wound may heal together so that the cyst or abscess is re-established, or complete healing from the bottom may occur.

The farcinous swellings are of an inflammatory nature, and appear on the limbs, generally the hind ones; they may occur around a joint only, as the hock, fetlock, or knee, or there may be a diffuse swelling of the entire leg, the limb being very much swollen, and the animal evincing great pain and lameness in it. Sometimes the lameness may appear before any swelling, and this lameness is very often coincident with the first appearance of the disease; hence lameness is often the first manifestation of glanders or farcy, even before any other symptoms appear. On the other hand, swelling of the limbs or obscure lameness is by no means a constant symptom. The tumefaction of a limb may be persistent or it may more rarely subside in a few days; but this subsidence is coincident with the appearance of the disease.

The eruption of farcy is always accompanied by fever, or else preceded by it; but this might easily escape the attention of an ordinary observer.

Chronic farcy is then characterized by "buds" or chancres on the skin, these yielding a peculiar pus; by swellings which may, or may not, be followed by ulceration of the contiguous lymphatic vessels; and by non-suppurating, non-ulcerating swellings of the lymphatic glands in which the vessels terminate.

Acute Farcy.—Like chronic farcy the acute form has the local and general symptoms; it resembles the chronic form, varying from it chiefly in degree. It is ushered in by well-marked symptoms, the animal is very feverish, refuses its food, and has all the signs of general constitutional disturbance noticed in acute glanders. After two or three days the fever subsides, the patient appears to be better, and regains its appetite and spirits; but in a few days the fever reappears, the pathological changes become general and rapidly reach their last stage. The farcy buds appear very suddenly, are more numerous, develop more rapidly, and ulcerate earlier than in chronic farcy. Fleming says that the "buds" may attain the size of a large nut and soften in the centre, ready to ulcerate during a single night. The legs may be swollen to an enormous size, and are then very painful. Each bud ulcerates toward the second or third day, the ulcer being wide and deep, and extends

rapidly. The matter from them is abundant and viscid, often wine-colored or streaked with blood. The chancres may be covered with exuberant purplish granulations, which may bleed at the touch; the ulcerations extend rapidly and may become confluent with others, forming large unhealthy looking sores, which may be bright red at points, or covered with brownish crusts.

The "farcy cords," so-called, develop rapidly, soon break down, forming secondary chancres, and may become a sloughing furrow from which exudes an abundant quantity of a sticky, blood-tinged pus. The lymphatic glands to which these vessels lead swell rapidly and are very painful to the touch, but have the usual characteristics of the glands in glanders.

In acute as in chronic farcy there are other symptoms than those already described, which although not exactly characteristic of the disease, are at the same time often present; these are the swellings of dependent parts of the body and limbs, and obscure lameness.

While these changes are going on, the fever continues with intermittent exacerbations; symptoms of acute glanders soon appear, the animals lose flesh rapidly, sink into a state of exhaustion, and soon die, if not killed before they reach this point.

From what has already been said it can be seen that, as a rule, any form of glanders is fatal in time. Fleming, in his "Sanitary Science and Police," whose classification and descriptions have been closely followed above, says that chronic glanders is more common in the horse, and that the acute type more frequently attacks the ass and mule, while, on the contrary, farcy is more likely to be acute in the horse and chronic in the ass and mule.

Farcy was formerly considered curable in equines; hence the distinction of glanders and farcy as two distinct diseases by the old writers, and it may be that in some instances this distinction is still made; but owing to the danger from a farcied horse to man and other equines, treatment is not permissible, and in most of the Northern States the law requires that all glandered and farcied solipeds must be killed; but in some of the Southern and Southwestern States there is a woful lack of sanitary legislation, and glanders and similar diseases are permitted to run riot without any attempt to check their ravages.

Diagnosis.—From the symptoms described above it can be readily seen that a typical case of glanders or farcy is not hard to diagnose, but there are cases where it is a very difficult matter if one or more symptoms are lacking. In such cases depleting the horse's system will sometimes cause the disease to develop more rapidly, and in this way enough evidences of the disease may be obtained on which to base a diagnosis. This is best done by giving the animal a powerful cathartic, thus depleting the system so that it has less power of resisting the invasion of the disease.

Inoculating another animal may be resorted to for the purpose of deciding an uncertain case. For example, a valuable horse may be suspected of having glanders, yet it is doubtful whether he has or not; in such a case an ass, or an old horse—preferably the former as being more susceptible—may be inoculated with some of the nasal discharge or exudate from a farcy sore, and if the inoculated animal develops glanders or farcy it is evident that the one from which the virus was taken has the disease; but if the inoculated animal does not have it, it does not always prove the health of the first, but may show the insusceptibility of the latter, although as a rule the test may be considered tolerably reliable. Guinea-pigs may be used for inoculation tests, as they are quite susceptible, and will develop the malady in eight or ten days, and die of it in six or eight weeks. Or, if the investigator has time and is enough of a bacteriologist to do so, he might try cultivating the bacillus on potato, and then inoculate guinea-pigs from the cultures.

The suspected horse should be quarantined, isolated from other horses, and should have a separate water-pail, separate currycomb and brush, etc. The attendant must not allow any secretion of a glanderous character to come in contact with a cut or scratch on his skin, and it is very dangerous, should a horse cough or blow any glanderous discharge into the nose, eyes, or mouth of a person.

There are various maladies of the horse that may resemble glanders for a while; here it is best to wait a few days and watch the course and development of the sickness, when it can soon be told whether the trouble is glanders or not. Some of the ailments that may simulate glanders are strangles, chronic nasal catarrh, or a discharge from the nose caused by a diseased upper molar. In various conditions where glanders is suspected, if the animal is kept under observation for a few days it will soon become evident whether he has the disease or not, with a few rare exceptions. Horse-pox may resemble glanders for a few days, and the scars left from sloughs on the pituitary membrane may sometimes resemble slightly the cicatrices of the ulcers in chronic glanders.

Chronic or acute farcy may be difficult at first to differentiate from lymphangitis, horse-pox, or other diseases causing much inflammatory swelling of the legs; here again a waiting policy is to be adopted for a few days, in order to ascertain what the leg does; observe whether sores upon them cicatrize, or whether they are chancrous; notice also whether the discharge from them is characteristic or not.

In considering the diagnosis of glanders, it would not be complete without a brief mention of mallein as an aid to diagnosis in doubtful cases. Mallein is a chemical product of cultures of the glanders bacillus, obtained by making a sterilized glycerine extract in the same way as Koch's tuberculin is prepared from cultures of the tubercle bacillus. It was first made by Kalning, a Russian veterinary surgeon, who conceived the idea from Koch's discovery of and experiments with tuberculin.

It is used as a subcutaneous injection in doses of two and a half c.c. of a ten per cent. solution, and is said to produce a reaction in glandered horses similar to the effect said to be produced in tuberculous cows by tuberculin, without having any marked effect on a healthy horse. It has been experimented with more extensively than tuberculin, and its effects so far seem to be more certain.

If the animal be glandered, there is a marked local swelling at the point of inoculation, hot and painful to the touch, and the temperature rises three or four degrees, the rise commencing in three or four hours, attaining its maximum in about ten hours, and remaining so until the expiration of from eighteen to twenty-four hours, when it gradually subsides. All the evidence at present obtainable points to mallein as a valuable diagnostic agent in suspected cases of glanders, and if all that is said of it be true it promises to become an invaluable aid in the confirmation of doubtful cases of this disease.

It can be obtained from the Pasteur Institute, in Paris, and the Bureau of Animal Industry, of the United States Department of Agriculture, also had a little to spare at one time, and may still have some.

Prognosis.—From what has already been said it is easy to see that the termination of glanders and farcy *must* be fatal, and as the disease is so dangerous, treatment, except in the case of man, is not allowable.

In man, if it is realized at once that he has become inoculated with glanders in any way, the point of inoculation should be thoroughly cauterized with the actual cautery, or if this is not possible, with the nitrate of silver. The treatment farther than this is, like the modern treatment of syphilis, mercury and iodide of potash, together with the hot baths which in some parts of the country seem to have a medicinal effect.

In the human the disease is not always diagnosed in time, as it occurs so infrequently in man that physicians do not in every instance recognize it at once, particularly if there happens to be no obtainable history of the case to aid in ascertaining what the trouble is.

Prophylactic treatment is then the only kind to follow in outbreaks of glanders and farcy.

Diseased animals should be killed, and their carcasses destroyed at once. Near our large cities the horses killed for this disease can be taken to large rendering establish-

ments, and the process of rendering destroys the germs of the disease. In the country the infected animal should either be cremated, or buried very deep, the remains covered with quick-lime before shovelling the earth in on top of them.

The stall where the glandered animal stood should be thoroughly disinfected; this can be done by using boiling-hot water, or going over the stall with a whitewash brush and a solution of corrosive sublimate 1 to 1,000, or a strong solution of sulphate of copper, afterward whitewashing the stall.

Woodwork on which the horse may have distributed much virus, such as the manger, rack, and floor, should be torn out and burned and replaced by new. His pail, halter, and blankets should also go into the bonfire, unless the blankets will stand boiling for twenty minutes to half an hour without being ruined. Saddles should have the lining taken out and burned, bits should be boiled, and harness cleaned with very hot water and soap. The curry-comb and brush should be burned.

In this way, removing the diseased animal or animals, and thoroughly disinfecting after them, an outbreak may be nipped in the bud; but for some weeks, or even for several months, all the horses in the stable should be kept under careful observation, and if a horse presents any suspicious symptoms he should be at once isolated and kept watch of until the symptoms either entirely disappear, or the disease develops enough to justify his slaughter. A horse thus isolated must not be allowed to come in contact with the others in any way, he must not drink at the trough with them, but have a pail exclusively for his own use; the currycomb and brush used on him must not be used on other animals, and his blankets and halter are for his use only. The moment there is no doubt as to his disease being glanders he should be killed, and the safeguards against the spread of the disease already described immediately adopted. Glanders is what is ordinarily spoken of as a contagious disease, that is, it is usually communicated by actual contact between diseased and healthy animals, but the germs may also be carried by some intermediary body, such as the woodwork, if a healthy horse is tied in a stall where an infected animal has been kept, or if he drinks constantly from the same trough with a diseased horse; the disease can also be carried from an affected to a healthy animal by means of the currycomb and brush, the virus on the implements entering through an abrasion of the skin. The virus may blow around in the dust of the air, but there is less danger from this source than in most communicable diseases, as the discharge containing the bacilli is sticky and apt to remain where it fell, and does not dry up and blow around readily, especially if the stable be at all damp.

Persons employed in taking care of glandered horses must be very neat and clean, particular not to get any discharge on the clothes or hands, and if they do not feel well, or have any sores appear on the face or hands, they should at once consult a physician.

In making post-mortem examinations of glandered animals care must be taken not to cut or scratch the hands, and a person with a cut or sore on the hand should under no circumstances make an autopsy upon a horse with this disease. The virus, so-called, is the material containing the bacilli, and they may be present in the pus from ulcers in the nose, from farcy sores, from nodules in the lungs, and may exist in the other lesions, besides being carried in the lymph-stream, and possibly in the blood also.

The vitality of the virus of glanders is considerable. Fleming says that instances are known where horses have contracted glanders and farcy in stables where the disease had existed, but in which no horses had been kept for periods of from six to twelve months prior to the introduction of healthy ones.

The disease is one peculiar to solipeds and is transmissible from them to various species of animals, although some are more susceptible than others. The degree of susceptibility also varies in different horses, some showing a much greater predisposition than others. Next to solipeds in susceptibility to glanders come the feline, canine, and human species, in the order named.

Sheep and goats may have this malady, the sheep taking it more readily than the goat. Bovines and swine are so difficult to infect that it can be said that they practically enjoy immunity

Guinea-pigs, as already mentioned, are easily infected and are of value for inoculation-tests of glanders and farcy. In Europe this disease has been observed in zoölogical gardens among some of the larger carnivora, such as lions and tigers, that have received the flesh of horses killed for glanders as their food.

The symptoms of glanders and farcy in other species of animals than the horse resemble the disease in him; that is, there is the same ulcerated condition of the mucous membrane of the air-passages, as the septum nasi, turbinated bones, larynx, and trachea, with the same viscid purulent discharge from the ulcerated surfaces, besides the enlarged lymphatic glands and the formation of nodules in the lungs, and perhaps in other internal viscera as well. Or if the malady assume the type known as farcy, the "farcy buds," "farcy cords," cutaneous chancres, and enlarged contiguous lymphatic glands may all be present.

The Post-mortem Appearances in Glanders.—In making an autopsy upon an animal which has died of glanders, or been killed on account of the disease, the nasal passages should first be examined. (This can be done by removing the inferior maxillary bone and its soft attachments, then sawing the head in two transversely just below the eyes; then saw off the pre-maxillary bone; after which, if the part of the head thus separated be divided longitudinally a little to one side of the median line, one nasal cavity is opened, exposing the septum on one side and the turbinated bones on the other. To examine the other half of the nasal cavity the septum can be removed with a sharp cartilage knife, when its other side and the turbinated bones in the other nasal chamber are laid bare for inspection.) If the horse had glanders the ulcers and cicatrices previously described will be found upon them, although they may have been too high up in the animal's head to have been seen during life. The submaxillary glands—or, in fact, any enlarged lymphatic gland in this disease, for all resemble each other no matter where situated—are at first swollen and inflamed and full of a yellow, citron-colored lymph; later, they may contain little cavities holding a yellowish, greasy pus, resembling the fresh pus from the chancres, and when older still this pus becomes cheesy, and later even calcareous.

"Farcy cords," when cut into, are found to be lymphatic vessels with thickened walls; the lymph in them is at first thicker than usual and somewhat opaque, later still it may become purulent. Fibrinous clots may also be found, upon post-mortem examination, in the superficial veins of the farcied leg or in the pulmonary veins, in cases of acute glanders.

In the lungs nodules are found resembling tubercles, but they are more vascular than the nodules in tuberculosis, and hence have less tendency to break down at their centres early; but later they may soften and contain the characteristic pus, which in time may become cheesy or even calcareous. The nodules of glanders are rarely found to be calcareous, as the animal usually dies or is killed before this stage is reached.

The purulent material from the chancres, nodules, etc., contains the germs of the disease. Ulcers in the larynx and trachea may also be found, and may even extend in an unbroken line from the larynx to the lungs.

Microscopically, the nodules of glanders, like the lesions found in all the diseases of this class (the infective granulomata), are found to be made up of granulation tissue. The granulation tissue in glanders is composed of a small, round-celled growth, which on free surfaces has a tendency to break down readily, forming ulcers, but in other situations forms nodules, the centres of which may soften and contain a few drops of pus. These lesions are due to the specific cause of the disease, the glanders bacillus.

Glanders nodules may also be looked for in the liver,

spleen, mediastinal and mesenteric lymphatics, and also in the intestinal walls, but are rarely found in any of these last-named organs.

The number of nodules in one set of organs is very apt to depend on the number in another set, in an inverse ratio; that is, if a great many chancres are found in the nasal cavities, but few nodules are likely to be present in the lungs, and *vice versâ*.

Glanders completes the list of the infective granulomata which may affect the lower animals. The two most important diseases remaining that may occur among our domestic animals and be communicated from them to the human species, are rabies and anthrax. A consideration of the former will first be taken up.

RABIES.—Rabies is a disease peculiar to the canine species, and is communicable by inoculation from them to man and other animals.

In natural infection, inoculation takes place by means of bites, the saliva being the medium for bearing the virus. The disease can also be produced by experimental inoculation, the medulla and upper part of the spinal cord being beaten up in a sterilized fluid, preferably veal broth, and some of the liquid injected under the skin of any small animal with a hypodermic syringe; or results may be obtained several days sooner by trephining the skull of the experimental animal and injecting a few drops under the dura mater, bringing the virus in much speedier contact with the nerve-centres.

The germ of rabies has not yet been demonstrated, except by means of inoculation experiments.

Rabies is derived from the Latin, meaning madness or raving; the malady is also popularly known as hydrophobia, but this term is clearly a misnomer, as in the dog there is no fear of water, but simply an inability to swallow, due to paralysis of the throat; the suffering animal will attempt to drink, but its efforts to lap water bring on a spasm which is pitiful to see. If a person with rabies evinces a fear of water, it is nothing more than the effect of a popular fallacy upon the imagination.

This disorder has been known since the earliest antiquity; it is mentioned in the writings of Homer, Hippocrates, Democritus, and Aristotle, and later by many authors, both physicians and veterinarians.

Rabies may occur among all members of the canine family, and in Europe a number of outbreaks have occurred among wolves; under such circumstances they may become very ferocious and may attack and bite people; a bite from a rabid wolf is said to be more dangerous than the bite of a mad dog. Blaine says that in 1271 there was a serious epizoötic of this disease among the wolves in Franconia; in this outbreak they became very savage and attacked humans in preference to anything else; many people were bitten, and upward of thirty men are said to have died of rabies at this time. In 1590 there was another epizoötic of this malady among wolves in the province of Montbelliard.

It is unknown in New Zealand and Australia; in the latter country all dogs imported to the colonies are quarantined for six months, and in this way rabies has been prevented from ever gaining access to this part of the world.

Causes of Rabies.—Like all contagious diseases, one case must come from a pre-existing one, and the theory that it can arise spontaneously is not tenable in this enlightened age. Formerly many incorrect views were held regarding its origin, such as, that it was caused by want of water; or by excessively hot weather; or by ungratified sexual desire. Some canine philanthropists, even at the present day, assert that no such disease as rabies exists at all; this view is incorrect, and it is needless to argue the point here farther than to say, that because officers of anti-cruelty societies and professional dog fanciers do not believe in the existence of rabies, or think that muzzling dogs is cruel, it is no reason that such a disease does not exist; and what they have to say on the subject should be taken for just what it is worth—that is, nothing.

It must be admitted, however, that many people that die because they are bitten by so-called "mad dogs," depart this life as a result of fright; this is always the case where the newspaper victim succumbs "in horrible agony twenty-four hours after being bitten by the rabid monster," as the incubative stage of rabies covers a period of at least three weeks after the bite takes place, and is more likely to be from one to two months in length.

Another popular idea is that rabies occurs less frequently in the bitch than in the dog; the reason for this is due to the fact that there are very few bitches kept in comparison to the number of dogs.

Like all contagious diseases, it is liable to lulls and outbreaks; it may be unheard of in a locality for a number of years, then it will be quite prevalent for several seasons, and will again subside for a period of greater or lesser duration.

This is shown by the vital statistics of Massachusetts, going back over a period of several years. In 1876 there were four human deaths from rabies; in 1877 fourteen, in 1878 fifteen; then it gradually subsided, there being five in 1879, three in 1880, three in 1881, and then none until 1888, when there were two; then it increased rapidly, there being fourteen in 1889, seventeen in 1890; then it began gradually to subside again, there being only nine in 1891. Before 1876 there were no cases in humans after 1870, when two deaths occurred.

If a record of the vital statistics of animals were obtainable, it would be found that the deaths among humans bore a direct relationship to the frequency of rabies among dogs, and that when there is an outbreak of this disorder among our canine pets covering three or four seasons, the fatalities among people from this cause correspond to the canine epizoötic, or enzoötic; and as it disappears among the animals, deaths from it among humans cease to be reported as frequently, and finally not at all, until the malady reappears again after a lull of several years.

It would be a matter of great utility if veterinarians (that is, qualified veterinarians) were required to make returns to the registrar of vital statistics of the contagious diseases that occur in their practice among animals. These returns could be tabulated, and although they might not be complete, yet they would show to some extent the relative frequency of the same diseases among men and animals in certain localities, and for this reason would prove of great interest and value.

That rabies is peculiarly a disease of the summer months, or a result of excessively hot weather, is easily disproved by almost any statistics upon the matter that one chooses to consult. For example, if the vital statistics of Massachusetts be referred to, it will be found that the cases of human rabies for several seasons occurred as follows:

For 1889.		For 1890.		For 1891.	
January	1	February	1	February	2
April	2	March	3	April	1
July	1	April	3	August	2
August	3	May	2	September	2
October	3	June	3	October	1
November	3	July	2	November	1
December	1	September	1		
		October	1		
		November	1		
	14		17		9

Of the persons bitten in 1890 in Massachusetts, fourteen were males, three were females, two were children under three years of age, five between five and ten, and all but four were under twenty. In 1891, all the persons bitten, or rather reported to have died of rabies, in Massachusetts, were males. These figures prove little beyond the fact that males have more to do with dogs than females, that the clothes of females perhaps afford more protection from dog bites than those of males, and that little children do not know enough, or are not able, to avoid a rabid dog as easily as an adult.

In a consideration of the pathology of rabies there are, according to Williams, three interesting peculiarities worthy of notice:

"First. The period of latency is very indefinite." Some veterinary authorities give the shortest time in which rabies can develop in the dog after being bitten as

seven days, and it is said to vary from this up to twelve or fourteen months after the infliction of the wound, in a few very rare instances. Repeated inoculation experiments in rabbits performed by trephining, however, show that rabies develops in them with a fair degree of constancy in from eight to twelve days; it is therefore very doubtful if it can develop in any animal by means of a bite in such a short space as seven days; certain it is, on the other hand, that in very exceptional cases the period of latency may extend over several months, even to the end of a year's duration. As a rule, however, it may be said that rabies develops in from twenty-one to thirty-five days after the infliction of the bite, that very rarely it may appear in from fifteen to seventeen days, and that if no symptoms develop at the end of sixty days the danger may be looked upon as very slight, and after ninety days it can scarcely be considered to exist at all.

"Fleming, in his 'Veterinary Science and Police,' quotes Haubner as reporting two hundred cases in which the disease appeared within two months of the bite in eighty-three per cent., between two and three months in sixteen per cent.; the other one per cent. occurred within four months.

"Second. The bite of the rabid animal does not always produce the disease" (Williams). This may occur if the saliva does not enter the wound inflicted by the teeth. For example, a rabid dog may bite a person through the clothing, thus wiping the virus from the teeth before breaking the skin, or he may attack a flock of sheep and the wool will clean his teeth so that only the first two or three bitten will develop rabies and the rest will escape. Bites upon the unprotected parts of the person are always the most dangerous, such as those inflicted upon the bare arms or hands, through the stocking, or particularly upon the neck and face. Rabies is also said to develop earlier from a bite upon the neck or face; this may be because the wound is situated nearer the great nerve-centres.

"Third. The disease is not transmissible to man, mammifers, or birds by the usual media at a period later than twenty-four hours after the death of the rabid animal, or after the cadaveric rigidity (*rigor mortis*) has completely invaded the body" (Williams). This is hardly a modern idea, and while it may be true of the saliva, blood, and the like, it is not true of the nervous centres, where the seat of the disease is now believed to be. Rabid rabbits may be kept after their death in a freezing temperature for months, and the medulla and cord are still found to be active if used for inoculation tests; but the germ is easily killed by heat, as, if the frozen rabbit be put in a steam sterilizing apparatus in order to hasten the thawing process, it will be found that the virus has lost its activity if the dead animal be subjected to enough heat to parboil the tips of its ears.

If, however, the medulla and upper part of the cord be removed from the rabid rabbit and be hung in a perfectly dry atmosphere, in a cool place, for ten or twelve days, it will lose its active properties; this is Pasteur's method of attenuating the virus to be used in protective inoculation against this disease.

Symptoms of Rabies.—There may be premonitory signs, such as pain at the seat of the bite, melancholy, irritability, febrile disturbance, or stiffness about the head and neck; these symptoms are however not generally noticed in the lower animals. In the dog the first symptoms to be noticed, as a rule, are that he is dull, restless, avoiding companions and shunning light; he is also often disposed to hide away in corners, behind chairs, under tables, and in similar places. He may become fidgety or easily excited, and often has a tendency to try and escape and wander about the country, and may at this roving period have a tendency to bite other dogs, animals, or men, and at this time is very dangerous. In short, there is a variable train of nervous symptoms that may affect him in different ways, and of gradually increasing severity. At first he knows his owner and will recognize and obey him even when acting peculiarly; the disposition is often changed—for example, a fierce dog may become playful and good-natured, while an animal formerly noted for his kindness may become savage and snappish. The appetite frequently becomes capricious or morbid, he refuses his food, and may have a tendency to pick up and swallow stones, bits of leather, feathers, and such substances. Later, he may have hallucinations, and may be noticed snapping at imaginary flies, or objects that exist only in his imagination. At first he drinks water with little or no difficulty, but later, when the throat becomes paralyzed, he is unable to do so, and when the attempt is made it brings on a peculiar paroxysm: the animal shudders, staggers back, and in advanced stages even falls; this seems to be accompanied with a spasm of the larynx. In some cases he may vomit, and the vomitus may be tinged with blood. A paralysis develops, the lower jaw drops, and it will be noticed that the tongue is coated, and that both the tongue and inside of the mouth have a curious dark reddish-brown appearance, and the breath is also said to be fetid.

It is said that in the human subject, in the early stages of rabies, there is a little vesicular eruption, *lysses*, on each side of the tongue. This has not been noticed in the dog; it is possible that it may be there, but no one has cared to examine the mouth to find out.

A canine brought into the presence of a rabid dog, or any other rabid animal, for that matter, often causes great fury in the afflicted one, and he will act as though he would like to attack the healthy creature.

As the disease progresses the animal loses the power of recognizing even friends, the pupils are dilated, and he will snap at any object easily within his reach; later, a general paralysis develops, and finally the victim dies of coma.

Owing to the varying manifestations of canine rabies it has been divided into two forms, furious rabies, and dumb rabies. The former has just been described, the animal being violent and showing a disposition to roam and do mischief.

In dumb rabies the animal does not have the furious stage, but it is dull and presents symptoms of coma throughout the course of the disease.

Rabies being a nervous disorder, it is highly probable that whether it assumes the furious or the dumb form, depends upon the presence or absence of exciting influences at the outset of the attack.

Dumb rabies is very much less dangerous than furious rabies, and fortunately is much the most frequently met with, the stricken animal dying without having done any damage; if this were not the case, loss of human life from an outbreak of canine rabies would be at least from four to six times greater than it is.

Williams describes the bark of a mad dog as unnatural, spasmodic, and husky, and more of a prolonged howl than a bark.

Symptoms of Rabies in other Animals.—The symptoms of rabies in other animals than the dog, are loss of or depraved appetite, prostration, restlessness, excitability, muscular tremblings, flow of saliva from the mouth, morbid sexual desire (especially in the bull), difficulty in swallowing, hallucinations, and painful sensations at the seat of the wound, shown by a disposition to rest the part or tear it with the teeth. There is a tendency to be violent and attack man and other animals, followed by exhaustion, paralysis, and death. A few years ago, in a certain deer park, in England, the deer were almost exterminated by an outbreak of rabies; those having been bitten by the dog in time became violent and attacked and bit their fellows, and as these became rabid they attacked others, until nearly the whole herd died.

Treatment.—The treatment of rabies is useless. A rabid dog should be killed as soon as the disease is recognized. If a dog is acting suspiciously he should be confined for a few days until it can be ascertained whether he is rabid or not. Dogs bitten by another known to be rabid should be shot, other animals should be isolated and kept under careful observation.

In outbreaks of rabies, if dogs are to be muzzled it should be general and not local, and should cover a period of from sixty to ninety days, a muzzling order in

one town and none in the adjoining township is of but little value, as a dog with furious rabies may run as far as forty miles, biting people and animals in his path; therefore, a muzzling order should at least include one or more counties, or better still a State. Furthermore, if it becomes necessary to adopt a muzzling order in case of an outbreak of rabies, it should be rigidly enforced, and every dog at large without a muzzle should be instantly shot.

In the treatment of bites inflicted upon persons by dogs believed to be rabid, there is probably little value in the customary cauterization; the better way is to have someone with an unabraded buccal mucous membrane suck the wound thoroughly, expectorating whatever can be drawn from it by this process, after which the injury should be dressed antiseptically.

Fortunately for the world, Pasteur's researches in rabies have now furnished an almost sure prophylaxis in the treatment of persons, or if necessary, animals, that have been bitten by a rabid dog, and a person having been bitten by a dog believed, or known, to be rabid should be at once sent to the Pasteur Institute in New York City, to undergo the preventive inoculation for this dangerous disorder.

Pasteur's preventive inoculation for rabies is based upon the fact that the medulla and cord of a rabid animal, hung in a glass jar for ten days, loses its virulency, the atmosphere in the jar being kept dry by means of a little caustic potash in the bottom, the virus-containing tissue being suspended in the jar by means of a thread, the orifice at the top being stoppered by means of a plug of sterilized absorbent cotton. Pasteur found that if an animal (he used apes for a while, owing to their resemblance to mankind) was inoculated first with an emulsion from a harmless cord, it could the next day receive an inoculation from one nine days old, then from one eight days old, and so on, until finally the fresh cord from an animal just dead from rabies could be used without injury to the inoculated animal, showing that the process granted immunity from the disease. He also found that an animal inoculated with the fresh cord could also be protected by means of the protective inoculation before the active virus could produce its effects. This same principle applies to persons bitten by rabid animals, and the loss of human life from dog bites among people thus protected is but a fraction of one per cent., the failures being due to the person to be inoculated arriving after too long a time has elapsed after being bitten by the rabid dog, or to the bites being numerous upon the face and neck, the rabid virus producing its effects before the protective inoculation has time to act. The death-rate from the bites of rabid dogs among persons not receiving the protective inoculation is said to be about sixteen per cent.

Scientists experimenting with rabies, or physicians or veterinarians in danger of receiving wounds from rabid animals, can undergo the protective inoculation, and then be bitten with impunity.

This treatment could also be applied to very valuable dogs, before or after being bitten, if the owner desired it.

Dr. H. C. Ernst, of the Harvard Medical School, has successfully demonstrated upon rabbits the correctness of Pasteur's work. Rabbits are now used in the Pasteur Institute for keeping up the supply of the virus of rabies, because they acquire the disease readily and are convenient to use, being easily handled and economical to breed and feed. The disease is communicated to them by means of trephining and introducing the virus under the dura mater.

Dr. Paul Gibier, director of the Pasteur Institute of New York, in his second annual report, April, 1892, gives the number of persons receiving the protective inoculation from its opening, February 18, 1890, to February 18, 1892, as 298; of this number 28 came from Massachusetts, undoubtedly making the death-rate in that State from this disease for 1890, 1891, and 1892, slightly smaller than it otherwise would have been.

Another point of interest as showing the subsidence of an outbreak in a certain community, is that from February 18, 1891, to February 18, 1892, twelve persons came from Massachusetts for treatment; while from April 1, 1892, to November 30, 1892, but three persons came from the same State.

Of the two hundred and ninety-eight persons treated at the Pasteur Institute of New York, during the first two years of its existence, but three died of rabies, and all of these were severely bitten, one, a child, in nineteen places, the other two men upon the right hand, wrist, or forearm.

No one should be allowed to run the risk of a terrible death from this disease, when in our own country there exists a place where he may receive treatment that is almost sure to save his life.

Another great mistake made in the management of rabies is the killing and destruction of the supposed-to-be-mad dog after he has bitten any one. The medulla and cord in the upper cervical region should always be carefully saved and forwarded to the Pasteur Institute, or some well-known bacteriologist, with which rabbits may be inoculated by trephining, in order to be sure of the correctness of the diagnosis; or if it is not practicable to remove the medulla and cord, the whole head may be cut off and forwarded by express. In hot weather the material should be packed in ice, so that decomposition will not set in in transit. Many a dog killed as mad is only suffering from some form of nervous excitement.

Post-mortem Appearances in Canine Rabies.—These are not well-marked, the most constant being a congestion of the membranes covering the brain and spinal cord. The only positive way of verifying the diagnosis is to test the medulla and cord, by means of inoculating some small animals, preferably rabbits. Two or three of these little animals should be tested, as a negative result in a single case is not enough to prove that rabies did not exist in the suspected dog.

Anthrax and Anthracoid Diseases.—Anthrax is the fifth and last of the diseases common to animals and man of sufficient importance to be considered at this time, although there are other maladies of minor significance that are by no means uninteresting.

Formerly a number of different diseases were all classified under the general name of anthrax, but now the term is applied only to that form known to be caused by the *bacillus anthracis*, and various other affections resembling anthrax in their symptoms, but due to another cause, are spoken of as anthracoid or as symptomatic anthrax.

Anthrax has been known since the earliest antiquity. It is undoubtedly spoken of in the ninth chapter of Exodus, in the eighth, ninth, and tenth verses: "And the Lord said unto Moses and unto Aaron, Take to you handfuls of ashes from the furnace, and let Moses sprinkle it toward the heaven in the sight of Pharaoh. And it shall become small dust in all the land of Egypt, and shall be a boil breaking forth with blains upon man, and upon beast, throughout all the land of Egypt. And they took ashes of the furnace and stood before Pharaoh, and Moses sprinkled it up toward heaven, and it became a boil, breaking forth with blains upon man and upon beast."

This is undoubtedly the first outbreak of anthrax upon record, possibly it may have been created for the occasion. When it is considered that the modern names of anthrax and charbon signify burning ashes, or a burnt coal, it seems somewhat remarkable that this name should have clung to it through the ages. Greek and Roman writers evidently describe the disease under various names in animals. When applied to man the former termed it anthrax and the latter carbunculus. In Arabian manuscripts of the middle ages it is found mentioned as *Atshac-al-Humrah*, or Persian Fire, all of these several terms evidently intended to convey some idea of the lesion. At least anthrax signifies a burning coal, while *charbon* is French, meaning black, from the dark-colored condition of the blood and organs engorged with it.

The Germans speak of the malady as *Milzbrand*, meaning inflammatory death of the spleen, as in anthrax the

spleen has always been found to be enlarged, softened, and dark-colored.

Fleming, in his "Veterinary Sanitary Science and Police," speaking of the geographical distribution of anthrax, says: "This is one of the most diffused and interesting of all the diseases of the lower animals, affecting as it does not only those which are in a state of domestication, but destroying wild animals as well. It prevails over almost the entire globe, in high latitudes as well as at the equator. It at times decimates the reindeer herds of the Laplander, and is only too well known in the tropics and in temperate regions by its dangerous and nearly always disastrous results. The carefully tended ruminants of the most highly civilized countries suffer equally with the wandering herds and flocks of the nomadic Arab, and it is as much dreaded by the Finn and Lapp as it is by the Mexican, South American, or Australian colonist. It has been carefully described by travellers and others, as they have observed it, as affecting animals on every continent and in almost every country."

In Europe the papers that have been published in regard to the nature and characteristics of anthrax are innumerable, as it has been more observed and studied there than elsewhere, for various reasons. First: In France and Germany there is more learning, and there exists there also a greater spirit of scientific research than anywhere else. Second: It occurs with more or less constancy in certain districts in Europe. Third: The losses it occasions are larger there because of the greater value of animals in thickly populated countries; hence it has on this account attracted much attention.

To just what extent it occurs in the United States it is difficult to say, owing to lack of reliable information on the subject, but it undoubtedly occasionally attacks animals, although happily true anthrax seems to be very rare. Perhaps in time, as our knowledge on such subjects extends, and more careful observations are made, it may be heard of more often than it is now. It must, however, be very uncommon in certain sections of the country, New England for example, as a light sandy soil with a gravelly subsoil is unsuitable for the spreading of anthrax, as "the regions where it abounds are in countries in which there are extensive marshes, or where the subsoil is tenacious; thus it happens that there are districts notorious for the prevalence of anthracoid affections, such as the marshes of Sologne, Dombes, and Bresse, and certain parts of Germany, Hungary, and Poland; in Spain the disease is enzoötic in the semi-submerged valleys and the maritime coasts of Catalonia, as well as in the Romagna and other marshy districts of Italy; while it is even epizoötic in certain districts of Russia and Siberia, where sometimes, in order to suppress the ravages of the terrible "*Jaswa*," the aid of the military authorities has to be invoked, and bodies of soldiers sent to bury or burn the carcasses of infected animals which float in the canals and swamps" (Fleming). In fact it is known all over the world since all time, and, as was shown in the scriptural quotation, it was one of the plagues of Egypt.

Virgil eloquently depicted its deadliness and contagiousness when he wrote:

> "The skins are useless, nor the tainted flesh
> Can water cleanse, or raging fire subdue;
> Nor is it possible to shear the fleece,
> All saturated with disease and filthiness:
> Nor can the weaver touch the putrid web.
> But should a man attempt the odious garb,
> With burning pustules and disgusting sweat
> His limbs offend; and in no lengthened time
> The fire accursed consumes his poisoned frame."

"Anthrax figures largely in the histories of the early and middle ages as a devastating pestilence among animals, and through them to mankind, and old Anglo-Saxon manuscripts contain many fantastic recipes, charms, and incantations for the prevention or cure of the 'blacan blezene' (black blain) and the 'elf shot' creatures. From those times up to the present day it has attracted more and more attention" (Fleming).

In man anthrax is known as malignant pustule; it has also been called "wool sorters' disease," because wool sorters may become infected by handling wool from sheep that had the disorder; it has also been seen among men who handle hides, as a result of being infected by skins which have been taken from animals suffering with this malady. Among the domesticated animals anthrax is seen most frequently in cattle and sheep, less commonly in the horse, although it seems to have a predilection for different species of animals in different localities. For example, in South Africa "Horse Sickness," and in India "Loudiana Disease," are looked upon as forms of this malady in the horse, while in England and on the Continent it is more commonly observed in cattle and sheep.

Texas cattle fever was formerly supposed to be a form of anthrax, and fowl cholera was believed to be an anthrax of fowls, but these views are now known to be erroneous.

Symptoms of Anthrax.—Anthrax may be general, without local manifestation, or there may be local lesions consisting of an immense amount of diffuse swelling near the seat of inoculation, as is seen in malignant pustule in man; in animals the local lesions are not so often seen as the general form, although the disease may be localized, as in "glossanthrax," where the tongue and throat are enormously swollen.

Ordinarily, in an outbreak of anthrax in a herd of cattle, or flock of sheep, the first symptoms noticed are not at all well marked; it may be that attention is first called to the matter by finding one or more animals dead in the field that had not previously been observed to be sick; if the creatures are then watched, it may be that an animal feeding quietly may be seen to suddenly throw up its head, fall down, struggle violently, emit a little blood from the rectum, and possibly a little bloody froth from the nose, and in a few minutes die.

If noticed more carefully, in some instances the animals affected may appear to be dull and depressed, and may separate themselves from their companions, and if the temperatures of the herd be taken the animals about to be attacked may show a good deal of fever, the temperature reaching 107° F., or 108° F., before any other signs are noticed, with the exception, perhaps, of dulness.

In some outbreaks the animals may have the disease in a modified form; here the cattle may appear dull, with loss of appetite, slight rigors, and a high temperature.

In dealing with such an outbreak, the pasture, food, and drinking-water should be changed, and all animals with high temperatures should be isolated from the rest, and treated with hyposulphite of soda, chlorate of potash, and similar remedies.

Anthrax is not contagious from one animal to another, but is spread by spores set free after the death of the patient by decomposition. These spores are very tenacious of life, and it is said that they may live for years in the soil; it is also believed that earthworms may bring them to the surface of the ground from carcasses of buried animals; and it is also believed that the disease can be carried by flies from diseased or dead animals, afterward biting men or healthy animals. Animals that die of anthrax should, therefore, be cremated, or if this is not possible, they should be buried very deep and covered with quick-lime, to destroy the spores and keep the earthworms away from the remains. Bacilli may also be excreted in the urine and fæces, thus infecting the ground, and are also found in the bloody discharges of moribund animals. Prevention then should consist in changing the pasture and water, cremating the dead, and in bad outbreaks, or in districts habitually infested with anthrax, Pasteur's preventive inoculation should be resorted to.

The mode of death in anthrax is, as a rule, the result of the bacilli multiplying to such an extent in the blood as to rob it of its oxygen and cause death in this way; it may, as has been described in the symptoms, occur even in the space of a few minutes.

The post-mortem appearances of an animal dead from anthrax are: first, the carcass is soon enormously swollen, the skin is tense and crepitates when handled, due to the accumulation of gases in the subcutaneous connective tissue; the blood is dark, tawny, and non-coagulable; the spleen engorged, softened, easily broken down, full of

black, tarry blood (hence the term "splenic apoplexy," one of the names given to anthrax in cattle); the lungs engorged, liver softened, kidneys softened and congested. If the disease is of a local character, the parts involved are swollen and infiltrated with serum—rigor mortis not well marked, or absent. Cover-glass preparations from the blood, or spleen, show numbers of the bacillus anthracis, and sections from the lungs or kidneys show the capillaries to be gorged with bacilli. If the gross appearances of anthrax be present on autopsy, but the characteristic bacilli cannot be found with the microscope, the disease is anthracoid, but not true anthrax.

In making post-mortem examinations upon animals supposed to be dead of anthrax, it must be borne in mind that a very dangerous disease is being investigated, and the veterinarian must have an unbroken skin on his hands, or wear rubber gloves; and the same advice applies to his assistants.

There is a disease of young cattle known in England as "quarter ill," or "black quarter," and by the French as "*anthrax symptomatique*," or symptomatic anthrax, that has been confounded with anthrax. In this disease there is local swelling, usually of one hind quarter, the skin crepitates over the affected part, and the animal is lame; often the disease is very fatal, but in this affection no rods are found in the blood and the spleen is not affected, but the lesions are in the subcutaneous and intermuscular connective tissue; the germ is found to be a vibrio, and is found only in the connective tissue, and not in the blood as in anthrax. From the symptoms and from some of its gross appearances, this malady of young cattle may be more easily mistaken for true anthrax, perhaps, than any other form of disease.

Etiology of Anthrax.—The anthrax bacillus was the first of the contagious disease germs to be discovered, probably because it is the largest; and as the microscope was improved and the subject of bacteria became better understood, the others were described one after another, although most of them were not recognized until within the last ten or twelve years. The discovery of the anthrax bacillus dates back over forty years, when in August, 1850, Davaine, a French scientist, described, in connection with Rayer, a rod-like body which he had found in the blood of animals suffering with this disease; these bodies had no spontaneous movement, and their length was equal to about twice the diameter of a red blood-cell.

Some years afterward a German savant, Pollender, described very exactly the bacillus of anthrax, its length, thickness, and constant existence in this affection; he compared it to vibriones, and considered it as belonging to the vegetable kingdom; he demonstrated its resistance to acids and alkalies and to coloring by iodine. The discovery of Davaine constituted a simple statement, while the memoir of Pollender contained a more complete description of the bacillus of anthrax, and he considered it as the essential cause of the malady. A little time afterward, Brawell described the same bacillus as being connected with human anthrax (malignant pustule). Davaine undertook later a large number of experiments, recorded in the Transactions of the *Académie des Sciences*, 1864 to 1873. He has inoculated the blood of animals with anthrax into a series of animals of different species, and has shown that even with a drop of this fluid, when very dilute, it was possible to reproduce the disease.

Koch (1876) and Pasteur (1877) found that the bacilli could be artificially cultivated outside of the animal body; they discovered the spores, and obtained pure cultures with which they reproduced the disease in all its integrity.

It can therefore be said, with our present knowledge, that anthrax is a disease entirely bacterian, the better established as such the more it is studied; there is no more doubt as to the etiology of anthrax, and the part which the bacillus plays in its production, than there is that acari produce mange.

The bacilli of anthrax are rods from 5 to 20 μ long and from 1 to 1.25 μ wide, and threads made up of rods and cocci, and the rods may be spore-bearing. The spores are more dangerous than the bacilli themselves, as they are very retentive of life, and will keep for a long time ready to form new bacilli, when they find a suitable soil for their development.

The growth of the anthrax culture in nutrient gelatine is characteristic: at first, a white line appears along the needle track, from this filaments grow out in various directions, giving it the appearance of what has been compared to an inverted Christmas tree; as the culture grows older the gelatine liquefies and the growth settles to the bottom of the test-tube as a white flocculent mass. It also grows on the surface of agar-agar as a snow-white plaque. It grows on potato, forming in thirty-six to forty-eight hours a creamy growth with a yellowish tinge, having the odor of sour milk.

It is aërobic, dying if deprived of oxygen.

In some instances the bacilli are so numerous in the capillaries of the lungs and kidneys of an animal dead from anthrax, that under a low-power lens the blood-vessels have the appearance of having been injected.

Dissemination of Anthrax.—It has been stated that when carcasses of animals which have died of anthrax are buried under the soil, spore development may still go on, and Pasteur believed that the spores were taken up to the surface by earthworms, which left them in their castings, and that animals grazing over the ground acquired the disease from these spores. This has not, however, been borne out by experiment; at the same time there are pastures where anthrax always exists. Bacilli occur in large numbers in the blood and discharges from the nose and mouth of moribund animals, as well as in the urine and fæces; they find a nourishing soil in decaying animal and vegetable matter, and having free access to oxygen, form copious spores, so that grass is extensively contaminated. In warm and marshy districts the spore formation is still more active, and they may be carried by floods over adjacent meadows.

Modes of Infection.—The animal may be directly infected through wounds of the mouth caused by siliceous grasses, or by the wounds of insects (insects have also been believed to carry the disease from place to place); and the intestinal and pulmonary mucous membranes are also regarded as pathways of infection.

In man the mode of infection is by the inhalation of spores, and ingress by the pulmonary or intestinal mucous membrane, or by direct inoculation through a wound or abrasion. In malignant pustule of man the bacilli are found in the serum of the pustule, the sputum, urine, fæces, and sweat, and if the disease prove fatal, in the capillaries throughout the body.

Davaine first discovered the bacillus of anthrax in 1850; others also noticed them, but did not realize the significance of their presence in the blood of animals suffering from anthrax. It was not until 1863 that Davaine, having had his attention once more drawn to these organisms in the blood, by Pasteur's discovery of the butyric ferment, was led to examine whether the anthrax bacilli, if introduced into the blood of an animal, would play the part of a ferment; for, if this were the fact, it would explain the rapid infection of the blood in a creature which had received into its veins, accidentally or experimentally, a certain quantity of this ferment.

Inoculating sheep and rabbits with the blood of a diseased sheep a few hours after its death, he constantly found these organisms, which he named *bacteria*; though when inoculated from the blood of an infected animal while it yet appeared in health and before these rods were visible, no effect was produced.

"In the present state of science," wrote Davaine, at this time, "nobody would think of going beyond these corpuscles to seek for the agent of contagion." This agent is visible, palpable; it is an organized being endowed with life, which is developed and propagated like other living things. By its presence and multiplication in the blood it undoubtedly produces modifications in that fluid, after the manner of ferments, which speedily destroy the infected animal."

This was the first direct evidence that a contagious disease is produced by a microscopic organism, and the

discovery converted into a fact what was before only a hypothesis. Davaine's announcement (like all new discoveries) was not received without doubt and hesitation by some, and two experimentalists (MM. Jaillard and Deplat) were unsuccessful in arriving at the same results by experiment, and consequently sought to refute his conclusions. Paul Bert also opposed his views and corroborated those of Jaillard and Deplat; "I can," he said, "destroy the bacteria in a drop of blood by means of compressed oxygen, inoculate with it and reproduce the disease, and cause death without any appearance of bacteria; therefore they are neither the cause nor the necessary effect of splenic fever; it is due to a virus." And so the controversy went on.

At this time a young physician in Germany, Dr. Robert Koch, who has since become famous as the discoverer of the B. tuberculosis, and the comma bacillus of Asiatic cholera, began to study the anthrax bacilli, or bacteria, as they had been indifferently termed; though Cohn, another German investigator, was also at work defining their morphology. Koch traced the life-history of the bacillus anthracis, and showed how widely it was distributed throughout the blood and organs, especially the spleen, of animals which had died of anthrax; after many attempts he succeeded in raising, or "cultivating," the fungus artificially, and watching its development under the microscope; noting that the rods, like those of the butyric ferment, multiplied by division, growing into long, straight or twisted filaments, in which in the course of time, if air is allowed free access, very minute oval spores are seen; then the filaments swell and burst, and the spores are set free. He found that these spores, if introduced into the blood of an animal, or cultivated artificially, grow again into the characteristic bacilli, which eventually become the long filaments that again form spores. Such is the life cycle of this deadly microbe, which multiplies so rapidly that the spores have been seen to germinate in three or four hours; and rodents such as rabbits, guinea-pigs, or mice, when inoculated with blood from an animal dead of anthrax, or with the bacilli or spores from an artificial cultivation, perish in from twenty-four to forty-eight hours, or more rarely sixty hours at the outside. Pasteur did not know possibly of Koch's researches, which were published in 1876, neither probably did the other disputants in France; for it was in 1876 that Bert gave an adverse opinion to that of Davaine. However this may be, Pasteur determined to settle the question as to whether Davaine or his opponents were right; and he adopted in his investigations the methods which had led him to such splendid results in his previous studies. He resolved to isolate the organism from infected blood, cultivate it artificially, and then test its action upon animals; in this work he was assisted by M. Joubert, as his paralysis would not permit his doing it alone. He reported to the Académie des Sciences, in 1877, that the bacilli were the only agents in producing anthrax, giving the behavior of the organisms as already described.

But it was necessary to explain the discrepancy between the results obtained by himself and Davaine, and those of Jaillard and Deplat. These latter had killed rabbits with blood from a cow that had died of splenic fever, and their blood was so virulent as to kill others, and yet no bacilli could be found in it; while Bert maintained that he had destroyed the bacilli by compressed oxygen, and still the blood retained its virulence. Pasteur demonstrated that the animals killed by inoculation where no anthrax bacilli were found, died of septicæmia, the compressed oxygen killing the bacillus anthracis, but not injuring the septic germs; he also succeeded in cultivating the anthrax bacilli and the septic germs separately, and found he could produce either anthrax or septicæmia, as he chose.

Pasteur also ascertained, when studying splenic fever, that the organism which produces it is under a particular influence which prevents it developing everywhere, and limits it to certain media, which one would not think differed from other media in any appreciable manner.

Thus in the ox, sheep, rabbit, guinea-pig, and some other creatures, it is easily inoculable and terribly fatal; but the dog and pig have to be inoculated several times before they are infected, and even not then with certainty; while fowls are proof against the disease.

Pasteur found that the reason why fowls are proof against the disease was due to their high temperature; he learned in his experiments that the germ could not be artificially grown at a temperature exceeding 112° F. Although the temperature of fowls is 105° F. to 107° F., the bacilli would not germinate there, and he thought this was due to the fact that the bacilli could not get oxygen as easily in the blood of fowls as in an artificial culture medium. He tried lowering fowls' temperature by having them stand in cold water (at 77° F.) until their temperature was lowered to about 98° F., when he found that when inoculated they readily acquired anthrax. He also tried the experiment of wrapping a hen, thus affected with anthrax, up in cotton wool and putting her in an oven at 95° F.; she gradually rallied and in a few hours was well. Fowls killed after being rescued in this way showed no trace of the bacillus anthracis in their bodies.

Pasteur in his researches in fowl cholera, which was formerly thought to be an anthrax of fowls, found that he could attenuate the germ of this disease so that fowls inoculated with cultures of it would not acquire the disorder, and yet, after being treated in this way, were found to have immunity from the malady when exposed to it.

This led to his attempting to produce an attenuated virus of anthrax which would protect inoculated animals from the disease. In this he was successful, and every year thousands of horses, cattle, and sheep in the anthrax districts of France receive protective inoculation with virus from Pasteur's laboratory in Paris, resulting in the saving of millions of francs to the nation.

The mode of attenuating the anthrax virus is by cultivating it artificially at a temperature of 108° F. to 109° F., and at this temperature it produces no spores; at that temperature, therefore, and in contact with pure air, the cultivation of bacilli destitute of spores, and of diminished vitality, can be effected. But in a few weeks the crop perishes, and sown on fresh media, produces no results; and it was found that after cultivating at this high temperature for two, four, six, or eight days, the strength was modified in proportion to the duration of the exposure. Animals can thus be protectively inoculated and given the same immunity from the disease as though they had had it in a severe form and then recovered.

Pasteur announced the results of his efforts to produce an attenuated virus for anthrax to the Académie des Sciences, on February 28, 1881.

It has been found best to use two vaccines, the first very weak (the *première*) and the second stronger (the *deuxième*), after which the animal suffers no ill effects if inoculated with a virus of full strength; the protection thus conferred lasts for at least a year or more; at the end of this time, if necessary, the animals can be reinoculated. "The discovery of this power in the weakened microbe," says Fleming, "of a contagious disease, to protect an animal from the lethal action of the same kind of microbe when in full virulency, must be held to constitute the most important part of Pasteur's services to medical science and to mankind, inasmuch as its effects may be of the greatest magnitude, and far-reaching, when made applicable to the many contagious disorders—so deadly and so little under the control of man—which affect our own species and the lower animals." "The destructive microbe is transformed in the laboratory, by the skill of man, and at will, into a benign, life-preserving agent."

In an extensive outbreak of anthrax, not easily controlled by ordinary means, and where it is likely to recur for several seasons, Pasteur's methods are well worthy of a trial, and in this case an investigation and preparation of vaccine should be undertaken by the United States Bureau of Animal Industry, or the nearest State experimental station, if properly equipped for such work, as Pasteur's vaccines often prove too strong to use upon animals in a foreign country, where the disease has hitherto been but little known. *Austin Peters.*

VITAL STATISTICS. Vital statistics are statistics relating to the chief events of the life of a human being in so far as they are of interest or importance to the community in which he lives. They, therefore, include statistics of births, marriages, sickness, and death, and as, in order to utilize the information they furnish for the good of the community, it is necessary to ascertain their relation to the community itself, as a whole, population has also to be considered in any discussion of vital statistics, although it belongs more properly to what may be called economic statistics.

The utility of such statistics can hardly be questioned at the present day, when it is so easy to demonstrate the improvement in the sanitary condition of civilized peoples, and to show that the first steps leading toward this improvement were statistical investigations and comparisons showing the possibility of better things. This is only one of the many directions in which such statistics are of use. They serve as a necessary guide in estimating the military strength of a nation, its fecundity, the prospects of future prosperity or decline, besides determining many commercial risks, and furnishing the sole foundation of life insurance.

In order to be thoroughly trustworthy, statistics should be complete and accurate; complete, because unreported figures might possibly change, in important respects, deductions made correctly from the figures that are reported; and accurate, because inaccuracy, if demonstrated, invalidates conclusions even more than incompleteness.

Sources of Vital Statistics.—The two main sources of vital statistics are the *census*, which furnishes an enumeration of the population, with various other useful information, and *current reports*, official and unofficial, compulsory and voluntary, which serve to fill in the gaps between the census years, and also to supply a continuous record of the sanitary and social condition of peoples and individuals.

The Census. History.—It is probable that enumerations of the people were made from very early times. Indeed, it would seem essential to the continued existence of a fighting nation to know how many fighting men it could depend upon in war; for such knowledge might often turn the balance for prudence or aggressiveness. A count of the warriors alone would not fully serve the purpose of a warlike chief, for he must also know, if he is prudent, and great leaders of men are usually prudent, what the hindrances to war are besides the lack of braves. He must know how many women and children are to be looked after, especially married and marriageable women, for, although in a savage race the old and crippled might be left to their fate as useless impedimenta, the young women are the hope of the tribe, and must be cared for at all hazards. So that even a count for military purposes alone must be a count of almost the entire population.

One of the earliest recorded enumerations is the one mentioned in the Book of Numbers, when the Jews were found by Moses and Aaron to comprise six hundred and three thousand five hundred and fifty fighting men. A census is said to have been taken in China in 2042 B.C., and in Japan about 100 B.C., but the authority for these statements is rather misty. The census, as an organized institution of the state, seems to have originated in Greece and Rome at about the same time, viz., during the sixth century B.C., and to have been established to facilitate taxation. In Athens the constitution of Solon divided the people into four classes, according to the income from property they owned, and as the amount fluctuated they had to be registered frequently. In some of the Greek states the valuation was made yearly, in others every two or four years.

In Rome, the census was established by the constitution ascribed to Servius Tullius, and the word census has come down to us from that time. It originally meant the registering and rating of citizens for purposes of taxation, from *censere*, to tax or assess, ultimately perhaps from *centum*, a hundred, through a verb-form *centere*, to hundred, or number by hundreds. The Roman census, although carried out for taxing purposes, elicited a good deal of information of the kind that is collected by our modern censuses. It called for the name, age, sex, class, relationship to others of the same household, and the conjugal condition, slaves and freedmen being also counted. The census, at first in charge of special officers called *censors*, was afterward conducted by the emperors, being taken every five years until about a hundred years after Christ, when the inter-censal periods became longer, even extending to fifteen years, and the institution finally disappeared with the dissolution of the empire.

From this time on there were partial enumerations of different peoples, none of them, however, worthy to be called a census. The most notable, perhaps, was the one carried out under William the Conqueror in 1081, in order to ascertain the number of landed proprietors in the kingdom, and the amount of their property, *i.e.*, to find out what resources he could depend upon in time of war. The results of this investigation are embodied in the famous "Domesday Book."

The first nation in modern times to obtain vital statistics in a systematic way, was Sweden. Early in the sixteenth century the clergy began to keep registers of the burials and baptisms in their parishes, and in 1686 this practice was made compulsory throughout the kingdom. A registry was required of marriages, births, and deaths, of persons moving to and fro from the parishes, a list of inhabitants by houses and families, and a record of extraordinary accidents in each year.

The first nation, however, to take a census under government control, seems to have been Russia, where partial censuses were taken in 1700, 1704, 1705, and 1710, and a more careful one in 1718 under Peter the Great, followed by others at irregular intervals of about twenty years through the remainder of the century.

The honor of the first systematic government census belongs to Sweden. In 1746 a census was taken by means of schedules of questions distributed among the population. The returns were not complete until 1749, and were not published until 1762. Subsequent censuses were taken at intervals of one or three years until 1775, and since that time have been taken every five years.

In England, singularly enough, although she had many a census taken in her colonies, no census worthy the name was taken before the present century. Records of deaths were kept in 1592, during the plague, but soon fell into disuse. In 1603 it was ordered that records of burials and christenings be kept in London, and parish registers were kept in many country places. In 1790 Sir John Sinclair undertook a census of Scotland at his own expense. He sent around schedules of questions to clergymen and others, receiving altogether answers from about nine hundred sources. The work occupied him seven years, and was published in twenty-one volumes, containing a great mass of well-digested and valuable information. Attention being thus called to the subject, Parliament, on December 31, 1800, passed an act providing for a census of England and Wales the following spring, and every ten years thereafter. The first census of England, accordingly, was taken March 10, 1801, and a little later one was taken in Scotland. In Ireland the first census was taken in 1811. The Imperial census was first taken in 1871, and is now simultaneous throughout the empire, being in charge of local officials, and generally taken the first Monday in April.

In the other states of Europe, censuses are taken at various intervals, as follows: *Austria*, since 1851, every six years; *Belgium*, since 1856, every ten years; *Denmark*, every ten years; *France*, first taken in 1801 and 1806, under the great Emperor, then in 1821, and every fifth year since; *Greece*, very irregularly; *Italy*, since 1861, every ten years; *Norway*, since 1815, every ten years; *Prussia*, since 1834, every three years; *Russia*, since 1850, every ten years; *Spain*, since 1857, every three years; *Switzerland*, since 1860, every ten years.

In other parts of the world, censuses are taken very irregularly. They are recently beginning to pay more attention to this subject in the various states of Central

and South America, in order to be able to furnish information for intending immigrants, and to aid in improving commercial relations with foreign countries. In Chili the sixth general census was taken in 1885. In Buenos Ayres, censuses were taken in 1869 and 1881, and in the Province of Santa Fé, Argentine Republic, the first general census was taken in 1887.

In the United States a census became a political necessity as a basis for popular representation in the legislature, and the constitution of 1787 accordingly provided that an enumeration of the people should be made "within three years after the first meeting of the Congress of the United States." Under this provision a census was taken in 1790, the returns being all referred to August 1st of that year, and has been taken every tenth year since. In 1830 the date was changed to June 1st, and this has been the date of all subsequent enumerations.

In most of the States provision is made in the constitution for a census at regular intervals. In some a census is required and in others only permitted. As a rule, the State census is taken at intervals of ten years and halfway between the United States census years, so that the census intervals are only five years.

Objects of a Census.—The chief purpose of a census is to ascertain the true number of people in any community or nation. But so many other items of information are desirable for different uses, that it has become the practice to collect in this way a vast fund of information upon other subjects, and the mass has become so unwieldy and the labor required of the census enumerators so onerous, especially in this country, that it has been a matter of serious discussion whether the amount of information sought to be obtained ought not to be considerably curtailed. The object being the procuring of trustworthy statistics for the use of the sanitarian, the student, the Government, and the tradesman, no more should be attempted than can be completely and thoroughly carried out.

The requirements of a good census are that it should be complete and accurate, and, for the sake of accuracy, that it should be taken rapidly and simultaneously throughout the country. These objects are, by common consent, best secured by distributing schedules of questions in advance, to be filled out by the head of the household or other trustworthy person, and then collected in one day by the officers who have been detailed for the purpose. This is almost the universal method of taking a census, excepting in this country, where the enumerators visit each household and fill out the schedules themselves by asking questions of whoever may happen to be in when they call. The chief objection to the use of prior schedules has always been that they necessitated two visits to each house, and a proportionate amount of extra trouble, and that in rural districts, and especially in those parts of this country that are very thinly settled and where the distances are very great, it would be almost impossible to induce people to take this trouble for the scanty pay they receive from the Government. But this objection, however valid in some places, does not hold in large towns, or through the greater part of the Eastern and Middle States, where the country is already pretty well settled, and exception could be made of those sections where the system of prior schedules was impracticable. Moreover, the use of prior schedules would save a great deal of time to the enumerator, the questions, in most cases, being all answered by the day for collection, so that he could in most cases easily cover his entire district in one day, gathering up all the schedules that he had distributed; or if, here and there, he found one that through ignorance or inadvertence, had not been filled out at all, or was filled out improperly, it would probably not make him over a day late in making his returns; whereas, in the United States census of 1890, enumerators had to use two entire weeks in going through their districts, even in large cities, and even then, in individual cases, the enumeration could not be completed within the time allowed.

By taking the census simultaneously in one day, another source of error is avoided, viz., omissions and duplications of names. Under our present methods, especially in large cities, where there is constant immigration and emigration, and incessant moving within the town itself, many persons may change their residence from one district, before they have been counted, into a portion of another district where the enumerator has already finished his work. This would result in the omission of many names from the record, repair of the error being possible only when the citizen himself takes the trouble to complain of it. The reverse case, the duplication of a name, is not so likely to occur, for most persons will object to answering the census questions twice, while few will take the trouble to hunt up the enumerator for the purpose of answering them.

A census ought to be taken at least every ten years, and it would be better to have one taken every five years, in order to minimize, so far as possible, the disturbing effects of migration. A more frequent census than this would involve more expense than would be fairly compensated for by the greater accuracy of the information obtained; for if a good census were taken every five years, the statistics for the intervening years could be calculated with a fair degree of approximation to the truth.

What Data Should a Census Aim to Secure?—For the purposes of vital statistics, the most important data given by a census are those relating to the sex, age, residence, birth-place, nationality, occupation, and conjugal condition. Other data, however, are of use to the community, and are usually collected by the census officials. This question has been discussed at the various International Statistical Congresses that have been held since the first one in 1853, and by the Congress held in St. Petersburg in 1872, the following recommendations were made, viz., that a census should be taken at least once in ten years; that it should be taken in one day, and preferably at the end of the year, when families are most likely to be in their homes; that the following data should be taken as an indispensable minimum, viz., name, sex, age, relationship to the head of the family, conjugal condition (single, married, or widowed), occupation, birth-place, and infirmities (deaf, dumb, blind, insane, or crippled). Also, when practicable, the language, religion, residence, and the state of the children as regards education. Naturally, the more numerous the items of information obtained, the more opportunity is afforded the compilers to detect errors by systems of cross-checking.

The comprehensive character of the modern census has been a matter of very gradual growth. In the first English census of 1801, which was taken under the direction of Mr. Rickman, the assistant clerk of the House of Commons, the following data only were obtained, viz., the number of persons, sex, number of houses, families, and a rough general classification of occupations. Ages were not taken until 1821. The first census that could be called fairly complete was taken in 1851, under the superintendence of Dr. Wm. Farr. In addition to age, occupation, and birth-place, which had been taken in previous censuses, inquiry was made about relationship, conjugal condition, infirmities, religious establishment, and education. The recent census of 1891 covered about the same ground.

The latest United States census, that of 1890, was much more comprehensive, and the schedule of population and social statistics included the following inquiries: name. sex, race, age, residence, relationship, conjugal condition, birth-place, birth-place of parents, occupation, illiteracy, infirmities, whether veteran of civil war, number of years in United States, whether alien or naturalized, number of children living and dead, and questions regarding ownership of residence, mortgages, etc.

Imperfections of the Census.—Some of these have already been referred to, as the omission or duplication of names, but these can be mostly avoided by great care in selecting intelligent and trustworthy enumerators, and taking the census in a single day. For example, in England, the census is taken under the direction of the Registrar-General, who issues instructions to all the sub-registrars throughout the kingdom. These men are all permanent employees of the office, and therefore well known,

and presumably careful and thoroughly acquainted with what is expected of them. The selection of enumerators rests with them, and they naturally choose persons on whom they, in turn, feel that they can rely for conscientious work. Moreover, they are especially advised, when possible, to persuade clergymen, school-teachers, and others of equal intelligence, to act as enumerators. The census of 1891 was taken on Monday, April 6th, and was intended to include all persons who slept in each place where a schedule was left on the night of Sunday, April 5th, special means being adopted for the enumeration of vagrants and gypsies, and persons living on boats and in caravans, travelling shows, etc.

The only very important error in a census that is properly taken, is one that can never be entirely done away with. It is that of the inaccurate reports of age. Many people do not know their real age, others do not care to tell, and others give round numbers off-hand, without taking the trouble to ascertain the true age of those whose history they are reporting to the enumerator. It is, therefore, better to take the ages, as far as possible, by single years, that is, to insist on the exact age being given; but even then this form of error creeps in, as will be seen in the following table, giving the number of the white population of Massachusetts, according to the United States census of 1880, at the ages ending in 5 or 0, with the number for the year before and after in each case:

Age.	Males.	Females.	Age.	Males.	Females.
4	18,133	17,703	34	10,707	11,914
5	18,037	18,115	35	17,873	18,678
6	17,618	17,395	36	10,962	12,384
9	15,977	15,793	39	8,798	10,153
10	16,847	16,690	40	20,146	20,748
11	14.964	15,110	41	6,624	7,277
14	16,325	15,938	44	7,474	8,710
15	15,114	15,479	45	14,739	14,911
16	15,156	16,404	46	7,627	8,467
19	17,425	18,661	49	6,516	7,480
20	17,481	21,555	50	14,847	16,399
21	16,422	17,774	51	5,061	5,568
24	15,858	18,934	54	5,916	6,580
25	17,502	20,201	55	8,109	8,674
26	14,652	16,816	56	6,045	6,326
29	11,813	13,102	59	4,297	4,555
30	20,583	21,967	60	9,556	10,441
31	9,493	9,946	61	3,600	3,856

The contrast between the numbers for 30, 40, 50, and 60, and the numbers just before and just after them, is almost ludicrous, and, contrary to the general opinion, the men seem to be as inaccurate as the women. The discrepancy, although marked, is somewhat less in the years ending in 5, and it is therefore better to combine the population, or the deaths, by the years ending in 5, as 25–34, 35–44, etc., rather than by those ending in 0, so as to minimize this source of error.

The universal tendency of females to understate their ages is well illustrated by the following table showing the white population living at certain age-periods in Massachusetts, in 1870 and 1880.

Age.	1870.	1880.	Age.
5–14	142,852	184,786	15–24
15–24	150,208	153,711	25–34
25–34	127,407	122,728	35–44
35–44	99,060	91,018	45–54

The arrangement of these columns is such that the number for each age-period for 1870, is opposite the number for the age-period ten years older in 1880. It is the rule, even allowing for variations in the birth-rate and in immigration and emigration, that the number of the population decreases with each successive year. Now, the persons who were between five and fifteen years of age in 1870, were between fifteen and twenty-five in 1880, and the latter number should be less than the former, whereas it is more than forty thousand larger. From the table it would appear that the tendency to understate the age declined a good deal after the age of thirty-five or forty, and that this great excess of women between fifteen and twenty-five was due to the including in this total a large number of women who were really overt wenty-five years of age. Errors of this kind, however, are so constant, that allowance can be made for them, and the numbers can be corrected so as to permit just conclusions to be drawn.

A somewhat similar difficulty occurs in the ages of infants as given in the census. There are found to be more children reported to be two years old than there are one year old, on account of the tendency of parents to advance the age somewhat. Thus the following are the figures for New York City from the United States census of 1880.

POPULATION, JUNE 1, 1880.

Age.	Males.	Females.	Total.
Under 1 year.	15,738	15,385	31,123
1 year.	12,054	11,712	23,766
2 years.	14,796	14,686	29,482
3 years.	13,975	14,199	28,174
4 years.	14,029	13,753	27,782

At the other extreme of life, the deviation from the truth is probably still greater. There are really very few persons who live a hundred years. and yet every census furnishes a long list of those who claim to be centenarians. The United States census of 1880 reported 4,016 centenarians, of whom 955 were white sand 3,061 were colored; the great disproportion of the races showing conclusively the tendency of the ignorant to overstate their age; for the total number of whites is given as 43,402,970, and of colored as 6,752,813, and the mortality of whites as 14.74 per 1,000, and of colored as 17.28.

In the New York State census of 1875, on page 199, will be found a table showing the "ages, as they appear in the records of former censuses, of persons whose names could be found in those returns, who, at the census of 1875, were returned as one hundred years of age and upward." There are 48 of these persons, but the names of only 11 of them appear in every one of the previous censuses, the records of which were examined for them. These are given below.

Number in the table.	Census of 1860.	Census of 1865.	Census of 1870.	Census of 1875.
1	79	83	96	102
8	82	80	94	100
9	80	100	94	108
10	85	89	95	100
11	87	92	97	102
22	78	86	96	101
36	78	90	97	105
43	85	90	96	100
44	56	70	70	100
46	65	90	97	102
48	87	92	96	102

Of these, No. 11 would seem to be genuine, and Nos. 10, 43, and 48 are also, perhaps; but the others are evidently wild guesses.

The total number of persons who are ninety years of age and upward, or who claim to be, is so small in comparison with the rest of the population, that such errors are of no practical importance, and cannot seriously affect any conclusions drawn from the population as a whole.

Data Obtained from Current Reports.—In most countries, the census enumerators are not called upon to ascertain any facts relating to births, marriages, or deaths, because the system of registration is so perfect that an account of these events is kept from month to month, or

week to week, or even from day to day. In this country, where, outside of a few of the large towns and some States, the registration is very imperfect, an attempt is made by the superintendent of the census to obtain these facts during the enumeration of the population. These attempts have not hitherto been very successful.

Births.—The only way to obtain these reports with any show of accuracy is to make them compulsory. In European countries, where everybody is followed up by the police, and is expected constantly to announce his whereabouts and almost every movement to them, there is ample provision for the procurement of such details. Parents are obliged to report births to the registering officers, generally within eight days after birth, and a child that has not been so reported, and whose name cannot be found upon the public records, has a hard time of it as he grows up. He cannot go to school without presenting his certificate of birth, and in many countries is not allowed to marry. In fact, he seems to be treated almost as an outcast. The consequence of such severe measures is that births are very fully reported. And the result justifies the means, for occasion may arise at any time, in any country, when the proof of the age of a particular individual becomes a matter of the first importance, and no evidence from private sources can ever equal in value and authority the contemporary record of the birth registered in a public office.

It is not probable that the record of births is complete in any place in the United States. Providence, R. I., long had the enviable prominence of being a town where the birth record approached completeness. The reports were collected by house-to-house visitation, and for some years the number returned was believed to be nearly what it should be. But of late years the system has been found not to work so well, and a certain proportion of the births, how large it is impossible to say, is not obtained.

In England and this country, where the inquisitorial methods of the continental police would not be tolerated, the reports of births are required from physicians and midwives. In England, the sub-registrars are also expected to use every means in their power to obtain perfect and accurate returns, for which they are paid a shilling a name. The system seems to work well there, and it is estimated by the Registrar-General that not more than five per cent. escape registration.

In this country, wherever registration is attempted, it is expected that physicians and midwives will make these reports, and penalties are provided by the laws in case they neglect this duty. Physicians often criticise this law as unjust, and, it must be confessed, they do so with some reason, for the ordinary form of certificate of birth requires the report of many bits of information which are not a matter of personal knowledge with the physician, and which he must ascertain by inquiry. Moreover, he is put to a slight expense and some trouble in sending the reports by post, or in carrying them himself to the office of registration. On the other hand, he holds a license to practise medicine from the State, which, in a measure, protects him from unlawful competition. In return for this, is it too much for the State to ask of him that he should report to public authorities all the particulars which the State may require about the births and deaths which occur within his personal knowledge, these being matters which it is of prime importance for the State to know. And it is not enough for the purposes of the State that he should report simply the place and date of birth, with the sex of the child, for more minute details are required for proper identification, such as the full names of the parents, with their birth-place and age.

Even under the most favorable circumstances, a certain proportion of births will escape registration. Some will not be reported through ignorance of the law; this will be the case especially when a child is born without attendance of doctor or midwife. Some illegitimate children will not be reported out of shame on the part of the parent, and others in order not to draw the attention of the authorities to private establishments of a disreputable character. And some children will be born of wandering people, gypsies and vagrants, who are both ignorant and negligent of the law.

In New York City, from time to time, attempts have been made to enforce the provisions of the law relating to the non-reporting of births. The penalty is ten dollars, but it has very seldom been collected. The unreported births are ascertained by a comparison of the record of deaths of children only a few months old with the list of reported births, and every time that action has been taken in this direction by the public authorities, there has been a notable increase in the number of births reported for a few months, when they again fall off, and the physicians and midwives become as lax as before. It is estimated that there are about sixty thousand births annually in New York City, and as only about forty-five thousand are registered, there is a deficiency of twenty-five per cent.

Marriages.—The registration of marriages is not of so much interest to the statistician as to the community at large. It is of the highest importance that this, the most marked and fateful voluntary act of a human lifetime, should become a matter of public record. It is of importance in connection with questions of legitimacy, of inheritance, of kinship, and as an index of the general prosperity, and a public record is especially necessary as a means for the detection of bigamy, and the protection of the wife and mother.

In New York, where the laws are very lenient regarding marriage, in order to enable women to protect themselves from the evil results of association with rascally men, the registration is imperfect. How many, or what proportion, of marriages escape registration it is impossible to say. It is probable that it is much less than the proportion of unregistered births, for the marriage-rate is as high in New York City as in almost any large city in the world. But some clergymen are forgetful, others are ignorant of the law, and some of the clergy of the Catholic Church, while they preserve a record of every marriage in the parish register, do not report them to the public authorities, because they do not wish to recognize in any way that the ceremony, which to them is a sacrament, is a civil contract. That this view is wrong is shown by the fact that the Archbishop of New York always reports to the civil authorities, all marriages solemnized by him.

In Massachusetts, Connecticut, New Jersey, and some other States, a license must be taken out before marriage, in order to make it legal. This regulation renders the registration probably nearly complete, and in this country it appears to be the only method of accomplishing this end.

Deaths.—By far the most important for vital statistics of all the events publicly registered are the deaths. Sanitary legislation depends largely upon the death records for its impetus and necessary changes. A study of such records furnishes vast stores of information regarding the origin, character, and methods of control of disease, and most of the sanitary improvements which are so marked a feature of our civilization within the last fifty years are based upon them. In these improvements, England is generally considered to hold the leading place, and Dr. E. A. Parkes did not overstate the truth in saying, "The fact that in modern times the subject of hygiene generally, and State medicine in particular, has commenced to attract so much the public attention, is undoubtedly owing to the application of statistics to public health. It is impossible for any nation, or for any government to remain indifferent when, in figures which admit of no denial, the national amount of health and happiness, or disease and suffering, is determined. The establishment of the Registrar-General's office in 1838, and the commencement of the system of accurately recording births and deaths, will hereafter be found to be, as far as the happiness of the people is concerned, one of the most important events of our time. We owe a nation's gratitude especially to him to whose sagacity the chief fruits of the inquiry are due, to William Farr."

In a considerable number of the large cities of the

United States the registration of deaths is quite complete and accurate. This is especially the case in Boston, New York, Philadelphia, Baltimore, Cincinnati, Chicago, New Orleans, and San Francisco. In some States, also, a good beginning has been made toward the registration of deaths, notably in New Hampshire, Massachusetts, Connecticut, New York, New Jersey, and Minnesota. Throughout the greater part of the United States, however, the registration is very imperfect, and although State Boards of Health have been established in thirty-eight of the States of the Union, they are in many places not yet in efficient working order, and are only slowly educating the public to a rightful apprehension of their duties in the matter.

The only way to procure complete registration of deaths is to render it very difficult or impossible to bury the body of a deceased person without notifying the authorities. Other methods have been tried, but without success. The collection of deaths from the books of sextons or undertakers, from church registers, etc., is a very uncertain method, and the non-compulsory report to a public authority is also untrustworthy. On the continent of Europe, the police methods render the registration of deaths as complete as that of births or marriages. A public officer, a "Todtenbeschauer," or "Vérificateur de décès," visits every house of death, inquires into the cause and circumstances of the death, and issues a certificate of interment. In England, "a person present at the death or in attendance during the last illness of the deceased person, goes to or sends for the registrar of the district in which the death happens, gives the requisite information, and signs the register book." This was the law up to the Compulsory Act of 1874, which imposed the obligation of making the report of death upon the medical attendant. There seems to be some opposition in England to making this report without remuneration, but in this country, although some physicians strenuously object to reporting births without pay, they acquiesce willingly in the necessity of reporting deaths.

It is believed that the system in use in most of the large cities of the United States is as good a one as can be devised.

The physician who attends the person during the last illness fills out the certificate of death so far as he is able, and signs it with his name and address. Certain items of family history, of course, can only be given by relatives of the deceased person, and those items are written in by some member of the family, or by the undertaker. The certificates are furnished by the office where the records are kept, and most physicians keep a supply on hand, which can be replenished, when necessary, on application at the central office. In New York City this certificate, properly filled out, must be presented at the office of registration, and a permit for burial is issued in exchange for it, the original certificate being retained, numbered, indexed, and bound for future reference. Every dead body must be buried within four days after death, unless a special permit has been granted allowing it to be retained above ground for a longer time. No bridge or ferry can be crossed without the presentation of this permit, and as most of the cemeteries are outside of the city, each permit has two coupons, which are torn off by transportation companies on the way. On arrival at the cemetery the permit is taken up by the keeper before the funeral cortége is allowed to enter the grounds, and is returned by him to the local Board of Health of the town in which the cemetery is situated. The coupons torn off at the bridges and ferries are returned to the Board of Health issuing the permit. Thus the only methods of getting rid of a dead body without reporting it to the office of registration and procuring a regular permit are: 1, To bury it in the cellar or yard of a house; an act almost sure to be seen and reported to the police; or 2, to throw it into the river, also exposing oneself to detection by the police or a curious on-looker; or 3, burning in a furnace or stove, subject to the same risk; or 4, to bury it in a cemetery, with the collusion of the police and ferry-masters, at the ferry, and of the keeper of the cemetery. As it is very little trouble to procure the proper permit, none of the above methods of eluding registration are likely to be adopted excepting in criminal cases, when risk must be run. But such cases, in any event, constitute a small part of the total number of deaths, so that we are justified in assuming that the record of deaths is virtually complete, excepting that a small number of children who were born alive and died shortly after may be reported as still-births, although every precaution is taken to prevent such reports.

In order to make these reports of value statistically, they must be full and accurate. In order to secure accuracy, they should all be examined by a medical registrar, who is qualified to judge of the sufficiency of the cause of death as given in each certificate. The lack of sufficient information is, as a rule, not so much the result of ignorance, as of carelessness or thoughtlessness on the part of the physician. At least this is the case in New York City. This point was illustrated recently by a certificate giving the cause of death as "Hæmorrhage, Anæmia of the Brain," with no indication whatever of the source or cause of the hæmorrhage. The certificate being returned with a request for further information, it was learned that the patient had suffered from a cancer of the neck for about three years, and the hæmorrhage was due to the erosion of large blood-vessels. In all such cases, a note to the physician usually brings out the information necessary to make the record complete, but if it does not, the certificate is sent to the coroner, who makes a special investigation of the case. This disposition of cases that are in any way suspicious is provided for by the following law: "Hereafter, when in the City and County of New York, any person shall die from criminal violence, or by a casualty, or suddenly, when in apparent health, or when unattended by a physician, or in prison, or in any suspicious or unusual manner, the coroner shall subpœna a properly qualified physician, who shall view the body of such deceased person externally, or make an autopsy thereon, as may be required (preparatory to an inquest)." Laws of 1882, Chap. 410, Section 1173.

There are some causes of death which, although at one time generally recognized as diseases by themselves, are now looked upon as symptoms merely, and should not be accepted upon a certificate. Probably the most common of these, and the one that shows the greatest tendency to persistence is *dropsy*. In New York City this has not been accepted as a sufficient cause of death since 1870, and the effect upon the death records of the rejection of all such certificates is very plainly shown in the following table:

Year.	Causes of Death.		
	Dropsy.	Heart disease.	Bright's disease and nephritis.
1868.....	177	615	594
1869.....	250	686	637
1870.....	116	699	890
1871.....	9	813	1,080
1872.....	9	894	1,040

The few cases of dropsy that will be found in subsequent reports are on certificates issued by coroners, which have to be accepted whether fully satisfactory or not.

The word *tumor* is another stumbling-block. This also is not accepted as a cause of death, excepting in the rare cases where no diagnosis has been possible, and an autopsy is refused. And even then the certificate is usually accompanied by a written explanation of the case from the physician, which is attached to and bound with it, so that the record is complete for legal purposes, although somewhat defective for the purposes of statistics.

The greatest latitude, however, has to be allowed in the reports of deaths of infants. The various ultimate causes of poor nutrition are so difficult to detect, when no subjective symptoms can be obtained, that a large proportion of infant deaths are returned under the rather

indefinite titles of marasmus, atrophy, debility, inanition, etc., and at present there seems to be no likelihood of any improvement in this direction. This difficulty is felt in other countries than this quite as keenly as here, as the following table shows :

Place.	Year.	Cause of death.	Number.	Total deaths.	Percentage of total.
Berlin.....	1888	Lebensschwäche.	1,723	29,294	5.88
London ...	1888	Debility, atrophy, inanition.	2,555	79,099	3.23
Paris.....	1891	Débilité congénitale.	1,371	52,262	2.62
New York.	1891	Marasmus, atrophy, inanition.	1,530	43,659	3.50

Besides these indefinite causes of death, some diseases require to be very fully reported on account of the possibility of criminality. The most prominent of these is peritonitis, which may result from criminal abortion, or from criminal assault. These chances render it necessary that every case of death from peritonitis should have the cause, if known, and the character of the disease (whether simple, puerperal, traumatic, tubercular, septic, etc.) stated upon the certificate. A few causes of death, the medical attendant feels obliged to slur over, or express in what to the friends are unintelligible or ambiguous terms, in order to avoid shame or offence to the survivors. For this reason, which is especially applicable to deaths from alcoholism and syphilis, it is very desirable to have the certificate of death entirely filled out by the family, with the exception of the medical certificate, before it goes to the physician. In New York many doctors use euphemisms, which are well understood at the permit office, but not understood by the family, such as temulentia for alcoholism, and lues, or specific disease, for syphilis. As a rule, certificates are honestly and conscientiously made out.

In England a certain proportion of deaths are uncertified as to cause, owing mainly to the fact that a report of death is often made by the laity, and a permit for burial issued in return. Thus cases which have died unattended by a physician may be reported as "wasting sickness," "sudden death," "visitation of God," etc. Even in London, about one per cent. of the deaths are uncertified as to cause. In New York, this cannot happen, for all such cases are referred to the coroner, every case being thus certified by a medical man ; infants who die within a few minutes after birth, when a midwife has been in attendance, being also referred to the coroner.

Of the total number of deaths in London, the coroner's or inquest cases constitute about seven per cent. (5,816 out of a total of 79,099 in 1888), while in New York they amount to about eleven per cent. (4,825 out of 43,659 in 1891).

It would be an excellent thing if the principal nations could agree upon a common nomenclature of diseases, so that it would be practicable to compare the statistics of one nation with those of another, with some degree of certainty that a comparison is being made between precisely similar things. This can, of course, be done even now, with some well-known and well-defined diseases, like small-pox, scarlet fever, and measles, and yet even here there are differences in methods which make it necessary to be very cautious. One must make sure whether the title small-pox includes or excludes varioloid and varicella, whether scarlet fever includes or excludes scarlatino-diphtheria, and whether measles includes or excludes German measles or Rötheln.

Another difficulty in the classification of diseases arises from the tendency of physicians to multiply causes of death in their reports. Often three or four causes of death are given, any one of which might have been fatal, with no indication on the part of the doctor as to which he considered to be the main factor in bringing about the death of the patient. A certificate, for example, giving as the cause of death, "cirrhosis of the liver, mitral insufficiency, chronic interstitial nephritis, hæmatemesis," throws a responsibility upon the registrar which the physician who attended the patient should take upon himself, viz., that of deciding under what heading the death ought to be classified. An attempt has been made, with some success, in New York, to obviate this difficulty by providing spaces upon the blank certificate for reporting the "chief cause" and the "complicating cause." This is not altogether satisfactory, for one physician might write down perforating ulcer as the chief cause and typhoid fever as the complicating cause, while another would more correctly report the ulcer as the complicating, and the fever as the chief, cause, and yet the ulcer was the real cause of death, being a fatal complication, while without the perforation the patient might have recovered. Better headings would probably be "Disease causing death," and "complications." These could hardly be misunderstood.

Still-births.—These should be reported, but by themselves and not as either births or deaths. The whole question of their proper position in statistics depends upon the question of what constitutes a birth ; for, of course, a human being, in order to die, must have been born. What then constitutes a birth ? A birth is the beginning of existence as an independent individual, as distinguished from one who is dependent for existence from moment to moment on the life of another individual. Now, the great change in the circulation of the child begins with the first breath, and whether the umbilical connection with the mother is severed or not, the circulatory connection will presently cease. The rule, therefore, should be never to report a child as still-born after it has breathed, if even only once. And it does not seem that any other dividing line than this can be found. "God breathed into his nostrils the breath of life, and man became a living soul."

The reports of still-births being largely made by midwives, most of whom are ignorant of everything exceptng the mechanical part of their business, they have to be scrutinized very closely in order to detect any indications of malpractice, and cases of live-born children returned as still-born because they have lived so short a time.

The registration of still-births, or at least the certification of them by a responsible person, is of great social and legal importance. Although they are not registered in England, they are required, under the new Registration Act, to be reported by the physician or midwife before burial. In New York City the certificates of still-births are arranged alphabetically and bound like the deaths. The proportion of still-births to the total number of births in England is estimated to be about four per cent. In France, under the provisions of the Code Napoléon, children who die before registration are counted among the still-born. It is estimated by Dr. Bertillon that twenty-two in one hundred of the children recorded as still-born breathed, and the percentage of actually still-born children, allowing for this correction, is about 3.6. In Belgium it is about the same. In New York City the number of still-births for 1891, as reported, was three thousand four hundred and fourteen, and of these two thousand five hundred and eight were seven months old or more and, therefore, viable children, and suitable for comparison with the statistics of other countries. As the birth-rate of France is very low, while ours is naturally high, a comparison with England is more appropriate, and if we take four per cent. as the proportion of still-births to births in New York City, we shall have about sixty-two thousand births a year, the same result arrived at in another way.

Reports of Contagious Diseases.—Probably no requirement which the law makes of physicians has met with more virulent opposition than the compulsory notification of cases of contagious disease. Many physicians object to it, not only as involving considerable trouble and expense, but as tending to bring them into conflict with the families of their patients, who look upon the report to the public authorities as a breach of confidence on the part of the physician, and who object strenuously to the visits of the sanitary inspectors. And yet it

is not difficult to see that such notification is necessary for the protection of the public. It is not only necessary in order that proper precautions may be taken by the relatives of the sick person, but that other persons living in the vicinity may also take their own precautions against infection. It has been found by experience that this notification must be given by the medical attendant. If it be left to the parent or householder, it will not be done at all, or will be done too late to be of service. The information should be given as soon after the diagnosis is made as possible, and in New York postal cards, specially printed in blank, are furnished by the Health Department for this purpose. The diseases required to be reported are small-pox, measles, scarlet fever, diphtheria, typhoid fever, yellow fever, typhus fever, and relapsing fever, also "any disease of a contagious or infectious nature;" and the report must be made within twenty-four hours after first visiting the case.

The information thus obtained is of use in various ways:

1. It enables the public authorities to combat epidemics at the very beginning, which is one-half of the fight. Abundant evidence can be adduced to prove that the spread of contagious and infectious diseases can be largely controlled by proper measures if all the cases are promptly reported.

2. It leads to the inspection of premises, and to the detection of unsanitary conditions which might otherwise have long escaped notice.

3. It educates the public to the idea that sanitary measures are effective, and so prepares the way for new legislation when needed.

4. In connection with other prophylactic measures, it enables the authorities to control the school attendance of children who have been exposed to infection.

5. It furnishes a large mass of material, larger than would be accessible to any single individual without such notification, from which the mortality of these diseases can be established, and the history and intensity of different epidemics compared, as well as their virulence as affected by locality.

There is no doubt that many cases go unreported on account of the objections of the parents, and these are more likely to be the cases that recover, for, as there is a severe penalty for not reporting, which, if the patient dies, can only be escaped by taking the risk of making a false statement of the cause of death, most fatal cases are reported before death, and thus mortality-rates made out by a comparison of the deaths with the number of cases reported are invariably too high. Many mild cases, too, are undoubtedly not detected, and if not followed by others, of course remain unknown. This is made certain by the frequency with which severe cases follow mild ones that have already recovered, and the true nature of whose illness is recognized for the first time when the subsequent cases develop.

Population.—The reports that have been mentioned are all that can usually be procured in England and the United States under the forms of law. On the continent the same stringent methods are used to preserve a running account of the population. Besides the census, taken at varying intervals, an account is kept daily of all persons entering or leaving a town, and this, with the accurate record of births and deaths, enables the authorities of each town to form a very close estimate at any time of the number of people it contains.

Voluntary Reports.—Various attempts have been made, at different times and in different countries, to procure statistics of sickness by voluntary reports from physicians. Many valuable statistical results have thus been obtained, partly by medical associations, partly by individual physicians, who distribute lists of questions to members of the profession, and partly by public officers. The most comprehensive and important reports of this kind, probably, are those compiled in Michigan, where the indefatigable secretary of the State Board of Health, Dr. Henry B. Baker, makes up weekly, monthly, and annual summaries of reports of prevalent diseases from different parts of the State. The system was instituted in 1876, and the reports include a great variety of diseases in addition to the infectious ones, which are most commonly the ones reported to the authorities. From these reports, carefully studied, Dr. Baker has been able to construct a theory of the causation of pneumonia, which has attracted by its ingenuity and plausibility the attention of the civilized world.

Such statistics must always rest under the imputation of being defective, unless the reports are made compulsory, and even then are very carefully looked after. But imperfect as they are, and probably always will be, they unquestionably afford valuable data, which can be used with advantage by one who is familiar with the deep pits of statistical fallacy and knows how to avoid them. A description of the methods in use in Michigan will be found in the article on "Registration of Disease" by Dr. Baker, in Vol. VI. of this work.

Methods of Using Vital Statistics.—I. *Population.* For the purpose of calculating birth, marriage, and death rates, the population is usually taken to be that in the middle of the year, *i.e.*, July 1st. As the census is generally taken on some other date, in the belief that the true number can thus be ascertained with greater accuracy, it becomes necessary, as a rule, to estimate the population for the middle of the year, *i.e.*, the mean population for the year. Thus in Germany the census is taken toward the end of December, in England on the first Monday in April, and in the United States on the first of June. All the numbers thus obtained have to be recast, in order to get the mean for the year.

Moreover, as the statistical reports are made up year by year, the population has to be estimated for the years intervening between two censuses, in some cases an interval of three years, in others of five, and in most of ten years. There are several ways of arriving at such estimates.

1. The total increase of population between the two censuses may be divided by the number of intervening years, and the quotient used as the annual increase, as expressed by the formula: $\frac{P' - P}{n} = R$, where P = population at one census, P' the population at a subsequent census, n the number of years between the censuses, and R the annual increase of population.

This method, however, is very faulty, because it assumes that the population increases by arithmetical progression, which could occur only in case the births exceeded the deaths by the same number every year, and there was no immigration or emigration, or else that the excess of immigration was precisely the same in each year—not the ratio of excess, but the numerical excess. These conditions could not occur, excepting as mere coincidences.

2. By keeping a record, or taking a yearly census, of the number of inhabited dwellings, and multiplying it by the average number of tenants to a dwelling as determined by the latest census. This method often gives excellent results, and is especially valuable for the correction of estimates procured in other ways. Of course, any decided change in the methods of building would make the method uncertain. In New York City, for instance, the tendency of late years has been very decidedly toward the building of large tenements and apartment houses and monstrous hotels, and the average number of tenants to a dwelling, as returned by the United States census, has steadily increased from 14.72 in 1870, to 16.37 in 1880, and 18.52 in 1890, while in London the number of persons to a house was 7.8 in 1861, 7.8 in 1871, and 7.9 in 1881, showing a remarkably even distribution of the population.

This method has been used with great success by Dr. James B. Russell, the widely known medical officer of health for Glasgow. The average number of persons per house, exclusive of the number in institutions and on the shipping in the river, was 4.738 in 1881 and 4.727 in 1891. Including the shipping population of 1881, the multiplier 4.738 was raised to 4.745. Multiplying the number of houses on the assessment roll of the City As-

sessor, he estimated the total population in the middle of 1891 as 574,800. The population, estimated according to the method of the Registrar-General, as described below, was 532,282. The population estimated on the basis of the census of 1891, which was taken in April, was 567,143, so that Dr. Russell's estimate was only 1.35 per cent. too large, while the Registrar-General's was 6.15 per cent. too small. Now, the number of persons on the shipping does not tend to increase very much, having been 639 in 1861, 569 in 1871, 590 in 1881, and 723 in 1891. Moreover, the discrepancy of about 1.5 per cent. between the census return of inhabited houses and the City Assessor's list of dwellings apparently represents the unoccupied dwellings. Dr. Russell therefore proposes, until the next census is taken in 1901, to use the following formula in estimating the population of Glasgow, viz.:

(Tenanted houses — 1% × 4.727) + Shipping + Institutions = Population,

and apparently this will give a very correct result.

3. The method in use in the office of the Registrar-General in London, based upon the assumption that the same rate of increase which existed during one inter-censal period, will hold good through a succeeding one. This is not by any means true, especially in a country like the United States, where immigration is so enormous in its proportions, and where there is such a constant shifting of population between different centres.

In order to estimate the population for the inter-censal years upon this assumption, the annual rate of increase has to be first ascertained in the following manner: The increase of a population by the excess of births over deaths, if the rates of both births and deaths to the population remain constant, is by geometrical progression, as the excess of births is annually increasing, owing to the continual introduction of newly married couples into the mass of the population. The problem, therefore, is the same as that of compound interest, and the annual rate of increase corresponds to the rate of interest upon a sum of money, and is obtained in a similar way. Thus, if p represents the population at one census, and p' the population at a subsequent census, n the number of years between the censuses, and r the annual rate of increase, then $1+r$ will equal the annual amount of each unit of population at the end of the year. That is to say, each unit at the beginning of the year will have become $1+r$ at the end of the year, just as one dollar at six per cent. becomes 1 + .06 or 1.06 at the end, and just as compound interest is calculated by multiplying 1.06 into itself for the required number of years, thus obtaining the final amount of principal and interest for one dollar, which is then multiplied by the whole sum to obtain the final amount; so $1 + r$ (whatever r may be), multiplied into itself for the entire inter-censal period, will give the entire rate of increase for each unit of the population, and this multiplied by the population of the first census will give the population of the second. To obtain the annual rate of increase, of course, this process must be reversed. The population of the second census must be divided by that of the first, giving the total rate of increase, or $(1+r)^n$; the root of the quotient thus obtained must be extracted, whose exponent is the number of inter-censal years. The formula then will read as follows:

$$\sqrt[n]{\frac{p'}{p}} = 1 + r, \text{ or } \frac{\log.\ p' - \log\ p}{n} = \log.\ (1 + r).$$

Having thus obtained the annual rate of increase, it is easy, by the use of logarithmic tables, to calculate the population for all the intervening years.

If the population has to be calculated for fractional parts of a year, the same method is used. Thus the United States census is taken as of the first of June, and the population must be estimated for the first of July. There are thirty days between the dates, and 365.24226 days in a year. The rate of increase has therefore to be calculated for $\frac{30}{365.24226}$ of a year. This can only be done by the aid of logarithms, the formula being—rate of increase for June $= \frac{365.24226}{30}\sqrt{1+r}$, *i.e.*, $\frac{\log.\ (1+r) \times 30}{365.24226}$.

This method is not altogether satisfactory, unless subject to correction. The census taken in 1891 in England brings out strikingly the imperfections of it. The following table shows the population for twenty-eight large towns of England estimated for the middle of 1891, by using the censuses of 1871 and 1881 as the base of calculation, with the population for 1891 estimated for the middle of the year from the censuses of 1881 and 1891, and in a third column the percentage of excess or deficiency in the first estimate as compared with the second.

	Population July 1, 1891, estimated from censuses of 1881 and 1871.	Population estimated from censuses of 1881 and 1891.	Percentage of excess or deficiency.
London	4,492,707	4,221,452	+ 6.43
Brighton	125,539	115,606	+ 8.59
Portsmouth	144 671	160,128	− 9.65
Norwich	96,202	101,316	− 5.05
Plymouth	79,339	84,464	− 6.07
Bristol	235,171	222,049	+ 5.91
Wolverhampton	84,277	82,799	+ 1.79
Birmingham	469,003	429,906	+ 9.09
Leicester	158,266	142,581	+ 11.00
Nottingham	252,217	212,662	+ 18.60
Derby	103,269	94,496	+ 9.28
Birkenhead	107,619	99,597	+ 8.05
Liverpool	620,443	517,116	+ 19.98
Bolton	117,034	115,253	+ 1.55
Manchester	506,325	506,469	− 0.028
Salford	251,024	198,717	+ 26.32
Oldham	151,158	132,010	+ 14.50
Blackburn	125,874	120,496	+ 4.46
Preston	106,141	107,864	− 1.62
Haddersfield	101,080	95,656	+ 5.67
Halifax	82,998	83,109	− 0.13
Bradford	246,101	216,938	+ 13.44
Leeds	370,261	369,099	+ 0.32
Sheffield	338,543	325,304	+ 4.07
Hull	219,812	200,934	+ 9.39
Sunderland	138,859	131,302	+ 5.76
Newcastle	165,016	187,502	− 11.99
Cardiff	121,477	130,283	− 6.76
Edinburgh	275,436	261,970	+ 5.14
Glasgow	532,282	567,143	− 6.15
Dublin	353,082	357,050	− 1.11

It will be observed that the tendency of this method has been to an excessive estimate of the population, ranging from an excess of only 0.13 per cent. up to 26.32, and that the extreme range in the estimates is between the latter percentage in excess and 11.99 deficiency. The excess of the estimated over the true population in London was 6½ per cent., amounting to more than a quarter of a million, while, on the other hand, the population of Manchester was estimated with extraordinary exactness, there being a difference of only one hundred and forty-four persons in a population of half a million. The table, however, abundantly shows the uncertainty of estimates made after this method, and the necessity of correcting them in some of the ways already mentioned. They afford also a powerful argument in favor of a more frequent census, for if sanitary measures are to depend in any degree upon death-rates, and the death-rate may vary twenty-five per cent. from the truth, the ground under our feet becomes very tremulous and unstable to build upon.

4. By adding to the population, as obtained by a census, the excess of births over deaths, and of immigration over emigration. In a community where one's information can be procured with a reasonable certainty that it is trustworthy, this is of all methods the best, for, of course, with perfectly accurate data, the correct number of inhabitants would be known directly, with a minimum of computation. In most countries this method cannot be used for lack of proper data, but it is very successfully carried out in Berlin, where the population is corrected week by week.

5. By a police census, which, as generally conducted

in this country, by personal visitation and inquiry, must of necessity be inaccurate and misleading. In the first place, it usually extends over several weeks, with no attempt to refer all information to a specific date, and, with so many ignorant and untrained men, will in many sections be slurred over in the most labor-saving manner possible. The census of a city or town might, however, be pretty well taken by the police, if use were made of prior schedules, the object and method of the census having previously been discussed in the newspapers. It would be very little trouble for every officer to leave in every house on his beat a sufficient number of schedules to supply the tenants, the schedules to be so carefully prepared as to indicate their purpose and the way they are to be filled out as to be understood by the dullest wits. These schedules being left on one day and gathered up on another, would give very little trouble to the police, and would at least serve as a valuable aid in correcting estimates of the population.

6. By a school census, in which the number of children of the school age is taken, and the total population estimated on the assumption that the proportion of such children to the total of all ages has remained the same as it had been found to be in the latest census.

Other methods to estimate the population are, by multiplying by a certain factor obtained by previous experience, the number of registered voters, or the number of names in the Directory. All of these methods are very faulty and give no result that can be depended upon, on account of the fluctuating character of the data. They can only be of any value as corroborative evidence of results that have been obtained by more accurate methods, or as correctives, if the tendency of them all is in the same direction, of results otherwise obtained, which appear upon their face to be inaccurate.

All of these methods, excepting those mentioned in 1 and 4, tend to an over-estimate of the true population, and thus to make the death-rate appear lower than it really is.

II. *Births.*—For the purpose of sanitary legislation the births are not as important as the deaths, but for commercial purposes, and especially in the solution of social and economical questions, it is very important to know accurately the true number of births in a community. For the purpose of making comparisons between one year and another, or between one country and another, or one town and another, with regard to relative fecundity, birth-rates are used, and these are obtained in various ways.

1. The usual birth-rate is the ratio which the births bear to 1,000 living of the total population. This is generally a little more than twice the marriage-rate, *e.g.* :

	Marriage-rate, *i.e.*, persons married to 1,000 living in 1888.	Birth-rate—births to 1,000 living in 1888.
England and Wales	14.2	30.6
Scotland	12.5	30.5
Ireland	8.4	22.9
Denmark	14.2	31.7
Norway	12 3	30.8
Austria	15.8	37.9
German Empire	15.7	36.7
Holland	13.8	33.7
Belgium	14.7	29.1
France	14.4	23.1
Spain	13.4	37.1
Italy	15.6	36.6

France, whose economists are so puzzled and apprehensive on account of her low birth-rate, is about the only exception to this general rule, that the birth-rate exceeds twice the marriage-rate. Applying this rule to New York City, where the marriage-rate for 1891 was 18.76 (although the reports of marriages are still known to be defective), the birth-rate should be nearly 38 per 1,000 ; or without reference to the population, the marriages reported having been 15,764 in number, *i.e.*, 31,528 persons married, the births should have been about 63,000, whereas only 46,904 were registered.

Throughout the United States, the registration of births is exceedingly imperfect, and even in the census year, when attempts are made to ascertain the true number, the authorities are always foiled. In the census of 1880 the enumerators furnished, so far as they were able to procure the information, the number of children living under one year of age, and the number reported as born and having died within the census year—which ought, leaving immigration out of account, to give the number born during the year. But the number obtained in this way is far too small, owing partly to the fact that not all were reported, and partly to the tendency of parents to call a child a year old when it is really only ten or eleven months. So the birth-rate of the United States was found to be only 31.4 in 1,000 living. For the different States the birth-rate varied from 19.1 in New Hampshire, to 41.9 in Utah, and 42.7 in Arkansas. From the total increase of population between 1870 and 1880, after eliminating some minor sources of error, Dr. Billings estimates the true birth-rate of the United States at 36 per 1,000.

The birth-rate is obtained by dividing the total number of births for the year by $\frac{1}{1000}$ of the population, or what is the same thing, multiplying the births by 1,000 and dividing by the population. It answers all practical purposes, but is not so accurate as the method immediately following, because it takes no account of the different age and sex distribution of the communities to be compared. It is evident, for example, that, with equal fecundity, there will be a higher birth-rate in a community of 10,000, with 4,000 married women of the child-bearing age, than in another of the same size with only 2,000 women of that age.

2. The birth-rate, as just indicated, may be estimated by comparing the number of births with the number of child-bearing women in the community, *i.e.*, of women between fifteen and forty-five years of age. Comparisons made between such rates are more satisfactory than those depending upon the first method.

The birth-rate is affected by various causes which tend to increase or diminish it in different years, and to make it greater or smaller in one country or one city than in another. Some of these causes may be mentioned here.

The influence of social condition is believed to be considerable, and it is the general opinion that the families in the well-to-do classes of the community are smaller than among the poor. There are very few data bearing upon this question, and it is always to be borne in mind that the upper classes are more prudent, as a rule, in regard to marriage, that marriage is entered upon later in life, and that as people improve their social condition their ages advance. Moreover, in the large cities of this country the poorest classes contain a large proportion of newly arrived foreigners, so that the race question is involved.

The statement is often made that the native American stock is gradually dying out, because the women are less fecund than the foreign-born women. Dr. Nathan Allen, of Massachusetts, maintained this with great vigor, and there seems to be small doubt that foreign-born women do, as a rule, have more children. This may, however, not be due to greater natural fecundity, or to the prevalent use of unlawful means to avoid pregnancy or end it abruptly on the part of American women, as has been urged in such a sensational manner by some physicians, but may be due to the recklessness with which they marry. To most foreigners, soon after their arrival in this country, the ease with which they obtain employment, and the high wages which, to them, must seem enormous, seem to lift a heavy burden from their hearts, and with the rebound, like that of a suddenly released spring, having no fear of the future before them, they rush precipitately into marriage. In New York City, marriages of young Italian and Russian girls of from fourteen to seventeen are very common, and beginning so early, their families are often large. Then, as shown by Dr. Edward Jarvis, a very distinguished statistician,

the greater mortality of the children of foreign parentage offsets their greater fecundity, so that the natural increase is at a lower rate in the foreign than in the American families.

The most recent statistics upon this point now accessible, are those in the city registrar's report of the city of Providence for 1891, from which it appears that in 1890 1,496 American mothers had an average of 3.17 children to a family, while 1,864 foreign-born mothers had 3.60 to each family; in 1891 the proportions respectively were 3.08 and 3.52. The total number of children born of American mothers in 1891 was 1,698, and the deaths of children under one year of age were 251, a ratio of 14.78 per cent. There were 2,178 births of foreign-born mothers, and 325 deaths of children under one year, a ratio of 14.92 per cent. The corresponding ratios for the thirty-six years from 1856 to 1891 inclusive, were 13.91 and 14.63. In New York City, in 1891, out of 38,689 children of unmixed parentage whose births were reported, 11,852, or 30.63 per cent., were of native parentage, and 26,837, or 69.37 per cent., of foreign parentage. The statistics of deaths by age and parentage are not published, but the deaths of children of unmixed parentage by marasmus, inanition, atrophy, etc., who were mostly children under one year of age, were 730 in all, of whom 270, or 36.98 per cent., were of native parentage, and 460, or 63.02 per cent., were of foreign parentage.

In the New York State census of 1875, some statistics were obtained that seem to be of especial value in relation to this point, for that census was exceptionally well taken, and in this respect particular care was exercised, as it was the first time such an inquiry had been made. Mr. Franklin B. Hough, the superintendent of the census, says (p. lxvii. of the Introduction): "In the present census an inquiry was first introduced having this object in view (viz., relative increase of population with women of American and foreign birth). The column was headed, 'Of how many children the parent?' The instructions gave the following instructions for reporting it: 'This inquiry is to be made only of adult *females*, and usually of wives or widows. It should, in all cases, include the number of living children the woman has borne, *whether now living or dead*, and *whether present or absent* from the family. These children may perhaps be themselves the heads of families and residents of another State, or they may have died in childhood. The object of the inquiry is to obtain data for determining the natural increase of the population in this State among the various classes, and it should be taken fully and uniformly to possess value. Be careful to note in this column the number of children borne by females now aged, as well as that of those now surrounded by their families. We can thus determine the relative rate of increase of a former age, for comparison with the present.'" These statistics were reported very uniformly, and quite as fully as could have been expected. The table on the next column shows the result:

Number of children born.	Nationality of women.		Total number of children.	
	American.	Foreign.	American mothers.	Foreign mothers.
0	74,366	40,886	0	0
1	82,279	42,038	82,279	42,038
2	79,346	44,573	158,692	89,146
3	65,904	42,420	197,712	127,260
4	54,099	37,827	216,396	151,308
5	42,581	30,870	212,905	154,350
6	33,015	25,356	198,090	152,136
7	25,242	18,160	176,694	127,120
8	20,024	13,502	160,192	108,016
9	15,164	9,677	136,476	87,093
10	11,288	6,991	112,880	69,910
11	7,259	4,069	79,849	44,759
12	4,995	2,772	59,940	33,264
13	2,431	1,440	31,603	18,720
14	1,303	912	18,242	12,768
15	512	391	7,680	5,865
16	246	214	3,936	3,424
17	89	73	1,513	1,241
18	42	49	756	882
19	31	28	589	532
20	14	19	280	380
21	7	10	147	210
22	7	7	154	154
23	1	6	23	138
24	2	0	48	0
25	3	2	75	50
Total.	520,250	322,312	1,857,151	1,230,774

These women, 842,562 in number, presumably all wives or widows, constituted 67 per cent., or about two-thirds, of all the females in the State above the ages of fifteen, the total being 1,250,220. Of the American-born women, 74,366, or 14.29 per cent., were childless, while of the foreign-born women only 40,886, or 12.68 per cent., had no children. If we take the total number of women in both classes, we find that the American women had an average of 3.57 children apiece, and the foreign-born women an average of 3.81 apiece; while if we leave the childless women out of the calculation, the American women had an average of 4.18 children, and the foreign-born an average of 4.38. Thus, as by the other data given, it seems that the fecundity of foreign-born women, as indicated by the number of children borne by each mother, is a little greater than the American, but by so small a margin that at any time the scales may turn the other way. In New York City, where the foreign-born population preponderates, the results, by the same census, were as follows: Total number of women about whom these statistics were obtained, 160,104; of these 44,084 were American, and 116,020 were foreign born; the American women had 122,344 children, or an average of 2.77, and the foreign-born women 351,840, an average of 3.03; or, excluding the childless women, who constituted 18.70 per cent. (8,247) of the native women, and 15.81 (18,346) of the foreign-born, the American women had an average of 3.41 children, and the foreign born an average of 3.60.

Now, this difference of fecundity is really very slight, in comparison with what has been assumed on rather insufficient data, and it is not at all improbable that it would disappear altogether if native women were in the habit of marrying at as early an age as the foreign, and lived under the same social conditions.

There is another potent cause of the higher birth-rate among the foreign-born population, that has been briefly referred to previously. It is the greater mortality among the infants of foreign mothers, partly, it would appear, for lack of acclimatization, and partly because they belong, as a rule, to the poorer classes, and live herded together under the most unsanitary conditions, surrounded by filth, neglectful of personal cleanliness, and eating insufficient and inappropriate food. A high rate of mortality among infants is always accompanied by a high birth-rate, on account of the shortening of the nursing period, and the consequent shorter intervals of child-bearing.

The birth-rate also varies with the race of the parents. In the United States the birth-rate among the colored people is much higher than among the whites, the rates, according to the census of 1880, being 32 for the white population, and 38.6 for the colored; or, for the whites 127.1 births for every 1,000 women between 15 and 49 years of age (the child-bearing period), and 163.8 for every 1,000 among the colored. Whether this is due to greater fertility of the colored race, or to earlier marriages and greater indifference to consequences, we have not the data to say, but the latter supposition is probably the true one.

The birth-rate is always higher in cities than in agricultural localities, and in industrial and mining districts than in those that are more sparsely populated. This is due to causes that have been already mentioned elsewhere, viz., early marriages, greater infant mortality, and also the greater proportion, as a rule, of women of the child-bearing ages.

The comparative fecundity of the mothers in different European states is shown in the following table, prepared by Dr. Farr:

Years.	States.	No. of births to a marriage.
1876	Italy,	5.15
1876	Prussia,	4.92
1876	Sweden,	4.84
1876	Holland,	4.83
1876	England,	4.63
1876	Belgium,	4.48
1870	Spain,	4.47
1876	Denmark,	4.24
1876	Austria,	3.73
1876	France,	3.42

The number of births to a marriage is estimated by Dr. Farr, by assuming that the interval between the mean age of marriage and the mean age of mothers, in England, is 6 years. In this way he estimates the number of births to a marriage, in 1874, by dividing the legitimate births for that year by the average number of marriages in the three years 1867–1869 = 4.57. In 1864 the proportional number was 4.30.

Proportion of Males to Females at Birth.—There is always an excess of male children at birth, more marked in some countries than in others, but giving an average result of about 104½ males to each 100 females. The following table is taken from Newsbolme's "Vital Statistics," p. 62, and shows the proportion of male to female births during the ten years, 1870 to 1879, in different European countries.

Country.	Males born to every 1,000 females born.
Italy	1,071
Austria	1,068
France	1,064
Switzerland	1,063
German Empire	1,062
Holland	1,061
Belgium	1,059
Scotland	1,057
Ireland	1,056
England and Wales	1,039

Illegitimacy.—The statistics of illegitimate births must always be somewhat defective, for in addition to the carelessness or ignorance which causes many mothers in wedlock to neglect to register the births of their children, or see that the professional attendant does so, there is the added reason of shame and consequent secrecy. In New York City almost all of the births that are reported as illegitimate occur in public institutions.

The most accurate method of stating the proportion of illegitimate births is to compare the number of such births with the total number of unmarried women of child-bearing ages. A comparison may also be made with the total number of births, or with the total number of the population, as so many per 1,000.

In England, in 1871, the illegitimate births were 5.6 per cent. of the total births registered. In London, the rate varies little, according to the Registrar-General, and is about 4 per cent., of the total births. In New York City, the illegitimate births in 1891, the first year for which an account of them was kept, numbered 1,104 out of 46,904 births, about 2.35 per cent. The following table, from Dr. Farr's thirty-ninth report, is suggestive as regards the causes of illegitimacy: it shows the relation between the illegitimate births and the proportional number of spinsters in different counties in England, the counties being arranged in groups in the order of the rate of illegitimacy.

Groups of counties.	Children born out of wedlock to every 100 births, 1876.	Proportion of spinsters aged 20–40 to every 100 women living at the same age in 1871.
1st group of ten	3.9	36.1
2d group of ten	4.6	37.9
3d group of ten	5.0	39.1
4th group of ten	5.9	38.5
5th group of six	8.0	41.3

Effect of Birth-rate on Age-constitution of Population.—When the birth-rate is high there will be an excess of young people in the community, and of course an excess of infants as compared with communities where the birth-rate is lower. As the mortality of infants is always high as compared with any portion of the community, excepting the very old, it has been maintained by some that a high birth-rate will always be accompanied by a high death-rate. That this is not the case has been conclusively shown by Dr. Farr and Mr. Noel A. Humphreys. This matter will be more fully dealt with hereafter.

III. *Marriages.*—The marriages are not of much importance to the vital statistician from a sanitary point of view, their interest relating chiefly to questions of social and political economy. The methods of estimating the marriage-rate most in use are two, viz.: as so many marriages per 1,000 of the population, and as so many persons married per 1,000; the latter rate being obviously twice as great as the former. Marriages may also be estimated as so many per 1,000 of adult males or of adult females, or as so many per 1,000 of adult unmarried males or females.

The marriage-rate is always higher in urban than in rural communities, partly on account of the practice of very early marriages among the poor, and partly because there is a greater proportion of young people of the marriageable age who are constantly migrating from the country into the towns in search of easier living.

The marriage-rate is considerably influenced by the national prosperity. As Dr. Farr puts it, the frequency of marriages depends largely upon the price of corn. A general tendency in this direction is shown by the following table, showing the marriage-rate and price of wheat in England for several periods of years.

Years.	Marriage-rate.	Price of wheat per quarter.
		s. d.
1838–40	15.6	72 6
1841–45	15.7	54 9
1846–50	16.5	51 11
1851–55	17.2	55 10
1856–60	16.7	53 5
1861–65	16.8	47 5
1866–70	16.4	54 7
1871–75	17.1	54 8
1876–80	15.3	47 6
1881–85	15.1	40 1

A more significant table, illustrating the way in which the marriage-rate is affected by crushing poverty and a wretched environment, is the following table, in which the marriage-rates of England, Scotland, and Ireland are contrasted for a series of years.

Year.	England.	Scotland.	Ireland.
1871	16.7	14.3	10.7
1872	17.4	15.1	10.0
1873	17.6	15.5	9.6
1874	17.0	15.3	9.2
1875	16.7	14.8	9.1
1876	16.5	15.0	9.9
1877	15.7	14.4	9.8
1878	15.2	13.4	9.5
1879	14.4	12.8	8.7
1880	14.9	13.2	7.8
1881	15.1	13.9	8.5
1882	15.5	14.1	8.5
1883	15.4	14.0	8.5
1884	15.0	13.5	9.1
1885	14.4	12.9	8.6
1886	14.1	12.4	8.4
1887	14.2	12.5	8.7
1888	14.2	12.5	8.4

The marriage-rate has been declining, as a rule, in all the civilized countries of the world during the past twenty years. In spite of the vaunted advance in civilization, as statistically shown by the increase of comforts and the growing cheapness of the necessities of life, the

struggle to get along seems somehow to be fiercer, and the effects are vividly shown in this single point. The following table shows the marriage-rates of various European countries since the war of 1866, at intervals of three years.

Countries.	1866.	1869.	1872.	1875.	1878.	1881.	1884.	1887.
Austria	13 0	20.7	18.6	17.1	15.2	16.0	15.7	15.6
Belgium	15.7	14.8	15.5	14.5	13.4	14.1	13.5	14.2
Denmark	16.8	14.7	15.0	17.0	14.8	15.6	15.6	14.0
England&Wales	17.5	15.9	17.4	16.7	15.2	15.1	15.0	14.2
France	16.0	16.5	19.5	16.4	15.1	15.0	15.3	14.5
German Empire	....	....	20.6	18.2	15.4	14.9	15.7	15.6
Holland	16.7	15.4	16 5	16.7	15.5	14.6	14.4	14.0
Hungary	....	....	....	....	18.7	20.0	20.5	17.9
Ireland	10.8	10.0	10.0	9.1	9.5	8.5	9.1	8.7
Italy	11.3	16.0	15.0	16.8	14.2	16.2	16.4	15.7
Norway	....	....	14.0	15.7	14.6	12.8	13.7	12.5
Prussia	15.6	17.9	20.6	18.0	15.7	15 2	16.1	16.0
Scotland	14.7	13.4	15.1	14 8	13.4	13.9	13.5	12.5
Sweden	13.4	11.3	13.9	14.0	12.9	12 4	13.1	12.5
Switzerland	....	14.4	15.7	17.9	14.7	13.6	13.8	14.2

The rates in 1872 are very high in the German Empire and in France, as usually happens after a devastating war, as if nature set herself to work immediately to repair the waste of life. The same phenomenon was noticed in this country after the civil war.

As to the ages of those who contract marriage, the following figures are given by Newsholme for England, corresponding figures for this country not being readily obtainable. Taking marriages and remarriages separately, the mean age of widowers married was 43.8 years; of widows, 40.1; of bachelors, 26.2; and of spinsters, 24.6 years. There has been in England a decided tendency of late years to postpone marriages, as the following table shows:

Year.	Age at marriage, in years.	
	Bachelors.	Spinsters
1880	25.8	24.4
1881	25.9	24.4
1882	25.9	24.4
1883	25.9	24.4
1884	26.0	24.5
1885	26.1	24.6
1886	26.2	24.6
1887	26.2	24.7

The marriage relation is entered into later in life by some classes than by others. Notably the professional men, who spend many years of struggle before they have an income sufficient to justify them in marrying, marry late in life, as shown by the following table, taken from the Registrar-General's report for 1886:

AVERAGE AGES AT MARRIAGE OF BACHELORS AND SPINSTERS IN OCCUPATIONAL GROUPS, 1884-1885:

Occupations.	Bachelors.	Spinsters.	Difference between ages.
Miners	24.06	22.46	1.60
Textile hands	24.38	23.43	0 95
Shoemakers, tailors	24.92	24.31	0.61
Artisans	25.35	23.70	1.65
Laborers	25.56	23 66	1.90
Commercial clerks	26.25	24 43	1.82
Shopkeepers	26.67	24.22	2.45
Farmers and sons	29.23	26.91	2.32
Professional and independent class.	31.22	26.40	4.82

It will be observed that the difference between the ages of husband and wife becomes greater as the age at marriage increases.

In New York City, in 1891, two-thirds of the grooms were under 30 years of age (10,663 out of 15,764), and two-thirds of the brides were under 25 (10,116 out of 15,764). About 3 per cent. of the grooms (460) were under 21 years of age, and 29 per cent. (4,609) of the brides; 431, or a little less than 3 per cent. of the grooms, were over 50 years of age, and only 119, or ¾ of 1 per cent. of the brides.

The following interesting note is made by Dr. Farr about English marriages: "Widowers are more inclined to marry than bachelors. At ages 35 to 40, to every bachelor who married in the three years, 1870–72, 4 widowers remarried; at ages 40 to 45, 5 widowers remarried to every bachelor who married. As age advances this disparity increases, and at ages 50 to 55, the relative proportions were 1 bachelor to 7 widowers; at 60 to 65, 1 bachelor to 8 widowers, and at 65 to 70 the same. These are marriages out of equal numbers."

As to the previous condition of those who marry, of course the great majority are bachelors and spinsters. In New York City, in 1891, they constituted 81 per cent. of the total. More widowers married spinsters than married widows, and more widows married bachelors than married widowers.

Still-births.—So little attention has been paid to still-births that very few statistics have been gathered relating to them. In England they are almost entirely ignored. In France they are mingled in a general hodge-podge with live-born children. And yet, for scientific interest and possible real importance, they certainly deserve more attention than they have received. I quote again from Dr. Farr (twenty-fifth annual report): "The age of man is reckoned from the date of birth, but before that date the fœtus has lived its intra-uterine life, and the instant in which the sperm-cell and germ-cell intermingle is the true time of the embryo's origin. Respecting the rate of embryonic mortality there is little definite information, but it is probable that, as the mortality in the first year of breathing life rapidly increases as we proceed backward from the twelfth to the third, second, and first month, the same law prevails during embryonic life, until we arrive at the destruction of an immense proportion of the spermatozoa and ova which are provided to secure the continuation of the species."

The still-births are probably reported with more accuracy and conscientiousness in the city of New York than in any other large city of the world, so far as can be judged from an examination of their mortality reports.

In the year 1891, 3,414 still-births were reported, being in the proportion of nearly 8 to every 1,000 deaths, and more than 5 to every 1,000 births. This great apparent excess of still-births in New York is due to the fact that the still-births, as reported elsewhere, include, as a rule, only the dead-born of fœtuses of a viable age, *i.e.*, of the seventh month of pregnancy and upward, while the figures for New York include abortions as early as the second month. In 1891, for instance, about 6 per cent. of the total number were earlier than the fifth month, 14 per cent. earlier than the sixth month, and over 26 per cent. earlier than the seventh month, while only 44 per cent. of those reported were born at full term, *e.g.*.

MONTH OF UTERO-GESTATION OF STILL-BIRTHS REPORTED IN NEW YORK CITY IN 1891.

1	2	3	4	5	6	7	8	9	10	Not stated.
..	7	69	142	264	422	487	507	1,508	6	2

More males than females are still-born. This is generally attributed to the fact that the male children, as a rule, have larger heads than the female, and thus parturition is rendered more difficult. The difference, however, is partly accounted for by the fact that, for some occult reason not yet found out, male births of any kind are in excess of the females. According to Newsholme, in the ten years 1865 to 1875, the male still-births were in France, 144 to every 100 females; in Italy, 140; in Belgium, 135; in Sweden, 133, and in Prussia, 129. In

New York, in 1891, the proportion was 137 males to every 100 females.

As regards nationality, in the same year, in New York, the still-births were in the proportion of 10 to every 100 live-births among the children of native parents, and only 6⅞ to the 100 among the children of foreign-born parents.

Sickness.—It is very difficult to procure sufficiently accurate data to enable us to judge well the actual amount of sickness in a community, and yet it is very important from an economical point of view that it should be known. A man who is sick enough to be incapacitated for work is a source of loss to the community until he recovers, and if he is ill enough to require the constant attendance of another person, there is so much additional loss. Most of the statistics we have upon this subject have been obtained from Mutual Benefit associations among workingmen, and from the reports of Army, Navy, and Police Surgeons. Such statistics apply only to male adults, and even then are the statistics of selected lives. From such sources Dr. Farr has estimated that for every death there are two persons constantly sick, or, stating the same thing in another way, there are two years of sickness for every death. He gives the following table regarding sickness and accidents among the laborers in the dockyards at Portsmouth and Woolwich:

	Mean number of workmen.	Days lost by sickness.	Days lost by accidents.	Constantly sick. Per cent.	Constantly suffering from accidents. Per cent.	Constantly ill from both causes. Per cent.
Portsmouth..	5,939	27,410	15,590	1.26	0.73	1.99
Woolwich....	2,243	10,593	8,594	1.29	1.05	2.34

The following table gives the number constantly sick to 100 living at different ages, and has been compiled from various sources by Farr. The statistics refer to members of English and Scotch benefit societies.

AVERAGE NUMBER CONSTANTLY SICK TO 100 LIVING AT EACH AGE.

Ages.	Friendly societies.				
	Scotland (Highland Society).	England (Ansell).	Scotland (Neison).	England (Neison).	East India Company's laborers.
20–30.....	1.14	1.54	1.65	1.69	1.62
30–40.....	1.32	1.83	1.66	1.91	2.06
40–50.....	1.97	2.56	2.44	2.89	2.69
50–60.....	3.60	4.32	5.17	5.21	6.58

The following table is of interest, showing the average loss of time by sickness per annum for males and females. It was prepared in 1884, for Sir James Paget, by the Actuary to the Registry of Friendly Societies, and is quoted by Newsholme:

Ages.	Population of England and Wales. Census of 1881.		Weeks sickness per annum, according to the experience of the Manchester Unity.		Average sickness per individual (per annum) in weeks.	
	Males.	Females.	Males.	Females.	Males.	Females.
15 to 20..	1,268,269	1,278,963	844,428	851,701	.666	.666
20 to 25..	1,112,354	1,215,872	820,183	896,685	.737	.737
25 to 45..	3,239,432	3,494,782	3,224,134	3,476,146	.995	.995
45 to 65..	1,755,819	1,951,713	4,803,760	5,368,229	2.736	2.751
All ages, 15 to 65..	7,375,874	7,941,330	9,692,505	10,592,761	1.314	1.334

These figures are made up from the experience of nearly 400,000 members, and may be considered approximately correct for the community at large. It will be noticed that, contrary to the general opinion, no more time is lost by sickness among the females than among the males, or, at least there is but a very slight excess, and that is entirely after the age of 45, the losses previous to that age being exactly the same in both sexes. The increase in the loss of time, which up to this age is very gradual, takes a sudden leap upward as the turning point of life is reached, and about three times as much time is lost by sickness between 45 and 65 as in the twenty years previous.

The following table shows the average duration of attacks of sickness, and was made up from returns of Scotch friendly societies by Mr. G. P. Neison:

Ages.	Total No. of attacks, including those ending in recovery and in death.	Total amount of sickness, including that ending in recovery and in death.	Average duration of each attack.
		Weeks.	Weeks.
10–15	12	39,428	3,286
15–20	117	749,571	6,407
20–25.....	637	2,830,285	4,443
25–30.....	985	5,483,000	5,566
30–35.....	1,074	5,014,143	4,668
35–40.....	872	4,524,714	5,188
40–45.....	758	4,158,714	5,486
45–50.....	519	3,445,714	6,639
50–55.....	537	6,634,285	12,354
55–60.....	491	7,171,571	14,606
60–65.....	350	9,102,286	26,004
65–70.....	135	5,934,714	43,960
70–75	116	8,867,999	76,448
75–80.....	29	4,588,857	158,236
80–85	19	4,027,000	211,947
85–90.....	0	.....	.....
90–95.....	1	353,000	353,000
	6,652	72,925,281	10,957

The following table is made up from the annual reports of the Police Department of New York City:

Year.	Number of days lost by sickness.	Total number of men in force.	Average number of days sickness to each man.	Average number of cases each day.	Total deaths per annum.	Number of days of sickness to each death.
1888...	31,780	3,328	9.5	87	40	2.2
1889...	34,122	3,398	10.0	93	37	2.5
1890...	39,339	3,502	11.2	108	41	2.6
1891...	45,848	3,623	12.6	126	48	2.6

The figures for 1889, 1890, and 1891 were raised somewhat above what might be considered normal by the prevalence of influenza, which was epidemic throughout the world.

IV. *Deaths.*—By far the most important data of vital statistics are those afforded by the deaths.

Death-rates are calculated in two ways: 1, As so many deaths per 1,000 of the living population; 2, as one death out of a certain number of the population; thus, if a village has a population of 1,000 and has 20 deaths in a year, we may give the death-rate as 20 per 1,000 living, or as 1 in every 50 living. The former method, introduced by Dr. Farr, is the one in most general use.

Besides these general death-rates, there are special death-rates calculated to subserve particular purposes, *e.g.*, to give an idea of the death-rate by sex, age, occupation, or in public institutions, or in proportion to the number of cases of sickness by particular diseases, all of which will be considered in their proper place.

All of these death-rates are usually estimated upon the same principle, which is to divide the number of deaths by one-thousandth part of the number of units to be considered, whether of population, cases of sickness, numbers engaged in any special occupation, etc. Thus, if in

a population of 5,000 there are 100 deaths in a year, the death-rate would equal $\frac{100}{5,000 \div 1,000} = \frac{100}{5} = 20$ per 1,000. In practice it is found to be much more convenient, instead of dividing the denominator by 1,000 (which would be awkward if decimal fractions remained), to multiply the numerator by 1,000, which amounts to the same thing, so that the formula for obtaining the death-rate would be $r = \frac{n \times 1,000}{p}$ where r is the rate, n the number of deaths, and p the population. In most towns which issue weekly mortuary reports, a weekly death-rate is given. These rates are really annual rates, and are supposed to indicate what the annual death-rate would be if the same number of persons died every week in the year. The total number of deaths in the week are therefore multiplied by the number of weeks in the year, which gives the total number of deaths that would occur in a year if the same rate of mortality continued throughout the year. The annual death-rate is then calculated in the manner previously described. In many towns the weekly deaths are multiplied by 52 in making out the death-rate, and this would be correct if there were just 52 weeks in the year. But there are 365.24226 days in the year, which is equal to 52.17747 weeks, and this is the multiplier used by the Registrar-General of England and in many places in this country. Thus, if a city contains 753,862 inhabitants and the total number of deaths for a week is 367, the death-rate would be equal to $\frac{367 \times 52.17747 \times 1,000}{753,862} = 25.4$.

These calculations are most easily and rapidly made by the use of logarithmic tables. It is the usual practice to make this estimate upon the mean population of the year, or the population in the middle of the year. It is evident that this makes the death-rates during the first six months a little smaller than they should be, as the population is really less than the number used in the estimate, and it makes the rates for the latter half of the year a little too large, for the real population is larger than that used in the estimate. In New York, it has been the practice for many years to divide the total increase of population for the year by the number of weeks in the year, so as to get the amount of weekly increase, and this is added week by week. A similar weekly addition to the population is made in Berlin, but there the estimate can be made with a fair degree of accuracy on account of the excellent police arrangements for keeping account of immigration and emigration, and the perfect system of registration of the births and deaths. As a matter of extreme refinement, the weekly increase might be calculated by extracting the 52.17747th root of the annual rate, but this would be a ridiculous attempt at accuracy; for, while theoretically correct, practically it would be useless, for the weekly death-rates are, in any event, of small value, excepting for comparing one year, or one season, with another in the same town. For purposes of comparing different towns with one another, they are practically of little value, on account of what mathematicians call the probability of error. This is greater in proportion as the number of data dealt with is smaller, and in the small number of deaths usually reported for a week, the mean or probable error is considerable. The mathematical formulæ for estimating the probable error are rather abstruse, but in the case in hand the mean or probable error may be considered to equal very nearly the square root of the number of deaths. This gives results that are somewhat too large, but is near enough to the truth to serve for ordinary calculations.

Thus, for example, in the instance already cited, how much might the death-rate vary from 25.4 without indicating any radical change in the sanitary condition of the town? Upon the supposition that the deaths were 367, the square root of which is 19, the deaths for the week might be either 386 or 348, without indicating any especial change in the sanitary condition of the town. This would mean a range of death-rate between 24.1 and 26.7. Dr. Billings, in the Cartwright lectures for 1889, gives the following illustration: "Suppose that in a village of 1,000 inhabitants there occur 25 deaths in the course of a year, and in a neighboring city of 10,000 inhabitants, there were 200 deaths in the same time. What is the probability that the death-rates of 25 per 1,000 for the first, and 20 per 1,000 for the second, indicate the relative healthfulness of the two places, supposing the data to be perfectly accurate, and that we have no other information in regard to them than that stated? The probable error for the village of 1,000 inhabitants, for 25 deaths, would be 5, and therefore the mortality in this place might vary between 20 and 30 per 1,000 without any certain indication of variation in the sanitary conditions of the place. In the city of 10,000 inhabitants, the probable error is a little less than 15, the variation between 185 and 215 corresponding to an average mortality of 18.5 to 21.5 per 1,000, there being a probable variation of only 3 per 1,000 instead of 10, as in the first case. It is very clear, then, that in comparing these two mortality-rates, no positive conclusion can be drawn as to the relative healthfulness of the two cities, seeing that the probable variations overlap, as it were, for the rates ranging from 20 to 21.5." General death-rates also, while not altogether meaningless in comparing the healthfulness of one town with another, are very misleading, unless the age-constitution of the populations of the two towns is similar. A marked difference in this respect may give rise to the singular paradox, that a city which is actually healthier than another may have a higher death-rate. This depends upon the fact that the death-rate is very much higher at some ages than at others. The mortality of infants under one year of age is very great, and also of people over sixty years of age, while the mortality of children between ten and fifteen is exceedingly low, and that of adults between twenty and forty is but little higher. Now, as the age-constitution of the inhabitants of different cities is seldom the same, it follows that in comparing the sanitary condition of one city with another, by means of the death-rate, the age-constitution has to be taken into account. The varying ages of the populations affect the result in precisely the same way as the varying amount of the components of a mixture affect the price of a compound, as explained under "alligation" in the common arithmetic. Different kinds of sugar, at different prices, may be mingled in different proportions so as to make mixtures of various prices. Let the following serve as an illustration: Suppose two cities, A and B, to have 100,000 population each. In A the death-rate for a particular year is 17.28 per 1,000, and that of B for the same year is only 16.70. Is B therefore in a healthier sanitary condition than A? Such a conclusion is often accepted as justified, but the table below will show that the reverse might be the case in certain contingencies. Of course, in preparing a schematic table like this, the age-proportions are a little forced and exaggerated, in order to bring out the salient points as boldly as possible, and do not represent in themselves the probable age-constitution of any actual community.

Age.	Number at each age.		Deaths per 1,000 at each age.		Total deaths at each age.	
	A	B	A	B	A	B
Under 5.....	25,000	15,000	60	70	1,500	1,050
5 to 14.....	22,000	20,000	8	10	176	200
15 to 24.....	20,000	25,000	7	8	140	200
25 to 44.....	24,000	30,000	18	20	432	600
45 to 64.....	7,000	8,000	40	50	280	400
65 and upward...	2,000	2,000	100	110	200	220
	100,000	100,000			17.28	16.70

Thus it is shown that, owing to a smaller population at the ages when mortality is high and a larger one at ages when the mortality is low, the death-rate for all ages, *i.e.*, the general death-rate as usually calculated, is less in B

than in A, although the death-rate at each age is considerably higher, and therefore the sanitary condition of the place must be considered inferior.

General death-rates, therefore, although valuable for estimating the varying condition, as regards health, of the same community in different years and different seasons, because the age-constitution of such a community remains virtually constant for considerable periods, must be used with reserve in comparing different communities, unless accompanied by a statement of ages, etc., which will enable the proper corrections to be made.

A similar source of error lies in the varying proportion of the sexes in different communities. The death-rate of males is always higher than that of females at each age, excepting for a few years before and after puberty, and the general death-rate of males is always highest. The following table shows the average annual death-rates of males and females in England at certain ages for a period of fifty years, viz., from 1838 to 1888:

	Under 5.	5 to 9.	10 to 15.	15 to 19.	20 to 24.	25 to 34.	35 to 44.
Males	69.5	7.8	4.4	6.1	8.2	9.4	13.0
Females	59.7	7.5	4.5	6.6	7.8	9.4	12.0

	45 to 54.	55 to 64.	65 to 74.	75 to 84.	85 and upward.	All ages.
Males	18.9	32.8	67.7	147.6	313 1	22.7
Females	15.6	28.0	59.9	134 2	287.7	20.5

If now the population of A consists of 40,000 males and 60,000 females, and the population of B of 60,000 males and 40,000 females, assuming the general death-rates per sex to be given above, there would be a general death-rate of 21.44 in A and of 21.86 in B, the difference being due solely to the difference in sex-distribution. An excess of females, therefore, in any town, tends to lower the death-rate, and an excess of males to raise it.

It is evident that, in order to make proper comparison between different towns by means of the general death-rates, some method must be devised by which these rates may be corrected, so as to allow for the effect of a different age and sex distribution of the population. The following method is used by the English Registrar-General in his annual reports. In the first place he adopts as a standard death-rate the death-rate at all ages calculated upon the supposition that the rate at each age-period in each town was the same as in England and Wales during the last previous inter-censal period of ten years. The following table, taken from Newsholme, shows the method of obtaining the standard death-rate for the city of Brighton.

Ages.	Mean annual death-rate for England and Wales. 1871 to 1880.		Population of Brighton in 1881.		Calculated number of deaths.	
	Males.	Females.	Males.	Females.	Males.	Females.
Under 5	68.14	58.10	6,213	6,371	423.35	370.16
5 to 9	6.67	6.20	5,655	5,533	37.70	34.30
10 to 14	3.69	3.70	5,294	5,447	19.53	20.15
15 to 19	5.23	5.43	4,480	6,512	23.43	35.36
20 to 24	7.32	6.78	4,326	6,398	31.67	43.37
25 to 34	9.30	8.58	7,217	9,927	67.12	85.17
35 to 44	13.74	11.58	5,356	7,305	73.59	84.59
45 to 54	20.05	15.59	3,910	5,552	78.40	86.55
55 to 64	34.76	28.54	2,707	3,988	94.09	113.82
65 to 74	69.57	60.82	1,409	2,343	98.02	142.50
75 and upward	169 08	155.83	631	974	106.69	151.78
			47,196	60,350	1053.59	1167.75

Now, the total population being 107,546 and the total number of calculated deaths being 2221.34, the death-rate will be 20.66, which constitutes the "standard death-rate" for Brighton in 1881. But the general rate for England and Wales, in 1871 to 1880, was 21.27, and the rate for Brighton being lower, shows that the age and sex distribution of the population was more favorable to a low mortality than in the whole of England and Wales; and in fact it is found by comparison, that the proportion of the population living of the ages when the mortality is high, is lower in Brighton and vice versa, *e.g.*:

Age, Distribution of Population, 1881.

	All ages.	Under 5.	5 to 9.	10 to 15.	15 to 19.	20 to 24.
England & Wales.	1,000	136	120	108	98	90
Brighton	1,000	117	104	100	103	99

	25 to 34.	35 to 44.	45 to 54.	55 to 64.	65 to 74.	75 and upward.
England and Wales	146	113	84	59	33	13
Brighton	159	118	88	62	35	15

The difference in the death-rate, it is readily seen, is due to a smaller number of persons under fifteen, and a larger number above that age. In order now to compare the death-rate of Brighton with that of other towns, its rate must be increased in the ratio of 20.66 to 21.27, *i.e.*, by 1.0296. This is called the factor for correction for age and sex distribution by which the death-rate of Brighton must be multiplied in any year in order to make it comparable with that of England and Wales, or with other towns whose rates have previously been corrected in the same manner. This standard death-rate, once obtained, is found to hold good throughout the decennium, until another census renders it possible to substitute a new one.

In this way a table is prepared which shows what the death-rate of each town would have been in any year, if the age and sex distribution of its population had been the same as that of the entire population of England and Wales. A portion of such a table is given below:

Towns.	Standard death-rate.	Factor for correction for age and sex distribution.	Recorded death-rate.	Corrected death-rate.
Brighton	20 66	1.0296	16.88	17.38
Hull	20.62	1.0316	19.25	19.86
London	20.04	1.0615	19.57	20.77
Birmingham	19.95	1.0663	19.72	21.03
Bristol	20.55	1.0351	20.39	21.11
Leeds	19.90	1.0689	21.06	22.51
Sheffield	19.78	1.0754	21.60	23.23
Cardiff	19.60	1.0853	21.92	23.79
Liverpool	19.39	1.0971	23.70	26.00
Manchester	19.09	1.1143	28.67	31.95

As remarked by the Registrar-General (Annual Summary, 1883), "It may naturally be asked, of what use are the general death-rates, as usually given, if they cannot be accepted without further and considerable correction? In the first place, if the death-rate in any given town or area in one year be compared with its death-rates in other years, no correction is required; for the age and sex distribution in an individual town or other area remains practically constant; and, secondly, although it is doubtless true that the general death-rates of towns or other areas cannot safely be used for accurate comparison between such towns or areas in respect of healthiness without further correction, yet they serve as a very valuable approximate indication; for if the column 3 be compared with column 4, it will be seen that whether the towns be arranged according to their recorded or according to their corrected death-rates, the order will scarcely be changed. The correction simply alters the amount of difference between the towns, leaving the position in which they

stand to each other but slightly changed." (Quoted by Newsholme.)

It is found in England that correction of the death-rates in this manner, as a rule, raises the death-rates of towns, and diminishes those of the rural districts, thus emphasizing the fact that the constant immigration into the towns tends to swell the number of the population at the ages when the mortality is lowest.

Newsholme quotes from Dr. Ogle a comparison of this sort made between two countries. In 1881 the general death-rate in England and Wales was 18.9 per 1,000 of all ages, while the general death-rate in France was 22.0, *i.e.*, 3.1 higher than England. But had the age-distribution of the French population been identical with that of the English population, the French general death-rate would have been 20.9, and not 22.0. Thus of the 3.1 difference between the two rates, 2.0 was due to difference of health condition, and 1.1 was due to difference of age-distribution.

Effect of Birth-rate upon Death-rate.—It has been already mentioned under Births, that a high death-rate among infants is generally followed by a high birth-rate, because the intervals of child-bearing become shorter, it being the practice with many, perhaps the majority of mothers, among the poor especially, to suckle their infants as long as possible in order to avoid pregnancy. On the ground that a high birth-rate results in a greater proportion of infants in a given population, and that the mortality among infants is very high even under the most favorable circumstances, it has been held, especially by Dr. Letheby and his supporters, that a high birth-rate always means a high death-rate, and as a high birth-rate is taken as an index of prosperity, being intimately connected with a high marriage-rate, it has also been maintained with great vigor that a high death-rate was an indication of the prosperity of the community. Dr. Farr, however, in the celebrated discussion which took place on this question, showed conclusively that a high birth-rate results in a low death-rate, because the constant addition of so many children to the population prolongs its effects over into the ages when the mortality is lowest, and so eventually produces an age-distribution of the population, in which there is a great excess of persons at the very healthiest time of life.

In the Cartwright lectures Dr. Billings has estimated the effect of a constantly high birth-rate in the following manner: "Starting with a population numbering in all 308,378, supposing that there are no migrations, we will calculate the progress of such a population for one hundred successive years, under two suppositions: the first for a constant birth-rate of 35 per 1,000, and the second for a constant birth-rate of 45 per 1,000. The death-rate at the commencement, say, is 32.42 per 1,000. Under the influence of a constant birth-rate of 35 per 1,000, this death-rate will increase during the first period of five years to 33.17, and after that steadily sink until, at the end of fifty-five years, it becomes less than the original death-rate, and at the period of sixty-five years will sink below it; after which it again rises until, at the end of one hundred years, it has reached the rate of 32.44.

"Taking now the same population, under the same circumstances, at a constant birth-rate of 45 per 1,000, we see that the death-rate rises in the first five years to 36, after which it steadily sinks as it did in the former case, until, after the lapse of sixty years, it is only 32.01, after which it again rises, and finally comes down to a point a little below that from which it started. In both these cases, then, it is evident that the high birth-rate for a time produces an increased death-rate, since there are no other circumstances present to account for the change. But after the first five years the proportion of those living at the ages at which there is the lowest mortality has been so much raised as to more than counterbalance the large numbers living in the first years of life, and, therefore, the death-rate steadily descends.

"But, to understand the full effect of this change it is also necessary to consider the average age at death. Taking the average age at death at 31.37, it will decrease to 29.65 under the influence of a constant birth-rate of 35 per 1,000; while, with the higher birth-rate of 45 per 1,000, it will diminish as the death-rate diminishes to the age of sixty-five, at which period it will be only 23.02, after which it will again rise as the death-rate increases."

Effects of Immigration.—The tendency of immigration is to lower the death-rate, because the majority of immigrants are men and women of mature years and of the most vigorous period of life. They are people who, as a rule, have the greater part of their lives before them, and if they come in sufficient numbers to form an appreciable proportion of the population, the death-rate is materially lowered. For this reason, among others, the death-rate of cities does not fairly represent their true sanitary condition, because there is a constant influx into them of young men and women from the country, of just the healthiest age, who are seeking their fortunes either in industrial or professional pursuits, or in domestic service. The death-rates of cities would be much higher than they are, if the increase in size was due solely to the excess of births over deaths. The same cause tends to increase the death-rate in countries and localities from which the emigration takes place, because they are continually losing the most vigorous and healthy individuals, leaving the population with an excess of persons of the ages when the mortality is highest, viz., the very young and the very old.

Climate.—The effect of climate on the mortality is very marked. In an equable climate, where changes of temperature are very gradual, and the extremes are not widely separated, the death-rate, other things being equal, will be much lower than where such changes are sudden, and the range of temperature is very great. Such contrasts of temperature are well shown in the cities of England as compared with the cities of the Northern United States. In London, a temperature of 90° F. in summer, or of zero in winter, is practically unknown, while in this country such temperatures may be expected every year. The following table shows this very clearly:

TEMPERATURES IN LONDON AND NEW YORK IN 1888.

	London	Month.	New York.	Month.
Highest day temperature	87.7°	August	96°	June
Lowest night temperature	18.4°	Feb.	0°	Jan.
Average for year of the maximum temperature by months	67.7°		73.5°	
Average for year of the minimum temperature by months	32.0°		27.7°	
Average of monthly means of daily maximum temperature	55.8°		74.7°	
Average of monthly means of daily minimum temperature	41.3°		30.3°	
Mean monthly temperature averaged for year	47.7°		49.33°	
Highest monthly mean	59.1°	August	72.56°	August
Lowest monthly mean	35.0°	Feb.	22.97°	Jan.

The effect of such a climate is shown in the figures of seasonal mortality. In England the summer months are the healthiest of the year, while in New York they are the deadliest, as shown in the following table;

Place.	Year.	Death-rates.			
		First quarter.	Second quarter.	Third quarter.	Fourth quarter.
England Urban Districts	1881	22.6	19.2	18.3	20.2
New York City	1881	29.14	30.40	35.07	28.83

In London, and, in fact, in Western Europe generally, deaths from thermic fever or sunstroke are very uncommon, while in the northern cities of the United States the reverse is the case. In New York City there have been as many as 320 in a year, and 68 in a single day. Such extreme heat is accompanied by a great mortality from diarrhœal diseases, especially among infants. It also causes indirectly the death of hundreds of persons who have been enfeebled by disease, and who, but for

the heat, might have recovered, or at least had their lives considerably prolonged. In London the fogs of November cause a greatly increased mortality from diseases of the respiratory organs, while in this country it is the most healthy month of the year.

Effect of Season.—It has been found that the prevalence of different diseases varies very greatly with the season. Some, like typhoid fever, are most prevalent in the autumn; others, like diarrhœal diseases, and especially cholera infantum, in the summer; some, especially the exanthematous diseases, in the winter and spring; while the hot weather is particularly fatal to the young, and cold weather to the aged. The following table shows the relative prevalence of certain diseases at different seasons of the year. (J. Netten Radcliffe, in Quain's "Dict. of Medicine," Art. Periodicity in Disease.)

	Winter.			Spring.			Summer.			Autumo.		
	Jan.	Feb.	Mch.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Small-pox	+	+	+	+	±	+	−	−	=	−	−	−
Measles	+	−	−	−	+	±	+	−	−	−	+	±
Scarlet fever	−	−	−	−	−	−	−	+	+	±	+	+
Diphtheria	+	+	−	−	−	−	−	−	+	±	±	±
Wh'p'g-C'gh	+	+	+	+	+	−	−	=	=	=	−	+
Typh'd fever	+	+	−	−	−	=	−	+	+	+	±	+
Dysentery	−	−	−	−	−	=	+	+	±	+	−	−
Diarrhœa	−	−	−	−	−	−	±	±	+	−	−	−
Rheumatism	+	+	+	+	+	−	−	−	−	−	+	+
Phthisis	+	+	+	+	+	−	−	−	−	−	−	+
Heart disease	+	+	+	+	−	−	−	−	−	−	+	+
Pneumonia	+	+	+	+	−	−	−	=	−	−	+	+
Bronchitis	±	+	+	+	−	−	−	=	−	−	+	+
Old age	±	+	+	+	−	−	=	−	−	−	−	+

\+ Above the average. ± Maxima. − Below the average. = Minima.

It is also to be noted that some diseases appear to recur after a certain number of years have elapsed, with some regularity, especially the contagious and infectious diseases. Thus it has been noticed in New York City, that scarlet fever and diphtheria, although more or less prevalent all the time, tend to reach a maximum every 3 or 6 years, *e.g.*, there were maxima of scarlet fever in 1870, 1873, 1879, 1882, 1888, and 1891, and of diphtheria in 1869, 1875, 1878, 1881, and 1887. This is undoubtedly partly due to the fact that the persons who are susceptible to these diseases are gradually attacked by them, as they become more and more prevalent, until all of the susceptible material has been exhausted, or the susceptible persons are so widely separated that there is no opportunity for the operation of the ordinary laws of infection. But, by birth and growth every few years, so many new susceptible persons are added to the community, that the distances between the centres of contagion are bridged over, so to speak, and new epidemics are started. So, too, as the epidemics of Asiatic cholera are often attributed to the Mecca pilgrimages, and as those occur annually, there should be a spread of cholera westwardly every year, instead of at long intervals, unless some influence is at work which is not yet recognized.

Public Institutions.—It is evident that if the deaths in public institutions are charged to the locality in which the institutions are situated, the death-rate of that locality will be considerably higher than that of the region round about it. The deaths in such houses, therefore, must be redistributed to the districts from which the patients came, and this is quite commonly done. But there are many deaths in public institutions which cannot be referred back to a former residence in which the disease may have been contracted, and they must be accounted for in the final estimation of the death-rate in some other way. Such are deaths in foundling asylums, in maternity hospitals (of children who were born in the hospital), of many inmates of almshouses, who have lived in them for many years, of old people whose only home for a long period has been a home for the aged, etc. These various sources of error would seem, at first sight, to vitiate local death-rates in a high degree, and so they would if they were left entirely uncorrected. The best way would seem to be to redistribute the deaths, so far as is possible, to the places from which the patients came to the institution; but if this is done, the population of the institutions should also be redistributed in the same way. This is not always possible, and if it were there would remain a certain proportion of population and deaths that could not be redistributed. This proportion is always comparatively small, and can be best disposed of by redistributing the population to the different districts or subdistricts in proportion to their population, and then also redistributing the deaths to the same localities proportionately to the number of deaths in each.

In the United States, where it is so difficult in many cases to procure the necessary information regarding the inmates of institutions, probably the best way would be to reapportion the total population and deaths of public institutions in the manner above indicated, without any attempt at making an accurate redistribution. The possible error in such case would be very small, although a certain proportion of the inmates of the institutions and of the deaths in them would, of necessity, be added to the population and deaths of some sections of a large city, largely occupied by the wealthy people, who, as a matter of fact, have hardly anything to do with the public institutions, excepting as patrons.

Effect of Race.—The death-rate, both general and special, is seriously affected by race or nationality. Some nationalities are especially prone to certain diseases, and if the sanitary environment favors these diseases, as for example overcrowding favors phthisis and diarrhœal diseases, the mortality of those who are most susceptible may greatly exceed that of those who are least susceptible. The following table shows the death-rate of various European nationalities for several years:

	Average 20 years. 1861 to 1880.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
Austria	31.1	30.8	30.1	29.4	30.1	29.4	28.8	29.2	27.3
Belgium	22.8	20.2	20.8	20.9	20.1	21.1	19.3	20.1	19.1
Denmark	19.7	19.3	18.4	18.4	17.9	18.2	18.3	19.7	18.6
England, Wales,	21.9	19.6	19.5	19.5	19.0	19.3	18.8	17.8	17.9
France	23.6	22.2	22.2	22.2	21.9	22.5	22.0	21.8	20.5
German Empire	26.9 (9 yrs.)	25.7	25.9	26.0	25.7	26.2	24.2	23.8	23.8
Holland	24.7	20.7	21.8	22.2	21.0	21.8	19.7	20.4	20.1
Hungary	36.1	35.3	32.0	30.8	31.6	31.4	33.5	31.7	....
Ireland	17.5	17.4	19.2	17.6	18.4	17.9	18.3	18.0	17.5
Italy	20.0 (18 yrs.)	27.5	27.5	26.7	26.6	28.3	27.5	26.8	24.9
Norway	16.9 (10 yrs.)	18.4	17.1	16.4	16.5	16.1	16.0	16.9	17.4
Prussia	26.8	25.4	25.6	25.7	25.4	26.1	23.9	22.9	23.2
Scotland	21.9	19.3	20.1	19.4	19.1	18.6	18.7	17.6	18.0
Sweden	19.2	17.4	17.3	17.5	17.8	16.6	16.1	16.0	....
Switzerland	23.6 (11 yrs.)	21.9	20.4	20.2	21.3	20.7	20.2	19.9	20.3

The differences in the death-rates in this table are, of course, not entirely due to the difference of nationality, but this undoubtedly has some effect, for it is shown in other ways. In the United States census for 1880, a table is given from which the following is an extract:

Cause of death.	Death-rates per 1,000 deaths from all causes.			
	White.	Colored.	Irish parentage.	German parentage.
Alcoholism	2.5	0.7	6.7	2.7
Cancer	19.1	7.8	24 3	25.8
Consumption	126.2	139.1	198.4	123.6
Croup	26.1	21.8	15.1	23.2
Diphtheria	39.8	17.4	42.1	72.7
Diseases of nervous system	119.1	96.9	94.7	109.4
Heart disease and dropsy	58.1	64.5	62.3	60.9
Malarial fever	30.7	48.3	12.9	14.1
Measles	9.1	17.7	5.3	8.5
Pneumonia	82.5	105.5	89.1	82.1
Scarlet fever	20.9	3.9	24 0	30.1
Suicide	3.2	0 5	2.7	7.2
Typhoid fever	33.9	31.7	17.4	29.6

Vital Statistics.

The greater liability of the Irish to phthisis and of the Germans to diseases of the nervous system, appears plainly here, as in every table of the kind that is constructed. The tendency of the Germans to commit suicide is also well known, appearing by this table to be about three times as strong as that of the Irish. In the mortality statistics of New York City, some of these tendencies are even more plainly indicated. Thus the numbers of Irish and Germans in the population are pretty evenly balanced; *e.g.*, in 1880 there were 198,595 Irish and 163,482 Germans, a difference of about twenty per cent., and there is no reason to suppose that this ratio has changed in any great degree since. If it has changed, the change has probably been in the direction of an increased proportion of Germans, making these two elements of the population more nearly equal than before. Now, in 1891, there died of phthisis 1,204 Irish, and only 663 (a little more than half as many) Germans; while of diphtheria there died 6 Irish, and 20 Germans. Out of 300 deaths by suicide, only 27 were Irish, and 106 (more than one-third of the entire number) were Germans. This proneness of the German to commit suicide when he is dissatisfied with the way things are going, is probably not altogether a blood defect, due to a more saturnine temperament, but is partly owing to his less religious nature. The figures first given apply only to the foreign-born, but the offspring of Irish and German parents show the same tendencies. For example, in the same year, 1891, the deaths from phthisis of the children of Irish parents numbered 2,158, against 1,009 of German; the deaths from diphtheria were 240 of German parentage, against 167 of Irish; and the deaths from suicide were 115 of German, against only 40 of Irish parentage. Italians show a marked susceptibility to acute diseases of the respiratory organs, and also to measles, which seems to be especially fatal to children of Italian parentage.

The general death-rates according to nationality, for New York City, are not yet available from the census of 1890, but the census of 1880 gave the following results:

Nationality.	Population.	Deaths.	Death-rates.
Austro-Hungary	8,844	126	14.25
Belgium	556	47	84.53
Bohemia	8,093	75	9.27
British America	7,004	148	21.13
China	747	16	21.42
Denmark	1,096	24	21.90
France	9,910	157	15.84
German Empire	163,482	3,258	19.93
England	29,664	621	20.93
Ireland	198,595	5,565	28.02
Scotland	8,683	191	22.00
Holland	1,860	34	18.28
Italy	12,223	265	21.68
Russian Poland	13,571	131	9.65
Spain	669	14	20.93
Sweden	3,194	77	24.11
Switzerland	4,545	102	22.44
Total population	1,206,299	31,937	26.47

The comparatively low death-rate for most of the foreign-born is chiefly due to the fact that so large a proportion of them are adults, mostly between the ages of fifteen and fifty, when the mortality is low. As New York is composed in great part of such elements, it is plain that the death-rate of that city is much lower than it actually should be, and does not properly represent its sanitary condition.

In 1890 a tenement-house census was taken of the city of New York, and the results, as published in the Annual Report of the Health Department for 1891, threw some light upon the mortality-rates as regards nationality. Although the nationality of tenants was not taken in the census, the population was divided up into small districts in such a way as to give the death-rates of considerable masses of people, who were almost entirely of one nationality or race. Thus the district between the Bowery and Norfolk Street, bounded north and south by Grand and Division Streets, is inhabited almost exclusively by Russian Jews, and the death-rate in the population of 35,190 was only 61.15 for children under five years of age, and 7.59 for persons five years old and upward. In a portion of the Fourth Ward chiefly occupied by Italians, the death-rate of children under five was 119.02, and of persons five years old and over, 21.29. In special diseases, also, the death-rate of the Russian Jews was unusually low, exhibiting in a striking light the strong vitality of the race, which may be due partly to their frugal and abstemious way of living, as well as to the inherent race vigor.

Effect of Marriage.—The statistics most frequently quoted upon this point are those of Dr. Bertillon, compiled from the reports of France for a series of years, which seem to show that marriage has a very beneficial effect as regards longevity on both the man and the woman. The following table from Newsholme is taken from Dr. Bertillou's figures for the years 1856–1865, a period of ten years.

Death-rate per 1,000 Living of Married and Unmarried.

Ages.	Males.			Females.		
	Single.	Married.	Widowers.	Single.	Married.	Widows.
20–24	12.88	8.92	49.60	8.32	9.92	12.31
25–29	10.17	6.24	21 84	9.02	8.98	23.62
30–34	11.51	6.82	19.17	9.87	9.36	16 90
35–39	13.15	7.52	17.50	10 87	9.29	15.03
40–44	16.62	9.55	18.89	13.28	10.14	12.73
45–49	19.60	11.47	22.20	15.71	14.69	13.30
50–54	25.80	15.61	26 80	20.97	19.11	15.20
55–59	32.10	21.50	34.17	26.90	19.29	24 47
60–64	45.92	32.60	47.50	40.52	30.75	37.07
65–70	58.50	44.80	62.97	58.30	45.30	53.50

This table gives some curious results. The mortality of married men and women as will be seen, is lower than that of bachelors and spinsters at every age period, and also much lower, as a rule, than that of widowers and widows. The mortality of widowers is higher than that of bachelors at every age, while that of widows is higher than that of spinsters up to the age of forty, after which it becomes lower. The extraordinary death-rate of widowers under twenty-five, which also showed itself in a similar manner in a previous table quoted by Dr. Farr, must be due to insufficient data, for the number of widowers at so young an age must be very small.

It has been objected to these statistics, that although they prove the greater healthfulness of married persons, they do not and cannot prove that this greater healthfulness is due to the permanent association of the man and the woman in the same home. It must be borne in mind that, at the start, it is the stronger, more vigorous, and independent of the race who marry, while the bachelors are often lacking in the qualities that attract a mate, and so, by a process of natural selection, the stronger ones are chosen to perpetuate the race. Then married men generally lead more domestic lives, keep more regular hours, and in various ways live under healthier conditions, entirely unconnected with the sex-relation.

Occupation.—The most successful investigations, with regard to the effect of occupation on health and on the death-rate, have been made on a limited scale by private individuals. In the taking of a census it is impossible to procure the minute information which is necessary in order to have particulars about occupations of much value. The name printer may include pressmen or compositors, who are exposed in the prosecution of their trade to very different influences. The word merchant also may include persons whose life, on the whole, is an easy one, and those who are daily harassed by petty detail work, very exhausting and unsatisfactory. The physician may either be a city specialist, with fixed office hours and considerable leisure time, or the head of a public institution, with a fixed income and spacious and sani-

tary surroundings, comparatively free from care and with only moderate responsibility, or he may be practising in the country, obliged to take long journeys over rough roads, often in stormy weather, irregular in his hours of sleep and eating, and early worn out. Moreover, in a country like this, where there is much shifting about from one occupation to another, many men passing the latter half of their lives in an entirely different occupation from the first half, another element of uncertainty is introduced. Then, too, there is in every country the lack of precise data due to the graduation of the individual from one rank in his business, trade, or profession to another. It is inevitable, for instance, that the longevity of professors should be greater than that of students, or that proprietors of any kind, manufacturers, the presidents of large corporations, etc., should be older, on the average, when they die than those employed under them, because of the comparatively few young men among them, whose early death among employees tends to reduce the mean age at death. So with seamstresses and domestic servants of all kinds, especially females, who often leave that occupation when they marry. So that any classification of female workers of any kind is liable to contain an unusual excess of young people, when compared with like occupations among males.

Special investigations, however, have been made in this direction, notably in England, where Dr. Farr carefully compiled a table showing the death-rates for several selected occupations, with proper precautions to avoid, as far as possible, all known sources of error. Dr. Farr's figures covered the years 1860–1861, and 1871. Dr. Ogle has since compiled similar statistics for the three years 1880–1882. The two sets of results are here given (taken from Newsholme).

MEAN ANNUAL DEATH-RATES PER 1,000 LIVING.

Occupation.	1860–1. 1871. Ages.		1880–1–2. Ages.	
	25 to 44.	45 to 64.	25 to 44.	45 to 64.
Clergymen	5.96	17.31	4.64	15.93
Gardeners	6.74	17.54	6 52	16.19
Farmers	7.66	17.32	6.09	16.53
Schoolmasters	9.82	23.56	6.41	19.98
Fishermen	11.26	15.84	8.32	19.74
Carpenters	9.44	21.36	7.77	21.74
Lawyers	9.87	22.97	7.64	23 13
Tanners	10.43	26.57	7.97	25.37
Shoemakers	10 39	22 30	9.31	23.36
Drummers (comm.)	12.28	29.00	9.04	25.03
Bakers	10.72	26.39	8.70	26.12
Bricklayers	11.43	27.16	9.25	25.59
Blacksmiths	10.07	23.88	9.29	25.67
Tailors	12.92	24.79	10.73	26.47
Printers	13.02	29.38	11.12	26.60
Physicians	13.81	24.55	11 57	28.03
Butchers	13.19	28.37	12.16	29.08
Plumbers	12.48	34.66	11.07	32.49
Cutlers	11 88	32.74	11.71	34.42
Brewers	19.26	36.86	13.90	34.25
Cab drivers	15.94	35.28	15.39	36.83
Liquor dealers	18.01	34.14	18.02	33.68
File-makers	16.27	42 30	15.29	45.14
Street peddlers	20.09	37.82	20.26	45.33
Laborers (city)	18.35	40.64	20 62	50.85
Hotel servants	21.91	42.19	22.63	55.30

When we come to discuss the relation of special diseases to occupation, the problem becomes still more difficult, on account of the enormous amount of data to be sifted and compiled. Accordingly the most that can be done is to take a comparatively small list of occupations and a small number of the most prominent causes of death, and make up a table by combining them. Moreover, it is exceedingly difficult to obtain accurate information with regard to such causes of death as alcoholism and syphilis, on account of the tendency to give the results of these causes, without mentioning the cause, out of sympathy with the surviving members of the family, who do not like to have the true cause spread upon the public records. The real cause of death, as influenced by the occupation, has to be in a measure inferred, as it may be from the following table from Dr. Farr's supplement to the Registrar-General's thirty-fifth annual report.

ANNUAL RATES OF MORTALITY PER 1,000, AT FOUR AGES AMONG CLERGYMEN, PROTESTANT MINISTERS, AND AMONG PUBLICANS AND WINE MERCHANTS.

Ages.	Clergymen.	Protestant ministers.	Publicans, beer sellers, wine and spirit merchants.
25–34	4.65	5.83	14.49
35–44	6.28	7.30	20.44
45–54	13.24	9.33	28.59
55–64	22.70	24.60	43.03

"Dr. Ogle's figures for 1871–80 show that the mortality from liver diseases (perhaps the most trustworthy test of alcoholic excess) is six times as high among innkeepers and publicans, and two and a half times as high among brewers, as among the generality of males." (Newsholme.)

Of other poisons giving rise to special forms of chronic disease, the most prominent, next to alcohol, is lead. Four occupations, according to Newsholme, especially expose workers to lead-poisoning, viz.: plumbers, painters, earthenware-makers, and file-cutters. During the four years 1879–82, 229 deaths of males were ascribed to this cause, distributed among various occupations as follows:

House-painters	91	Iron-moulders	2
Plumbers	28	Calico-printers	2
Earthenware-makers	16	Paint, color-makers	2
File-cutters	14	Glazier	1
Lead-workers	8	Artist	1
Printers	6	Lead-roller	1
Lead-miners	3	Lead-mine agent	1
Gas-fitters	3	Caulker	1
Coach-painters	3	Children (under 15)	6
Whitesmiths	2	Others	36
Glass-cutters	2		

Of 64 deaths of plumbers, on the other hand, in New York City, in the two years 1879–80, not one died of lead-poisoning, but more than a third, 22, died of phthisis, and 10, an additional sixth, of pneumonia.

Relations of Density of Population to Mortality.—It had long been known in a general way that the crowding together of human beings increased the mortality among them, but it was reserved for Dr. Farr to show that this mortality increased with increasing density with such regularity that a fixed formula could be furnished, which should enable comparisons to be made, and the probable death-rate of one locality computed from the known death-rate of another, if the density of the population were known in both.

The density of the population is usually indicated by the statement that so many persons to the square mile are living in the area under consideration. Or it may be given as so many to the acre, or conversely, as so many acres or square miles, or fractions of either to each person. In making his computations, Dr. Farr used the more common of these methods, which is the first one. The first formula he fixed upon was the following one: Let m = the mortality in any group of persons, m' a higher mortality in any other group, D = the density of population in the first group, and D' the density of population in the second group, then $\frac{m'}{m} = \sqrt[6]{\frac{D'}{D}}$, that is, the mortality in different districts varies as the sixth root of the population in these districts. After frequent trials of this formula, Dr. Farr changed it to the statement that the mortality varied very nearly as the eighth root of the density, or more exactly, using instead of $\frac{1}{8}$, the fraction 0.11998 or 0.12, so that the expression in the formula would be $m' = m\left(\frac{d'}{d}\right)^{0.11998}$. The difference in the re-

sults obtained by the two formulas, however, is very slight, so that they are practically the same.

Thus, if in three hundred and forty-five groups of districts with a mortality of 19.2, the density was one hundred and eighty-six persons to a square mile, then, in nine groups of districts with a density of 4,499 to the square mile, what was the mortality? The method of ascertaining the answer to this question would not be by working out the following proportion, viz. : 186 : 4,499 : : 19.2 : x, but this, viz. : $(186)^{0.12}$: $(4.499)^{0.12}$: : 19.2 : x, which would give a calculated mortality of 28.08.

As an illustration of the close correspondence between death-rates calculated by this formula, and the actual rates as determined by the recorded deaths, the following table is of interest :

Rates of observed and calculated mortality in seven groups of districts in England, outside of London :

	1	2	3	4	5	6	7
Number of persons to square mile.....	166	186	379	1,718	4,499	12,357	65,823
Observed mortality....	16.75	19.16	21.88	24.90	28.08	32.49	38.62
Calculated mortality...	18.90	19.16	20.87	25.02	28.08	37.70	38.74

Dr. Farr found that the calculated rates for different localities corresponded so closely with the actual ones, when other sanitary conditions appeared to be identical, that he proposed that in any inquiry relating to the sanitary condition of a community or locality, the death-rate should be first calculated from the comparative density of the population, and when the real death-rate was above or below this, the causes of the variation should be investigated.

It has been found that while Farr's law holds good to a remarkable degree with very dense populations, there is more lack of correspondence between observed and calculated rates where the population is sparse. And this was really to be expected, for, as far as the effects of crowding are concerned, it can make little difference to a family whether the adjoining house is two hundred or four hundred feet away.

The evil effects of overcrowding are more intensely felt by the very young, who are more susceptible to all the influences that tend to impair the health. This is well shown in the following table, given by Newsholme, and representing the same seven groups of districts in England just quoted in connection with Farr's law.

	1	2	3	4	5	6	7
Number of persons to a square mile..	166	186	379	1,718	4,499	12,357	65,823
General death-rate at all ages..... ..	16.94	19.18	21.90	24.81	28.02	32.92	38.67
Death-rate of children under 5	37.80	47.53	63.06	82.10	94.04	111.90	139.52

It will be noticed that while the death-rate for all ages, in the densest population is but a little more than twice that of the sparsest, the death-rate of children under five years of age is more than trebled.

In many parts of England it is the practice to build what are called back-to-back houses, *i.e.*, houses where rear walls are in contact or nearly so, so that through and through ventilation is impossible. These houses are occupied, as a rule, by the poorer people, and show clearly the effects of crowding, when the air is so confined that the results of density of population have full play.

The Salford statistics, prepared by Dr. Tatham, present this in a clear light, as seen in the following table :

		Population.	General death-rate.	Death-rate from phthisis.	Death-rate from diarrhœa.
Greengates Subdistrict.	I. No back-to-back houses.	8,713	27.5	2.8	1.42
	II. Average of 23 per cent. of back-to-back houses	11,749	29.2	3.3	1.55
	III. Average proportion of 56 per cent. of back-to-back houses	11,405	30.5	3.6	2.12
Regent Road Subdistrict.	I. No back-to-back houses	54,264	26 1	2.7	1.54
	II. Average of 18 per cent. of back-to-back houses	8,773	29.1	2.7	1.85
	III. Average of 50 per cent. of back-to-back houses.....	4,380	37.3	4.5	2.83

On the other hand, in New York City, it has been noticed that the larger houses, which contain more people on a single lot of land (containing 2,500 square feet), do not show the effect of crowding so much as might be expected. The following table is taken from the report upon the Tenement-house census of 1891 :

DEATH-RATES, ACCORDING TO CAUSE AND DENSITY OF POPULATION.

Houses containing	Death-rate from		
	Diarrhœal diseases.	Phthisis.	Other tuberculous diseases.
Less than 20 tenants..... ...	1.97	3.38	.53
20 and less than 40.	1.89	2.86	.51
40 and less than 60.....	2.41	2.71	.61
60 and less than 80.....	2.57	2.41	.66
80 and less than 100	2.62	2.37	.61
100 and over.....	2.00	1.95	.65

This has been attributed to the fact that the larger houses are, as a rule, newer ones, are better built, with better facilities for light and ventilation, and, as the rents are generally higher, are occupied by people slightly higher in the social scale, or at least, possessed of more means, and therefore able to live in more comfort, than those who live in the smaller houses. The whole matter, however, needs further investigation.

Much the same result has been noticed in new buildings of this kind in London, where the Peabody and Artisan's Block buildings are occupied by a large population on a small area. In the Peabody buildings there were in 1884, 18,453 persons living in 10,144 rooms. The death-rate, corrected for hospital deaths, was 19.1 per 1,000, or 1.2 below the general death-rate of London. The birth-rate, on the contrary, was high, being 44.6 per 1,000, this of itself showing that the houses are occupied by young and vigorous people at the healthy ages. The mortality among infants, the most sensitive test, was only 138.7 per 1,000 births, 13.7 below the average for London.

The higher death-rates which are found in the denser populations are not, of course, entirely due to the crowding *per se*—*i.e.*, to the vitiation of the atmosphere by the breath and the bodily emanations of the population, but to a variety of other causes also. The densest populations are, as a rule, also the poorest, and all the evil effects of poverty exist among them. They have unwholesome and insufficient food, are often badly housed, exposed to winter cold and summer heat, in an unusual degree, by reason of lack of fuel and of suitable clothing, and generally have long hours of labor with little leisure, and few means of gratifying the social instincts even when they are at leisure. Owing to the hopeless feeling engendered by their surroundings they are, more often than not, filthy in person and in their immediate belongings, and even those who have the scantiest means are prone to endeavor to mitigate the horrors of their life by the tem-

porary oblivion which intoxication brings to them. Besides all these causes, the close proximity of others under the same roof renders the propagation of contagious and infectious diseases much more certain, more extensive, and more difficult of control.

Effect of Sanitation on Mortality.—The death-rate, as before shown, has decreased during the past twenty years, in almost all the civilized countries of the world, and that this decrease is due to the great attention everywhere paid to improving the sanitary condition of communities admits of no doubt whatever. For example, in Vienna, the deaths from typhoid fever averaged 700 to 800 per annum from 1851 to 1873. In the latter year arrangements were completed for a new water-supply, and a new system of sewerage was completed. The number of deaths from typhoid fever then began to decrease as follows: In 1873, 742; 1875, 502; in 1878, 200; in 1880, 152; in 1884, 95. In Munich, the sewerage system was completed in 1880. The average annual mortality from typhoid fever from 1866 to 1880 was 594, and from 1881 to 1888 only 104, notwithstanding a marked increase in the size of the city. In England, twenty-eight towns, with a combined population of 8,752,354, gave up the privy-vault system and substituted sewers, between 1860 and 1870. The mortality from typhoid fever in these towns shows the following changes:

DEATHS IN 100,000 INHABITANTS.

1850–1860 (before the construction of sewers)	91
1860–1870 (during the construction of sewers)	89
1870–1880 (after the construction of sewers)	49
1881	27
1884	29

The following table is extracted from a much more elaborate one contained in the reports of Mr. Simon, medical officer of the Privy Council, showing the effect of new drainage-works in England. The original figures were prepared by Dr. Buchanan, in 1867:

Towns.	Periods for which death-rates are compared.		General death-rate.		Typhoid fever.		Phthisis.	
	Before the works.	After the works.	Before	After.	Before	After.	Before	After.
Banbury	1845-53	1857-64	23.4	20 5	1.6	.85	2.67	1.57
Cardiff	1847-54	1859-66	33.2	22.6	1.75	1.05	3.47	2.87
Croydon	1845-50	1857-64	23 7	19.0	1.5	.55	....	....
Dover	1843-53	1857-65	22.6	20.9	1.4	.9	2.65	2.13
Leicester	1845-51	1862-64	26.4	25.2	1.5	.75	4.34	2.93
Macclesfield	1845-52	1857-64	29.8	23.7	1.43	.85	5.15	3.54
Merthyr	1845-55	1862-65	33.2	26.2	2.13	.87	3.87	3.44
Rugby	1845-51	1855-64	19.1	18.6	1.00	.90	2.85	1.63
Salisbury	1844-52	1857-64	27.5	21.9	.75	.18	4.44	2.27
Stratford	1845-53	1860-64	21.7	20.2	1.25	.40	2.67	2.65
Warwick	1845-55	1859-64	22.7	21.0	1.90	.90	4.00	3.24

A remarkable illustration of the effect of sanitation upon the public health is afforded by the English reports, which have been accurately kept since 1838, when the office of the Registrar-General was established. The death-rate, in spite of all that had been done, although slightly lowered on the whole, was not as much influenced by the sanitary improvements from year to year as had been anticipated or desired, until the new Sanitary Acts were passed in 1874, when a decline in the death-rate began almost immediately. At first this decline was supposed to be temporary, like previous declines, but it has kept steadily on, until at present the death-rate for all England is very near to the point which Dr. Farr fixed upon as the ideal death-rate for healthy communities, viz., 17 per 1,000. The following table will make this clear:

DEATH-RATES PER 1,000 LIVING IN ENGLAND BY PERIODS OF FIVE YEARS.

Years.	Death-rate.	Years.	Death-rate.	Years.	Death-rate.
1838-40	22.4	1856-60	21.8	1876-80	20.8
1841-45	21.4	1861-65	22.6	1881-85	19.3
1846-50	23.3	1866-70	22.4		
1851-55	22.7	1871-75	22.0		

In order to show how precisely the decline indicated in this table coincided with the passage of the Sanitary Acts, the death-rates are given below for single years, before and after 1875:

Years.	Death-rate.	Years.	Death-rate.	Years.	Death-rate.
1870	22.9	1877	20.3	1884	19.5
1871	22.6	1878	21.6	1885	19.0
1872	21.3	1879	20.7	1886	19.3
1873	21.0	1880	20.5	1887	18.8
1874	22.2	1881	18.9	1888	17.8
1875	22.7	1882	19.6	1889	17.9
1876	20.9	1883	19.5		

It is a common practice in the United States to estimate the improvement or decline of the sanitary condition of a community by the proportion which the deaths of children under five years of age bear to the total number of deaths. While this may, under some circumstances, afford a fair test for comparing the health of the same town for successive years, it can only be trusted where the age-constitution of the population remains practically the same through the series of years for which the comparison is made. The following table of this kind has been prepared for New York City:

Year.	Percentage of total deaths.		Year.	Percentage of total deaths.	
	Under 5 years.	5 years and over.		Under 5 years.	5 years and over.
1866	47.25	52.75	1879	45.08	54.92
1867	52.90	47.10	1880	45.87	54.13
1868	52.50	47.50	1881	45.92	54.08
1869	51.09	48.91	1882	46.20	53.80
1870	49.06	50.94	1883	40.74	59.26
1871	48.08	51.92	1884	43.59	56.41
1872	49.58	50.42	1885	42.79	57.21
1873	48.76	51.24	1886	43.16	56.84
1874	48.58	51.42	1887	43.06	56.94
1875	48 35	51.65	1888	43.21	56.79
1876	48.74	51.26	1889	43.23	56.77
1877	46.97	53 03	1890	40.66	59.34
1878	45.95	54 05	1891	41.74	58.26

It is evident, by inspection of this table, that the percentage of deaths under five years of age cannot be looked upon as a death-rate, or as resembling a death-rate in any way, for the percentage of deaths of persons five years of age and over increases in precisely the same ratio as that of the children decreases, so that if the latter were to be looked upon as indicating more salubrious conditions for the children, the former would have to be looked upon as indicating more unhealthful conditions for older people. It is also evident that any great change in the age-constitution of the population would change these percentages without really indicating any change at all in the sanitary conditions under which the population was living. And these changes in age-distribution are precisely what New York City is especially liable to on account of the disturbing effect of immigration, which in some years injects into her population a considerable mass of people over five years of age, and comparatively few children under that age, so that the percentage of deaths of children under five, upon the total, might in any year be suddenly lowered, as it was, for instance, in 1883 (the year the Brooklyn Bridge was opened, when there was probably quite an exodus of infants with their parents to Brooklyn), without indicating any change in sanitary conditions.

A better way to use the infant deaths as a test of sanitary condition is to calculate the death-rate upon the total number living under five years of age. In populations where immigration is not so much of a disturbing factor as here, this can be done. But in New York City, on account of this factor, the age-distribution of the population cannot be calculated for the inter-censal periods with

any degree of accuracy. A comparison of London and New York in this respect will illustrate this.

LONDON.

Population by census.

	Total.	Under five years.	Percentage of persons under five years of age on total.
1851	2,362,236	293,562	12.43
1861	2,803,989	362,296	12.92
1871	3,254,260	423,629	12.99
1881	3,816,483	497,044	13.02
NEW YORK.			
1865	726,386	95,020	13.08
1870	942,292	111,205	11.80
1875	1,041,886	128,162	12.30
1880	1,206,299	140,327	11.63

While the ratio in London remains almost stationary, that of New York shows very plainly the effect of adult immigration. A better method still is the one adopted pretty generally in Europe, and that is, to compare the deaths of children under one year of age with the total number of births for the year, as so many deaths per 1,000 births. The mortality under five years of age, in any case, is mostly of children under one year, *e.g.*, in New York City in 1891, out of 18,224 deaths of children under five years of age, 11,241, about sixty per cent., were under one year, and 3,523 more were between one and two, making together over eighty per cent. of the whole under two years of age. Therefore, in taking the deaths of children under one year, we are making use of a much more sensitive test than if we take all those under five; and in comparing them with the births we have a positive number for the comparison every year, instead of the uncertain number obtained by computation for the inter-censal years. This method, however, can only be used where the registration of births is complete, and is, therefore, out of the question at the present time, in this country.

The following table allows of a comparison between the two methods most in use for estimating the mortality of infants.

DEATH-RATES IN ENGLAND PER 1,000 LIVING, AND PER 1,000 BIRTHS, FOR TEN YEARS.

Year.	Children under five. Deaths per 1,000 living.		Children under one year. Deaths per 1,000 births.
	Males.	Females.	
1881	56.4	47.9	130
1882	62.5	53 6	141
1883	59.3	49.7	137
1884	62.3	52.8	147
1885	57.5	48.4	138
1886	60.3	50.9	149
1887	57.8	48.9	145
1888	52.7	44.0	136
1889	55.6	47.0	144

Another method, which is sometimes used for comparing the sanitary condition of one place with another, or of the same place year by year, is to fix upon some disease whose prevalence is believed to indicate faulty sanitary conditions, and compare the deaths from that disease with the total number of deaths. But this furnishes an altogether unstable basis for comparison, for it is an attempt to fix upon ratios between events, both of which fluctuate, sometimes violently. Dr. Ransome gives the following illustration of the uncertainty and untrustworthiness of comparisons made in this way. Suppose two towns, each containing a population of 100,000. Suppose that in A there are 2,000 deaths a year, making a death-rate of 20 in 1,000, and in B there are 4,000 deaths a year, making a death-rate of 40 per 1,000. Suppose that in A there are 500 deaths a year from phthisis, and in B 1,000 deaths from phthisis. Now, if the comparison is made between the deaths from phthisis and the total number of deaths, it is the same in both cases, viz.: twenty-five per cent. of the total number of deaths, and in so far as this test goes, the sanitary condition of B is as good as that of A. But as a matter of fact, the death-rate of B is twice that of A, and the deaths from phthisis in B are 10 per 1,000, while in A they are only 5 per 1,000.

Sickness-rates.—For the purpose of comparing the results of treatment, and of comparing one epidemic with another, ratios are computed between the number of deaths and the number of persons attacked. In making such comparisons the total number of cases should always be given, so that others can judge for themselves whether they are sufficiently numerous to justify rigid conclusions. For in this respect, as in most others, there is danger of drawing conclusions from an insufficient number of data. Moreover, a bare comparison of deaths with the number of cases of sickness can give no valuable information, because the mortality may vary so much with the age or sex of the person attacked, and also at different times. It is well established that some epidemics of a disease are much more fatal than others of the same disease, as in the recent successive epidemics of influenza throughout the world. Also, in the same epidemic, the mortality varies greatly, the disease generally being quite fatal at the commencement, increasing in virulence for a certain time, and then growing less and less fatal during the decline. Dr. Farr, in his second annual report, made a series of calculations relating to the epidemic of small-pox in England in 1838 and 1839, which show this in a singular manner. The deaths are given below by quarters (periods of three months).

DEATHS OBSERVED IN THE DECLINE OF EPIDEMIC.

1	2	3	4	5	6	7
4,365	4,087	3,767	3,416	2,743	2,019	1,631

DEATHS IN A REGULAR SERIES.

1	2	3	4	5	6	7
4,364	4,147	3,767	3,272	2,716	2,156	1,635

The mortality decreased at accelerated rates; the rate of acceleration being 1.046, which may be called the constant. The decrease from one number to another is successively 5, 10, 15, 20, 26, and 32 per cent., and the rates of decrease, 1.052, 1.101. 1.152, 1.205, 1.260, 1.318. The division of 4,364 by 1.052 reduces it to 4,147, etc. The constant 1.046, by successive multiplications, will produce all the rates first given, 1.052, 1.101, etc.

The decline of the epidemic in London is shown below:

	1	2	3	4	5
Mean quarterly deaths registered. ..	1,103	959	611	240	91
Calculated series.....	1,103	967	611	278	91

The first rate of the calculated series was 1.14, and the others were obtained by multiplying 1.14 four times in succession by 1.39, the constant.

WALES AND THE WESTERN COUNTIES OF ENGLAND.

Mean quarterly	1	2	3	4	5	6	7	8
deaths registered.	1,157	813	621	489	304	194	116	81
Calculated series..	1,157	858	621	440	304	206	136	88

The first rate was 1.35; the constant, 1.023.

In the short tables just quoted, some necessary corrections have been neglected, and there are discrepancies between the actual and the calculated series. But in the following table these corrections have been made. Thus the quarterly rate of mortality by small-pox has been obtained by dividing the deaths in a quarter by the population in the middle of the quarter, and then the annual rate is obtained by taking four times the quarterly rate. But the quarters vary in length from 90 to 92 days, and to be strictly accurate, the mortality of the March quarter would have to be raised in the proportion of 90.5 to 91.25. Now, making the proper corrections on

this plan, the subjoined table was constructed for England:

	1838				1839	
	Mch. 31.	June 30.	Sept. 30.	Dec. 31.	Mch. 31.	June 30.
Annual rate of mortality (observed)	.114	.105	.096	.086	.070	.051
Ditto (calculated)	.114	.105	.096	.086	.070	.050

Here the agreement is extraordinary; the rates of decrease were 1.08, 1.09, 1.11, 1.24, and 1.39. The first three were produced by multiplying by 1.011; the two last by 1.12.

There are several ways of calculating the death-rates in hospitals, but they are all more or less unsatisfactory, because the conditions under which they are conducted differ so much that a fair comparison is almost impossible. Moreover, it is very difficult to decide with what numbers the deaths ought to be compared in order to obtain the death-rate. One method is to comparet he number of deaths with the number of occupied beds as ascertained by a census—what Dr. Newsholme calls a *bed death-rate*. This obviously takes no account of the number of times each bed may have been occupied, and a death-rate of one hundred per cent. would mean simply that there had been one death for every bed. The information thus given is of absolutely no practical value. The death-rate is sometimes calculated on the total number of admissions during the year. But this again is often misleading, for if the account is made up for each year separately, the number remaining at the end of each year will be counted twice, once in each of two successive years, being counted as admissions iu one year and as remaining over in the subsequent year. If a calculation is made for a series of years, this source of error should be carefully guarded against, as it is one into which one is very likely to fall.

A better method than this is that of Dr. Bertillon, who adds to the number at the beginning of the year one-half the sum of those admitted and those going out; but the plan which is generally agreed upon as the best for a crude death-rate for hospitals, is to compare the number of deaths with the total number of cases treated to a termination, either by discharge, transfer, or death.

A comparison of one hospital with others by means of death-rates gives rise to all sorts of false conclusions, and is practically worthless. Of course, no proper comparison can be made at all between the mortality in hospitals devoted to the treatment of special diseases, *e.g.*, it would be ridiculous to institute such a comparison between an orthopædic hospital and a cancer hospital, between an institution devoted to the treatment of venereal diseases and one for the treatment of phthisis. But a comparison between the death-rates of general hospitals is almost as misleading; for, entirely independent of the sanitary condition of the institutions, or the skill of the treatment to which patients are subjected, much depends upon the age and sex of the patients themselves. For instance, a large proportion of children, among whom scarlet fever became prevalent, might raise a death-rate materially. In typhus fever, the difference in the mortality of the disease among adults, to whom the disease is very fatal, and children, who almost all recover, is well known. Then, too, the attendance of physicians or surgeons of great eminence in any particular institution is certain to attract the most desperate cases, so that, as the consulting physician in private practice is likely to have the highest death-rate among his patients, so the hospital which has the most distinguished staff, and therefore presumably the most skilful treatment, will probably have the highest death-rate.

Hospital death-rates, therefore, are not susceptible of comparative statement, unless the cases are reported in much greater detail than they are at present, or than they are likely to be for many years to come. Not only the number of patients treated should be given, but the diseases, the ages and sex, and the duration of treatment in days.

The general death-rate of a population being, as already shown, a very unsatisfactory means of comparing the sanitary condition of any place or country with another, various other methods have been devised, which must be briefly mentioned.

Mean Age at Death.—This is obtained by dividing the sum of the ages at death by the number of deaths. For example, if out of 100 persons, 20 die at 5 years of age, 30 at 25, 30 at 40, and 20 at 60, the mean age at death will be obtained as follows:

$$\frac{(20 \times 5) + (30 \times 25) + (30 \times 40) + (20 \times 60)}{100} = \frac{100 + 750 + 1200 + 1200}{100} = \frac{3250}{100} = 32.5 \text{ years.}$$

This method, however, like the general death-rate, is not suitable for comparing different communities, unless the age-constitution of the two are the same. For obviously, the number who die at each age will depend upon the number living at that age. The following illustration is given by Dr. Guy. If A has 46 per cent. of its population under 20 years of age, and B has 54 per cent., then if half the inhabitants of A and B die under 20, and the mean age of these at death be assumed to be five years, and of all over 20 to be 60 years, then the mean age at death of 50 persons in A would be $= \frac{\frac{46}{2} \times 5 + \frac{54}{2} \times 60}{50} = \frac{115 + 1620}{50} = \frac{1735}{50} = 34.7$ years, and in B would be $= \frac{\frac{54}{2} \times 5 + \frac{46}{2} \times 60}{50} = \frac{135 + 1380}{50} = \frac{1515}{50} = 30.3$ years. Thus, assuming that the general death-rate of A and B is the same, the mean age at death differs by 4.4 years, owing to the different age-constitution of the population. This source of error will vitiate comparisons between different periods in the same country, and between cities and country towns, as well as different countries. The mean age at death has also been used for the purpose of comparing the healthfulness of different occupations, but in this case it is so misleading as to be almost worthless, unless the age-constitution of the masses of persons compared are the same. It would be obviously incorrect to compare the mean age at death, for instance, of bishops and other clergymen, for clergymen do not often become bishops until they reach middle life. Other instances of this fallacy have been given elsewhere.

The *probable duration of life* (*vie probable*) means the age at which any number of persons followed from birth would be reduced one-half, *i.e.*, the age at which one-half are already dead. It differs greatly from the mean age at death, and does not seem to be of any practical importance. If out of a population of 100, 10 die at 5 years of age, 10 at 15, 10 at 25, 10 at 35, 10 at 45, 10 at 55, 10 at 65, 10 at 75, 10 at 85, and 10 at 95, then the probable duration of life would be 45 years, at which age 50 of the number would have died; but the meau age at death would be:

$$\frac{50 + 150 + 250 + 350 + 450 + 550 + 650 + 750 + 850 + 950}{100} = 50 \text{ years.}$$

The *mean duration of life* (*vie moyenne*), in a stationary population, where births equal deaths and there is no immigration nor emigration, is the same as the mean age at death. But in the ordinary population, where the births do exceed the deaths, and there is more or less migration, the mean duration of life is the same as the mean after-lifetime taken at birth, or the expectation of life at birth. This figure is obtained from a life table, the method of constructing which will next be considered.

Life-tables.—The earliest life-tables were drawn up by Ulpian, the distinguished Roman lawyer, early in the

third century A.D. (Billings). They are given in the Pandects of Justinian, and were based upon the registers giving age, sex, and deaths among the population of Rome since the time of Servius Tullius, a period of about one thousand years. From these data Ulpian constructed a scale for estimating the purchase value of communities, and calculating annuities.

The earliest English life-table was constructed by the celebrated astronomer Halley, and published in 1693. It was calculated on the deaths in the city of Breslau from 1687 to 1691.

The first National life-table ever made was constructed by Dr. Price in 1783, for Sweden, and was based upon abstracts of the living and dying in Sweden during twenty-one years, arranged by quinquennial periods after the fifth year.

The first life-table used for life-insurance purposes was also constructed by Dr. Price, and is known as the Northampton table. It was used by the Equitable Office on its establishment in 1762. This table, like Halley's, was constructed from the deaths alone, taking no account of the number of the living. Such tables are only correct in a stationary population, in which the births equal the deaths, and there is no migration.

The table known as the Carlisle table was made by Mr. Milne, and based upon the observations of Dr. Heysham upon the mortality of Carlisle for the nine years 1779–1787, and two enumerations of the population made at the beginning and end of the term; the mean population amounting to 8,177 and the deaths to 1,840.

In 1834 the Equitable Assurance Society published an abstract of the facts in their possession, from which Mr. Morgan constructed a table of mortality.

The English life-tables, Nos. 1, 2, and 3, were constructed by Dr. Farr. No. 1 was based upon the census returns of population for 1841 and the recorded deaths for the same year. In order to avoid the criticism that it was based upon the statistics of too short a time, he constructed No. 2, based upon the census enumerations of 1831 and 1841, and the deaths for the seven years 1838–1844, embracing the age records of 29,810,945 persons, and the death records of 2,436,648. English life-table No. 3 was based upon the census enumerations of 1841 and 1851, and upon the deaths registered during the seventeen years 1838 to 1854, numbering 6,470,720. The results obtained by these three tables were very nearly alike.

Besides the value of a life-table, by common consent, as the only true basis of comparison between different communities as to their sanitary condition or the general vitality of the population, it is absolutely necessary as a basis for the calculation of premiums in the insurance of lives. Accordingly, most large insurance companies have their own tables, made up by their actuaries, from their own records. Being constructed in this way from the statistics gained from the observation of selected lives, they may differ to a slight extent from a table based upon the entire population, but they are generally made up after careful corrections for all possible sources of error, and the construction of them is a very laborious task.

It is necessary, for the construction of a life-table, to have the numbers of the living, with ages, and the number and ages of the dying. Theoretically, it would be advantageous to have the exact number of the living at each year of their age, and the exact ages of the dying for each year; but practically, the liability to error in any attempt to obtain such figures renders it more desirable to use mortality and census statistics, in which the population and deaths are grouped by five- or ten-year periods. It is said by Dr. Farr that "no authentic table of mortality in practical use has ever been calculated from an enumeration of deaths at every separate year of age; and no actuary has yet shown that tables can be deduced more accurately from deaths so enumerated than from quinquennial or decennial periods."

In making up life-tables certain things have to be assumed. The first suggestion on this point came from the mathematician De Moivre, who formulated what is known as De Moivre's hypothesis from the deaths at Breslau. He concluded that the numbers living decrease in an arithmetical progression, down to nothing, at the age of eighty-six, or, in other words, that of every eighty-six persons born one dies every year until all are dead. This is an understatement of the mortality toward the beginning and end of life, and is only approximately true for the middle period. It has since been assumed, with Milne, "that the number of living in any year of their age is an arithmetical mean proportional between the number that annually enter upon and that annually complete that year." It is also assumed that the deaths occurring in any year are equally distributed throughout the year. It is obvious that the number of deaths, for instance, given for two years of age, do not all occur at the precise time when the persons completed their second year, but are distributed throughout the ensuing year, while the persons are still said to be two years of age and not yet three. A slight error is involved in the assumption of equal distribution, for the deaths are much more numerous at some seasons than at others, and even as regards age, if the mortality at two is much greater than that at three there will evidently be a larger proportion of deaths in the early part of the year than in the latter part. This source of error may, however, be safely disregarded.

It will now, perhaps, be most conducive to a clear understanding of the subject if a short life-table is first given, and the method of constructing it explained in detail afterward. The following is quoted from Farr's tables by Newsholme:

ENGLISH LIFE-TABLE FOR MALES.

Age (or past lifetime) x	Annual mortality per unit at age x $= m_x$	Probability of living one year from each age $= p_x$	Number born and living at each age $= l_x$	Mean population in each year of age $l_x + \frac{1}{2} = P_x$	Years which the males at each age will live $= Q_x$	Mean after-lifetime of males of age x $= E_x$
0	.18326	.83212	511,745	468,789	20,426,138	39.91
5	.01369	.98640	370,358	367,672	18,410,252	49.71
10	.00563	.99438	353,031	352,007	16,698,936	47.01
15	.00519	.99482	244,290	343,415	14,866,429	43.18
20	.00832	.99171	333,608	332,231	13,169,656	36.48
25	.00920	.99084	319,442	317,892	11,536,677	36.12
35	.00105	.98901	288,850	287,229	8,492,601	29.40
45	.01554	.98458	253,708	251,763	6,774,489	22.76
55	.02485	.97664	209,539	206,984	3,447,708	16.45
65	.04698	.95410	150,754	147,315	1,631,508	10.82
75	.10391	.90122	75,777	72,012	491,685	6.49
85	.21966	.80208	16,877	15,151	63,030	3.73
95	.42035	.65265	833	678	1.806	2.17
105	.....	.....	4	3	5	... .

The letter x in the heading of the columns signifies *age*, *e.g.*: m_x means mortality at the age of x, l_x means *living* at the age x, etc.

The first column, or m_x, is obtained from the total number of living at each age, as returned by the census, and the total number of deaths recorded for each age. The numbers in the column are the death-rates for the respective ages, only they are death-rates per unit, instead of rates per 1,000. They are obtained by the formulas previously mentioned, viz.: death-rate $=$ $\frac{\text{total number of deaths}}{\text{total population}}$. The first number, for instance, .18326, indicates the death-rate during the first year of life, *i.e.*, 183.26 per 1,000 living, or .18326 per unit living.

The second column, or p_x, represents the probability of living one year, *i.e.*, the probability that a person who is living at the beginning of a year will live to see the end of it. The number in the first column represents the death-rate of the mean population of the year, *i.e.*, as it is there expressed, the mortality of one individual in the middle of the year. But as the deaths are assumed to be equally distributed throughout the year, the number living at the beginning of the year will evidently be greater than that living in the middle of the year by just one-half the number of deaths for the year, and the number living at the end of the year will be just so much smaller.

So if m represents the annual number of deaths, and 1 represents the unit of population living in the middle of the year, then $1+\frac{m}{2}$ will equal the number living at the beginning of the year, and $1-\frac{m}{2}$ will equal the number living at the end of the year. Now, the number living at the end of the year, divided by the number living at the beginning, will give the probability which each person at the beginning of the year has of living to the end. If 100 are living in the middle of the year, and the mortality is 4 a year, there will be 102 living at the beginning and 98 at the end of the year, and $\frac{98}{102}$ will represent the probability of living a year for each of the 102. So $p_x = \frac{1-\frac{m}{2}}{1+\frac{m}{2}} = \frac{2-m}{2+m}$. In the table, the mortality being .18326, the probability of living one year equals $\frac{2-.18326}{2+.18326} = \frac{1.81674}{2.18326} = .83212$, which is the first number in the second column.

The next column, or l_x, represents the number of persons living at the beginning of each year. In the table, the first number, 511,745 represents the number of newly-born children, and the next number, 370,358, the number who are five years old, *i.e.*, who have completed their fifth year and are beginning the sixth. The intervening years are not given in this table, for the sake of brevity, but the number for each year is obtained by multiplying the number living at the beginning of the previous year by the probability of living a year, this evidently giving the number surviving at the end of the year. That is, each successive number in the third column is obtained by multiplying l_x by p_x. Thus the number living at one year of age (which is omitted from this abbreviated table) would be obtained by multiplying 511,745 by .83212, which gives 425,833. This would be the second number in a complete life-table, and the third number would be obtained in like manner, by multiplying this one by the p_x for one year.

The fourth column contains the mean population for each year, which is obtained by taking half the sum of those living at the beginning and the end of each year. If the table were complete, each number in this column would be half the sum of the corresponding number in the column headed l_x and the one next succeeding. In the present case it is equal to $\frac{511,745+425,833}{2} = 468,789$. This is called P_x.

The fifth column, headed Q_x, *i.e.*, the quantity of life, as it might be called, at each age, represents at each age the number of years of life remaining to the persons living at that age. Each number in this column is equal to the sum of all the numbers at that and the subsequent ages in the previous column, headed P_x. The reason of this is plain. The same number of years of life are lived whether one man lives 100 years, or 100 men live one year. Now to take the example previously used, if there are 102 living at the beginning of the year and 98 at the end (*i.e.*, the beginning of the next year), on the supposition that the deaths are evenly distributed through the year, the 102 live only one-half of the year, and the 98 the other half of the year, making in the one case 51 years of life, and in the other 49, or 100 years of life together, *i.e.*, $\frac{102+98}{2} = 100$. So in the next year, the death-rate remaining the same, the number of years lived would be equal to $\frac{98+94}{2} = 96$, making the total number of years lived by the 102 living at the beginning of the first year equal to 196 at the beginning of the third year, or end of the second. But 100 and 96 represent the mean population of the first and second years respectively, and so would be in the column P_x.

The sixth column, headed E_x., *i.e.*, the expectation of life at any age, is the column for which all the other columns have been preparatory, and represents the number of years of future lifetime for each unit of the population. Each number in this column is obtained by dividing the corresponding number in the column headed Q_x by the one in the column headed l_x. For if, for instance, there are 511,745 males living at the beginning of a year, and the males at that period have a total future lifetime of 20,426,138 years, it is evident that the future lifetime of each unit, *i.e.*, the mean after-lifetime, or expectation of life at that age, will be equal to 20,426,138 divided by 511,745, which gives a quotient of 39.91.

A shorter method of constructing life-tables is given by Dr. Farr, as follows:

"The arithmetical labor involved in the construction of correct life-tables, showing the living at every year of age, is very considerable. But for a great many purposes the number surviving every five years, after the five first, and the expectations of life at those intervals, furnish quite sufficient information, *e.g.*:

"Up to the age of five years the method is the same as that already described, and it was thus found that of 50,521 boys born in Surrey, 43,637 live a year, 41,857 two years, 40,704 three years, 40,031 four years, 39,550 five years. The next point was to determine how many of the 39,550 attain the age of ten years. The living enumerated at the age five to ten were 13,588, the deaths 145; and after the proper correction the mortality m was ascertained to be .01050; so $\frac{m}{2} = .00525$ and $\frac{1-\frac{1}{2}m}{1+\frac{1}{2}m} = \frac{.99475}{1.00525} = .98955$, the probability of living *one year* at the middle of the period, or at seven and a half years of age. But it may be assumed that $\left(\frac{1-\frac{1}{2}m}{1+\frac{1}{2}m}\right)^5 = (p_5)^5 =$ the probability of living the five years from the age of five to ten; and $(.98955)^5 = .94885$; which multiplied by 39,550 gives 37,527 = the number surviving at the age of ten.

"If the calculation be continued down to 15, 20, 25, and every fifth year to the end, the following table will be obtained:

SURREY LIFE-TABLE. MALES (1841).

Age.	Living.	Quinquennial periods + ½ lm	Age.	Living.	Quinquennial periods + ½ lm
0	50,521	476,444	45	28,069	149,225
1	43,637	.....	50	25,973	121,156
2	41,857	.....	55	23,892	95,183
3	40,704	.....	60	21,459	.....
4	40,031	.....	65	18,235	.....
5	39,550	425,923	70	13,976	.....
10	37,527	386,373	75	9,836	.....
15	36,469	348,846	80	5,393	.....
20	35,338	312,377	85	2,031	.....
25	34,061	277,039	90	290	.....
30	32,742	242,978	95	58	.....
35	31,189	210,236	100	11	.....
40	29,822	179,047	105	2	.....

"Add up the column headed living to the number 39,550 (against the age five years), and the sum will be the number of five years—of *lustres*—which the 39,550 persons will live $+\frac{39.550}{2} = 19.775$. Subtract, therefore, 19,775 from 425,923, and 406,148 will remain; which, divided by 39,550, gives for quotient 10.269 *lustres* as the expectation of life at that age. A lustre is five years; consequently the expectation of life in years is five times 10.269, or 51.3 years. If 425,923 be divided by 39,550, the quotient will be 10,769; and $10,769 - .5 = 10,269$, the same result as before.

"A life-table still shorter may be constructed by taking intervals of ten years, and using the formula $\left(\frac{1-\frac{1}{2}m}{1+\frac{1}{2}m}\right)^c$.

The errors in the calculation of the expectation of life from the living at every tenth year can be corrected. They are always of the same nature, causing an excess, between 10 and 50, from .1 to .2 or .3 of a year."

A still shorter method was described by Mr. Noel A. Humphreys, in a paper read before the Statistical Society, in April, 1883, on "The Recent Decline in the English Death-rate." As an illustration, he took the mean annual death-rate in the seventeen years 1838–54, and in the five years 1876–80, at each of the twelve gronps of ages given by the Registrar-General in his annual reports. Having then calculated the rate of increase or decrease of the relative rates of the two periods at each group of ages, he started with the annual mortality for males and females, respectively, in each year of life, as given by Dr. Farr's English life-table, No. 3, and raised or lowered these in accordance with the increased or decreased mean mortality prevailing during 1876–80 in the several gronps of ages. There is an obvious defect in this series of corrected annual rates of mortality, which is pointed ont by Mr. Humphreys himself. This lies in the "assnmption that the changes in the proportions of decrease in the mean rates of succeeding age-periods, took place suddenly at the commencement of each period instead of coming gradually into operation, as was certainly the case." But for the purpose of estimating the mean after-lifetime, this method is sufficiently accurate, and forms a comparatively easy method of constructing local life-tables (Newsholme).

This was the method used in constructing the life-tables for States and cities for the United States census report of 1880, some of which will be found qnoted below.

The table on next column (also from Newsholme) shows the expectation of life (mean after-lifetime) according to various well-known life-tables.

Life-tables based upon American experience will be found in the article on Mortality, in Vol. V. of this work, pp. 25, 26. An inspection of these tables will show that, while the progress of sanitary reform has resulted in an appreciable diminution of infant mortality, there has been an increase of the mortality among adults. A comparison of English life-table, No. 3, with the more recent one of Dr. Ogle, shows a considerably increased expectation of life up to fifteen years of age, and after that a decreased one. This is due partly, perhaps chiefly, to the saving

Age.	De Moivre's hypothesis.	Northampton table.	Carlisle table.	English life-table, No. 1.	English table, No. 2.	English table, No. 3.		New English life-table (Dr. Ogle's).	
	Persons.					Males.	Fem.	Males	Fem.
0	43.	25.2	38.7	41.1	....	39.91	41.85	41 35	44.62
5	40.5	40.8	51.3	50.0	....	49.71	50.33	50.87	53.08
10	38.	39.6	48.8	47.2	47.5	47.05	47.67	47.60	49.76
15	35.5	36.5	45.0	43.6	43 4	43.18	43.90	43.41	45.63
20	33.	33.4	41.5	40.3	40.0	39.48	40.29	39.40	41.66
25	30.5	30.9	37.9	37.0	36.6	36.12	37.04	35.68	37.98
30	28.	28.3	34.3	33.6	33.1	32.76	33.81	32.10	34.41
35	25.5	25.7	31.0	30.4	29.8	29.40	30.59	28.64	30.90
40	23.	23.1	27.6	27.1	26 5	26.06	27.34	25 30	27.46
45	20.5	20.5	24.5	23.8	23.1	22.76	24.06	22.07	24.06
50	18.	18.0	21.1	20.6	19.9	19.54	20.75	18.93	20.68
55	15.5	15.6	17.6	17.1	16.7	16.45	17.43	15.95	17.33
60	13.	13.2	14.3	14.0	13.6	13.53	14.34	13.14	14.24
65	10.5	10.9	11.8	11.1	10.9	10.82	11.51	10.55	11.42
70	8.	8.6	9.2	8.7	8.6	8.45	9.02	8.27	8.95
75	5.5	6.5	7.0	6.7	6.6	6.49	6.93	6 34	6.87
80	3.	4.8	5.5	5.1	5.0	4.93	5.26	4.79	5.20
85	.5	3.4	4.1	3.7	3.7	3.73	3.98	3.56	3.88
90	....	.8	3.3	2.7	....	2.84	3.01	2.66	2.90
95	....	....	3.6	2.1	....	2.17	2.29	2.01	2.17
100	....	....	2.3	....	....	1.68	1.76	1.61	1.62

in infancy and childhood of many lives of delicate and weakly persons, who succumb to the stress of adult life more easily and in greater numbers than when the adults were the result of a more rigorous natural selection in childhood. The great increase of town population of late years has probably also had much to do with this increased mortality of adults, for the death-rates of cities are always higher than those of rural districts.

It should be kept in mind that the expectation of life, as given in life-tables, is merely an average made up from data derived from a large number of persons, and has no relation to any single individual. It does not imply that any single person may expect to live a certain number of years, for some will live much longer and others die much earlier.

The following table, taken from the United States census report of 1880, shows the expectation of life in many cities and some States in this country:

Ages.	Baltimore.		Boston.	Brooklyn.	Chicago.	Cincinnati.	New Orleans.	New York.	Philadelphia.	San Francisco.	District of Columbia.		Massachusetts.	New Jersey.
	White.	Colored.									White.	Colored.		
0	38.18	23.26	38.08	38.61	39.70	40.44	25.56	35.02	41.93	41.32	42.36	25.25	44.64	46.82
1	46.04	35.32	46.65	45.94	47.30	48.44	36.58	43.70	49.54	48 68	49.34	36.32	51.19	53.44
2	49.80	41.91	49.84	49.66	50.96	51.26	40.11	47.94	51.56	49 94	51.81	42.29	53 18	55.05
3	51.05	43.66	50.52	50.66	52.00	52.16	41.25	48.90	52.24	50.16	52.21	44.26	53.74	55.54
4	51.58	44.07	50.90	50.97	52.74	52.32	41.08	49.20	52.30	50.03	52.20	44.58	53.90	55.48
5	51.72	44.32	50.86	51 02	52.90	52.06	40.76	49.14	52.02	49.54	51.85	44.48	53.80	55.18
10	49.66	42.40	47.96	48.62	51.12	49.11	37.50	45.91	48.56	45.76	48.71	42.13	50.97	52.04
15	45.46	39.42	43.68	44.42	47.10	44.78	33.75	41.62	44.30	41.38	44.38	38.44	46.86	47.88
20	41.50	36.62	40.14	40.36	43.20	40.76	30.63	37.64	40.37	37.42	40.42	35 34	42.29	43.90
25	38.06	33.68	36.99	36.94	39.52	37.20	29.02	34.20	37.01	34.00	36.72	32.76	40.12	40.48
35	31.42	27.62	30.68	30.45	32.53	30.41	24.95	28.02	30.68	27.78	30.54	27.68	33.54	33.54
45	24.67	21.74	24.04	24.01	25.58	23.96	20.04	22.14	24.24	21.92	24.19	21.58	26.72	26.47
55	17.86	16.10	17.76	17.71	18.70	17.58	15.52	16.34	17.98	16.50	17.92	16.22	19.72	19.56
65	12.17	10.72	12.22	12.21	12.68	11.75	10.90	11.19	12.26	11.36	12.10	11.18	13.52	13.44
75	8.32	7.02	7.94	8.20	8.31	7.77	7.07	7.70	8.12	7.51	7.56	7.22	8.72	8.57
85	5.98	5.72	6.33	5.69	6.28	5.71	5.85	5.60	5.68	6.96	5.54	5.52	5.97	6.20

The figures given for each age are the arithmetical means of the males and females in each case. The table was made up from the deaths for one year in every instance excepting the District of Columbia, where the deaths for the three years 1879–81 were used.

In cases where a life-table is obtainable, the *formula of Willich* gives approximate results for ages between 25 and 75, as follows: if x = expectation of life and a = present age, then $x = \frac{2}{3}(80 - a)$. Thus, at the age of 40 years, the expectation of life according to this formula would be $\frac{2}{3}(80-40) = 26.7$ years. By the English life-table, No. 3, the expectation of life for this age is 26.06 years for males, and 27.34 for females.

Dr. Farr gives another formula, by means of which an approximation to the expectation of life at birth may be obtained, when the birth- and death-rates are known.

If b = birth-rate and d = death-rate per unit of population, then the expectation of life $= \left(\frac{2}{3} \times \frac{1}{d}\right) + \left(\frac{1}{3} \times \frac{1}{b}\right)$

Thus in the decennium 1871–80, the birth-rate was 35.45

per 1,000, = .03545 per unit, and the death-rate was 21.4 per 1,000 = .0214 per unit. Then the expectation of life $=\left(\frac{2}{3}\times\frac{1}{.0214}\right)+\left(\frac{1}{3}\times\frac{1}{.03545}\right)=40.55$ years. By the English life-table, No. 3, the expectation of life at birth for males was 39.91, and for females 41.85, the arithmetical mean being 40.88.

The *mean duration of life* is the same as the mean after-lifetime (expectation of life) added to any age. Thus, at birth, the mean duration is the same as the mean after-lifetime. At twenty years it equals twenty plus the mean after-lifetime. Thus by the English life-table, No. 3, the mean duration of life for males would be, at birth, 39.91 years, and at 20 years of age it would be 20 + 39.48 = 59.48 years.

Dr. Farr gives the following illustration of the untrustworthiness of the mean age at death as a test of the duration of life :

	Mortality, or 1 death.	Mean age at death.	Mean after-lifetime, or, expectation of life.
England, 1841.	In 46 living.	29 years.	41 years.
France, 1841.	In 42 living.	34 years.	40 years.
Sweden, 1841.	In 41 living.	31 years.	39 years.

It will be seen that, although the mean age at death was lowest in England, the rate of mortality was also the lowest. This is owing to the great excess of young persons in the population of England as compared with that of France.

One more method of estimating the vitality of a community has been suggested by Mr. Neison, viz., to divide the number of living at any age by the number dying at that age. The result he calls the *specific intensity* at that age. Thus, out of 100,000 males born, 76,504 survive at the age of 40 years, and 927 of this number die during the year. Then the specific intensity at the age of 40 $=\frac{76,504}{927}=82.528$.

Sources of Error in Dealing with Statistics.—Many ways have already been mentioned in connection with the various subjects treated of in this article, in which fallacious conclusions may be drawn from statistics that have been improperly collected or handled, and it is not necessary to recapitulate them here. But there are a few sources of fallacy that have been temporarily passed by or insufficiently dealt with, which should be mentioned before the article is brought to a close.

1. *The Data may be too Few in Number to Justify any Trustworthy Conclusion.*—It must be always kept in mind that generalizations from insufficient data are worse than useless, because they are misleading. It is a well-known mathematical principle that the relative values of two or more series are as the square roots of the number of observations, so that by increasing the number of observations in any inquiry, the accuracy increases as the square root of the number. Absolute truth cannot be obtained by any number of observations, but the limits of error may be so reduced that the variation either way may be practically disregarded, being so small. *Poisson's formula* gives us the means of ascertaining the limits of error in any case. It is as follows : Let M = the total number of cases recorded, and m = the number in one group, and n = the number in another group, both groups making up the total number, so that $m + n = M$. Then the proportion of each group to the total will be expressed by $\frac{m}{M}$ and $\frac{n}{M}$, and the extent of the variation, or the limits of possible error, will be expressed by the formula $\frac{m}{M}+2\sqrt{\frac{2m\times n}{M^3}}$ and $\frac{m}{M}-2\sqrt{\frac{2m\times n}{M^3}}$. It is plain that the larger the value of M the less will be the value of $2\sqrt{\frac{2mn}{M^3}}$, and therefore the less will be the variation from $\frac{m}{M}$.

Thus (to use Newsholme's illustration), if out of 10 cases of cholera, 7 recover, how near is this to the true average of recoveries. The probability of recovery is $\frac{7}{10}$ and of dying $\frac{3}{10}$. According to Poisson's formula the possible error will be :

$$2\sqrt{\frac{2m\times n}{M^3}}=2\sqrt{\frac{2\times7\times3}{10^3}}=2\sqrt{\frac{42}{1,000}}=.4098.$$

Thus the possible error is as .4098 to unity. Now, what would be the possible variation in 100,000 cases ?

The average, as given, would be 70,000 recoveries out of the 100,000 cases, and the possible error is 40,980 ; therefore the number of recoveries may range between 110,980 and 29,020 (an absurdity, showing that the number of cases is too small to base any conclusion upon). Now, if 100 cases be collected, out of which 70 recover, the proportion is the same, the only difference being in the larger number of observations ; but by Poisson's formula the error is only .13 to unity, or 13,000 in 100,000 cases, so that the range of recoveries on that basis would be between 83,000 and 57,000 cases. If 1,000 observations are made with the same proportion of recoveries, *i.e.*, 700, the error, according to the formula, would be only .04, *i.e.*, 4,000 in 100,000 cases, and the range of recoveries would be between 74,000 and 66,000. And so the possible error constantly decreases, until, after the number of observations rises into tens of thousands, it may be altogether disregarded. The following table shows this clearly :

Total number of cases.	Number of recoveries.	Possible number of recoveries in 100,000 cases, by Poisson's formula.
10	7	29,020 or 110,980
100	70	57,000 or 83,000
1,000	700	66,000 or 74,000
10,000	7,000	68,700 or 71,300
100,000	70,000	69,600 or 70,400
1,000,000	700,000	69,870 or 70,130

It is evident from this table that the variation is so slight after 100,000 is reached that the collection of additional facts would be useless labor.

2. *Data should be collected on a uniform plan*, in order to make them strictly comparable. In summing up results of treatment, for example, or the fatality of the same disease in different places, attention should be paid to the fact that the mortality of a disease usually varies in the beginning, culmination, and decline of an epidemic, and care should be taken to make comparisons accordingly.

3. *Death-rates or birth-rates should never* be combined or compounded. For instance, if A, containing a population of 100,000, has a death-rate of 30 per 1,000, and B, with a population of 50,000, has a death-rate of 20 per 1,000, the common death-rate of the two places is not to be obtained by halving the sum of these rates, *i.e.*, $\frac{20+30}{2}=25$. The death-rate of the two cities taken together would not be 25 per 1,000, for the death-rate of A gives 3,000 deaths, and that of B gives 1,000 deaths, so that both places together have 4,000 deaths in a population of 150,000, giving a death-rate of 26.67 per 1,000, instead of 25.

4. *Deaths for one year should not be compared with those of another without allowing for increase of population ;* this allowance may be made either by using death-rates instead of deaths, or in the following manner :

The deaths from measles during the year 1890 were 408. How does this number compare with the annual average of deaths from this disease for the past ten years ?

The mean population of the ten years, found by adding together the populations for each year and dividing the sum by ten, was 1,388,737. The population in 1890 was 1,631,232. The average annual number of deaths from measles for the same ten years was 653.1. This number must therefore be increased, in order to compare it with the number for 1890, by the ratio expressed by $\frac{1,631,232}{1,388,737} = 1.175$. $653.1 \times 1.175 = 767$, which therefore represents the proper number for comparison with the deaths for 1890. So with whooping-cough. Annual average of deaths for 10 years = 451.6, and this multiplied by 1.175 gives 531 as the corrected average, to be compared with the deaths for 1890, viz., 487.

In conclusion, too much stress cannot be laid, in statistical investigations, upon a strict adherence to the rules formulated by Quetelet, the distinguished Belgian statistician, viz.:

1. Never have preconceived ideas as to what the figures are to prove.
2. Never reject a number that seems contrary to what you might expect merely because it departs a good deal from the apparent average.
3. Be careful to weigh and record *all* the possible causes of an event, and do not attribute to one what is really the result of the combination of several.
4. Never compare data which have nothing in common.

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Roger S. Tracy.

VOMITING OF PREGNANCY. By way of introduction it may be assumed that no more common source of discomfort, distress, and even danger, besets the condition of pregnancy than the symptom which serves as the subject of this article. It may be asserted also, that very few who have not experienced it have any adequate idea of how distressing it may, and often does, become. It is doubtless a fact that the nausea accompanying, or at times taking the place of, the actual vomiting, is of such intensity, is of such a sickening and depressing character, is so much worse than the ordinary and commonplace nausea due to other causes, as to be to many the hardest to bear of all the trying experiences of the process of maternity.

At other times, it must be admitted, the vomiting is easy, accompanied by little, if any, nausea, and it is a noticeable fact that even in some cases in which vomiting has been frequent and persistent for months, the patients have held their flesh and strength to a wonderful degree. In these latter cases the body must hold its own with a very meagre supply of food, for to a casual observer it would appear that none is retained.

It has been customary to draw a line of demarcation between the slight and the severe cases, or between those which are rebellious to treatment and threaten life, and those which do not. The former have been called the "physiological" or "simple" vomiting of pregnancy; the latter the "pernicious," or incoercible," or "uncontrollable" vomiting of pregnancy. The correctness of these descriptive terms will be called in question elsewhere.

On the other hand, Dr. Graily Hewitt has very properly pointed out the important distinction which exists between the vomiting *of* pregnancy and the vomiting *during* pregnancy, the latter being merely an accidental occurrence in the course of pregnancy, while the former is a direct result from the fact of pregnancy.

As regards the history of this troublesome complication, it is probably the history of the human race, for from the nature of the case it must have been a frequent symptom during pregnancy at a very early period in the history of the world. What Hippocrates and other ancient worthies have to say upon the matter, however, is of far less importance than the fact that so many men in the present day show plainly by their writings how little they understand either the cause or the treatment of the trouble. The very multiplicity of theories as to the cause, and of remedies for working a cure, serves as a sufficient commentary upon the unsettled state of medical opinion upon one of the most common and important symptoms which the physician is called upon to treat. It does not seem right that so simple and every-day an experience as the vomiting of pregnancy should remain at the present day a matter of mystery, and that its treatment should continue so unsatisfactory, uncertain, and often futile. The writer believes that most, if not all cases, may be explained according to a very simple theory, and his experience demonstrates that treatment along that same line may be confidently expected to give prompt and complete relief in the vast majority of cases.

SYMPTOMS.—The most common form of this complaint is the occurrence of one or more attacks of vomiting directly after rising from bed in the morning. This may end the attack for the day, or the vomiting may recur during breakfast as well as at intervals throughout the day. So frequent is this experience on rising, that the affection has come to be universally known as "morning sickness."

At times vomiting is absent, but the patient experiences attacks of nausea instead. Either the nausea or the vomiting may begin before rising, at times even awaking the patient from her sleep, and may then recur as above stated.

In the severer forms of pregnancy vomiting every attempt to take food is followed by fresh paroxysms, and indeed, not infrequently, vomiting is well-nigh constant, irrespective of anything which is taken into the stomach. The symptoms may be so urgent that sleep is prevented, nutrition wholly fails, loss of flesh and strength are rapid, elevation of temperature, small and rapid pulse, delirium and death supervene, all in the course of a few weeks.

It has been customary to divide these severe cases, commonly known as the pernicious vomiting of pregnancy, into three stages. During the first stage the symptoms develop with more or less rapidity, as a rule giving no indication of the gravity of the situation which is to follow until, after a period varying from a few days to several weeks, the vomiting becomes so frequent and so urgent as materially to affect the patient's strength. The threatening aspect of the case now visibly augments from day to day. Nothing whatever is retained upon the stomach, and, in default of food or drink, vomiting of mucus, bile, and even blood, continues at short intervals.

No one can now overlook the serious nature of the complication. Suffering and anxiety are plainly depicted in the patient's face, the pulse has already become markedly accelerated, and then, with the advent of fever, is ushered in the second stage.

In this stage the temperature remains persistently above 100° F., the pulse varies from 100 to 140 per minute, the skin is hot and dry except that in some cases the extremities remain cold and clammy. Thirst is a prominent symptom, the mouth is parched and dry, the tongue may be cracked, and sordes may appear upon the teeth. Ptyalism and jaundice are commonly present. The urine is scanty, often albuminous and tinged with bile. As a rule, diarrhœa exists.

With the onset of the third stage most of these symptoms abate, the patient being able once more to take and

retain small amounts of food. The friends and even the physician may be deceived, thinking convalescence about to be established, while in fact this is merely the period of grave disturbance of the nerve-centres preceding death. Delirium is present, with loss of one or more of the special senses. Neuralgic pains are commonly present. The pulse remains between 120 and 140. Coma gradually supervenes and continues until death.

The period of pregnancy at which nausea or vomiting most frequently occurs is during the first six or eight weeks, though they may appear at any time up to delivery. One case is reported in which the patient was married on Monday, began vomiting on the following Saturday, and was delivered normally at such a time as to establish the fact that conception immediately followed marriage. It is probable, however, that discomfort is first noticed, in the majority of cases, somewhere near the end of the first month of pregnancy. Beginning as a slight nausea on rising in the morning, or at the breakfast-table, it may go on to the serious train of symptoms described above, or after a few days may wholly disappear. Usually the experience is one of annoyance rather than of actual suffering, and rarely continues after the fourth month.

Diagnosis.—The points involved in the diagnosis are, *first*, to determine the fact of pregnancy; *second*, to decide whether the vomiting is due to the pregnancy or is simply incidental to it—in other words, whether we have to deal with the "vomiting *of* pregnancy" or the "vomiting *during* pregnancy;" and perhaps I may be permitted to add, *third*, to ascertain the local cause of the vomiting.

It is by no means easy to establish the fact of pregnancy at an early stage, and indeed it is often impossible. Until after the first catamenial period has passed it must be chiefly a matter of inference, based upon the opportunity which has been afforded for pregnancy to occur, and upon the possibility or otherwise of the vomiting being due to other causes. As soon as one menstrual period has passed, or when other signs of pregnancy have been discovered, the diagnosis may be made to rest upon a surer basis.

The difficulties in the way of deciding the second point in diagnosis are usually less marked. The peculiar characteristics of pregnancy vomiting are usually sufficiently well marked; yet in some cases it may be necessary to avail one's self of an eliminative diagnosis, making careful examination for disease of stomach, liver, kidney, or other organ which might be productive of the symptoms, and failing to find such cause the diagnosis must rest upon the pregnancy as responsible.

The diagnosis of the abnormal conditions which serve as a cause for the vomiting will be considered under the next heading.

Cause.—Here we reach the great point of difference which exists between observers, and yet the point upon which it is most important that definite and correct views should exist, for upon it must rest the most successful treatment. It has been customary to attribute the vomiting to a reflex irritation proceeding in some mysterious way from the developing ovum, but more stress has commonly been laid upon the condition of the patient, whether as concerning her stomach or her nervous system, which made this irritation potent for evil, than upon the source of irritation itself. Moreover, as regards the nature of this irritation, men have held, and hold to-day, most divergent views, though it is coming to be admitted more and more generally that its origin is to be found in some abnormal pelvic condition.

My own preference is to consider that a number of causes may operate in different cases, or even in the same case, to produce the symptoms, and these causes should be classified as predisposing and exciting.

As to the predisposing causes, the chief is undoubtedly that state of exalted nervous sensibility which shows itself in so many and in such unmistakable ways during pregnancy. It is a matter of universal observation that trifling emotions, whether of fright, grief, annoyance, or otherwise, produce in the pregnant woman results far surpassing those which she would ordinarily experience. Similarly, it is doubtless true that conditions giving rise to irritation of sensory nerve-fibres may give rise to correspondingly exaggerated results in the way of reflex phenomena.

Undoubtedly an important factor in this connection lies hidden in racial conditions. In no other way can we adequately explain the fact that Carl Braun, in his enormous experience, has never met with a fatal result, nor even with a case sufficiently serious to require induced abortion, while in France, England, and America a fatal termination is far from being a rarity. Hirst, in the recently published "System of Therapeutics," shows a mortality of 95 in 239 cases reported.

Other factors may possibly be found in the hydræmic condition of the blood; the condition of fear, or at least the state of introspection and anticipation in which so many newly pregnant women find themselves; the various functional perversions of taste, smell, appetite, and digestion; and lastly, and more generally, in the presence of gastric catarrh in more or less marked degree.

Far more important, however, are the exciting causes which, as has already been suggested, will usually be found in some abnormal condition of the pelvic organs.

The theory which has been held in favor the longest is perhaps that of Bretonneau, who considered that the distention of the body of the uterus by the growing ovum, caused pressure upon, or tension of, the nerve filaments, so setting up a reflex irritation. To a superficial observer this serves as a very satisfactory explanation, yet it fails utterly in many cases and must be rejected as inadequate. This distention occurs in every case, and yet many escape the nausea altogether, while others have it in one pregnancy and not in another. Moreover, the symptoms cease in most cases, while this distention is still going on, and often the cessation is sudden and complete.

Another theory rests upon the supposition of metritis, yet metritis is more common in those who have borne children, while the vomiting of pregnancy is more common in primiparæ.

Still others, notably Veit, believe that endometritis, pre-existing and aggravated by pregnancy, is the source of the reflex irritation. That this may be a factor in some cases is quite likely, but it can hardly explain the phenomena in most, or even in many, cases.

There are those who hold lacerations and erosions of the cervix responsible, but in most cases such lesions do not exist.

Coming now to the theory advanced and ably advocated by Dr. Graily Hewitt, I believe we find the chief, though not the only, cause. He is often quoted as teaching that anteflexion is the sole factor, but this interpretation is far from correct. He finds that "the alterations of the uterus proved by recorded cases to be most frequently present in cases of severe vomiting are:

"*a.* Marked flexion forward and backward.

"*b.* Rigidity of tissues of the cervix.

"*c.* Impaction or detention of the uterus in the pelvis.

"These three factors are most frequently associated in various degrees of severity."

Upon these facts rests his theory that the reflex irritation consists in "undue pressure or tension of the nerve filaments distributed in the walls of the cervix, especially those in the vicinity of the internal os;" . . . "this pressure or tension may arise in any case where that expansion process in the tissues of the cervix which is natural to pregnancy is delayed or obstructed by the condition of the cervix."

Now, if it be borne in mind that during the early weeks of pregnancy the uterus commonly gravitates toward the pelvic floor, it will at once be seen that any previously existing flexion must be exaggerated. If it be still further remembered that the normal condition of the uterus is one of moderate anteflexion, which our modern methods of dress, together with other injurious influences of civilization too often make pathological anteflexion, the preponderance of cases of anteflexion in these statistics of vomiting of pregnancy will not be wondered at.

It will be noted, however, that flexion need not neces-

sarily be present in order to explain the vomiting in accordance with this theory. If by reason of a laceration of the cervix, with subinvolution and chronic metritis as a consequence, the tissues at and about the internal os have become so indurated as to prevent their normal and equable expansion, injurious tension of the nerve filaments is produced. If, again, the uterus be held down in the pelvis by firm adhesions, or by the added weight and bulk of a fibroid, impaction and injurious pressure is just as surely produced as in the case of a flexion.

Other ingenious but less plausible theories have been advanced, but aside from admitting the general truth that almost any form of pelvic disease may in isolated and exceptional cases be a prominent factor, these theories need not be considered here.

My own belief is more liberal than is that of many who have written upon the subject, for while I hold most tenaciously to the general fact of a local cause to be found within the limits of the true pelvis, I yet admit most of the special theories above mentioned. Most prominently I should place Dr. Hewitt's explanation in its broadest interpretation, viz., anything that prevents the free and uniform expansion of the cervix, particularly in the immediate neighborhood of the internal os.

Following this are to be grouped indifferently the various factors of metritis, endometritis, lacerations and erosions of the cervix, and the sundry other forms of pelvic disease which may be operable in rare cases.

Having now ascertained that, whatever the degree of pregnancy vomiting, it springs from some abnormal condition and not at all as a natural and inevitable result of pregnancy, we cannot escape the conclusion that there can be no such thing as "physiological" vomiting, and that, therefore, no difference save one of degree exists between the light and the severe cases. All vomiting during pregnancy, as at other times, is abnormal and must be so regarded and so treated.

Treatment. — It having been established that the chief factor in practically every case of vomiting of pregnancy is some abnormal condition of the pelvic organs, it follows naturally that the most effective treatment must be directed toward the removal or cure of such condition. And just here it should be urged that success in treating the vomiting will be in very close ratio to the accuracy of the diagnosis of the pelvic cause and the intelligence of the treatment applied to it. Let no one who has not good cause to consider himself competent to correctly map out the true condition of the pelvic organs rest content with the delusiou that there is no pelvic cause for the vomiting because he can find none. In such a case no one but a well-trained gynæcologist is competent to pass final judgment, and it must be confessed that even he is fallible.

Most frequent in the list of abnormal pelvic conditions is anteflexion of the body or cervix, associated in most cases with more or less prolapse. For this Graily Hewitt recommends gentle elevation of the base of the bladder and the superimposed fundus of the uterus with the finger. Failing thus he advocates the use of the air-ball pessary, which is to be inflated after insertion. This pessary must be perfectly spherical, and must, when distended, measure not over two and one-quarter inches in diameter, the size rarely needing to be over two inches.

Antiseptic precautions are to be observed before and after insertion, the patient to maintain the horizontal position, and the pessary to be removed at the end of six or eight hours. It may be necessary to repeat this treatment daily until the position of the uterus becomes permanently improved. Care must, of course, be exercised to prevent the induction of abortion by too great or too prolonged pressure due to the presence of the pessary.

Personally I have no experience with this method, though it is a means well worth remembering, but have relied upon the knee-chest position, digital elevation, and packing.

In fact, so common is this condition as a factor, and so effective is the first part of the treatment alone, that I am in the habit of prescribing it as a routine treatment in the ordinary cases of pregnancy vomiting as they present themselves in the hospital clinics and in private practice, and I do not hesitate to assert that relief is complete in eighty per cent. of the cases.

The patient is told to assume a position on her knees, her hips high in air, her chest touching the bed, *every band being loose about the waist*, and then, either by opening the vagina with the finger or by introducing a glass-tube, to admit air to the genital tract. This is done regularly night and morning, and at any other time when nausea is felt.

This failing, I place the patient either in the knee-chest or Sims's position, and, after attempts at digital elevation of the fundus, place a soft but firm packing of cotton tampons *wholly anterior* to the cervix. The first half of the packing is prepared with glycerine, for its depleting effect, the remainder being dry, to act as an elastic air-cushion. In order to get this latter result the cotton must be non-absorbent, the grease in the fibre serving to repel moisture and hold the air.

In one of these ways most cases of pregnancy vomiting may be relieved, but there remain those cases in which other causes are operative.

Retroversion and retroflexion are to be corrected by the aid of the knee-chest position, bimanual manipulation, and packing placed as high up as possible *behind* the cervix and extending down to the perineum. Once replaced the uterus is to be retained by some form of pessary.

In cases presenting erosion of the cervix, and in not a few cases showing no such sign, relief has promptly followed the nitrate-of-silver treatment. Indeed so successful has this treatment proved in some hands that it is now the routine method in the Vienna clinics. It is applied as follows: The cervix is exposed by a cylindrical glass speculum, the end of which it just fills, and after a thorough cleansing enough ten per cent. solution of silver nitrate is poured in to cover the exposed surface. After ten minutes this is decanted and the mucous membrane is dried. A second, and even a third, application may be called for after an interval of two or three days.

Should inflammatory processes be present, either in or about the uterus, the ordinary measures of rest, hot douches, and vaginal medication are in order. It is probably in such cases that benefit is had from vaginal suppositories or dressings of belladonna, cocaine, and morphia.

In all the more serious forms of the complication absolute rest in bed, in the horizontal position, is of much importance. Besides its general therapeutic value it permits the uterus more easily to rise above the brim, and aids us in our endeavors to correct displacements and lessen impaction. Coitus, and whatever may tend to cause sexual excitement or otherwise to increase pelvic congestion, must be avoided.

First discovered accidentally, and then practised empirically, Copeman's procedure has an established place in the treatment of severe cases. This consists in the careful dilatation of the cervical canal up to, but not through, the internal os. The index-finger is used by preference, though Wylie has used in a number of cases a steel-branched dilator. Whether this acts by separating constricting bands of tissue, by straightening flexion, by breaking up impaction, or by some less apparent means, is not as yet agreed, but in many cases where abortion has not resulted a cure has been obtained.

Besides the local cause, however, it is usually desirable to treat the conducting apparatus by which the reflex stimulus is conveyed. In other words, it is well to endeavor to lessen susceptibility to reflex irritation by the use of nerve sedatives, such as bromide, valerian, chloral, and even morphia. Chloral in full dose by rectum, night and morning, sometimes gives great relief, as does also morphia, introduced hypodermically or placed dry upon the tongue.

Chapman's ice-bag to the spine has occasionally been found of service.

Then comes the long list of drugs for lessening the real or fancied irritability of the stomach. These must always be of secondary importance, and yet where symptoms are trivial they may answer every purpose at a min-

imum of annoyance to the patient, and where the outlook is grave we cannot afford to lose any help, however trivial, which may tend toward a cure. While, then, such remedies may always be given a place, reliance should not be bestowed upon them to the extent of wasting valuable time, or to the neglect of more rational measures.

In not a few cases gastric catarrh plays a more or less important part and claims attention. The ordinary remedies may be used, particularly the alkaline salines, taken well diluted before rising. Cocaine in small doses frequently repeated ; creasote, or creasote and comp. tr. iodine in equal parts, given in one-drop doses every half-hour ; oxalate of cerium in five-grain doses alone or combined with bismuth ; calomel and ipecac in minute doses ; hydrocyanic acid ; tr. nux vomica ; pepsin ; ingluvin ; champagne ; hot water ; ice—these and other empirical means may be employed for their direct effect upon the stomach.

The diet and the mental surroundings of the patient must be carefully guarded. Our endeavor must be to keep up the strength at the same time that we spare the atomach needless effort by giving the lightest and most digestible foods. These are best given in small and frequent portions, bearing in mind that often food will be retained if given just after a paroxysm of vomiting has spent itself. It must be remembered also that a patient can sometimes retain and assimilate an article of food for which she experiences a marked longing, when seemingly more appropriate articles are at once rejected. The simple expedient of giving a light and easily digestible breakfast an hour before rising will sometimes solve the problem in those ordinary cases which are known as "morning sickness."

When, however, the stomach rebels to such an extent that the patient's strength perceptibly fails, resource must at once be had to rectal alimentation. Milk, eggs, and predigested beef form the best basis for these enemata, to which may be added, if necessary, a few drops of laudanum and half an ounce of whiskey. Four injections, of four ounces each, given within twenty-four hours, can generally be retained, provided that once daily the lower bowel be well emptied by a cleansing enema of warm suds. Life can be sustained for weeks in this way when all else fails.

Recognizing the fact that mental conditions play an important part in some cases, the patient must be cheered and encouraged at all times, and at the present day it is a pertinent question whether hypnotic suggestion might not prove a valuable aid in properly selected cases.

We now come to that class of cases which resists all the measures at our command. The patient has reached the second stage described above, and the question of emptying the uterus presents itself. Of course it is assumed that no one will lightly decide upon this last resort without good and sufficient cause ; yet on the other hand there is need to urge the danger of too long delay. Provided a faithful trial has been made of less radical measures, and in spite of them the gravity of the symptoms continues, let no time be lost in producing abortion, preferably by emptying the uterus at one sitting, under ether. The reason for thus urging against delay lies in the fact that even abortion may fail to avert the fatal issue if the third stage be permitted first to make its appearance. *Rufus A. Kingman.*

WALLER'S LAW. In 1852, Waller, in his paper in Müller's *Archiv*, entitled "Sur la reproduction des Nerfs," announced the discovery that after section of a peripheral nerve that portion lying beyond the injury suffers characteristic changes. The axis cylinder and medullary sheath degenerate, and the nuclei of the sheath of Schwann at first proliferate and then disappear, leaving only a fibrous rudiment of the sheath in the place of the nerve. Waller explained this degeneration by assuming that the central organ exerts a trophic (nutritive) influence upon the peripheral portion, which influence is removed by section of the nerve. In conformity with this it was concluded that degeneration pursues the path of the stimulus. These conclusions were expressed as the now famous "Waller's Law." In 1868–69 Vulpian published results of a study of the spinal cord of persons who had suffered amputation years previously. He found that the corresponding half of the cord was greatly reduced in size, especially in the segments whose nerves had been amputated. Vulpian discovered only an attenuation of the fibres without any inherent change of structure, but both white and gray substance were reduced in the cord (in some cases in the dorsal, in others in the ventral, cornu). The ganglion cells were normal, and he described the change as simple atrophy. Dickson ("Transactions Pathological Society of London"), in 1873, called attention to diminution in size of the anterior cornu and the degeneration and pigmentation of the cells, and, a little later, Hayem stated that the number of cells is reduced and that the vestiges of the lost cells can be detected. Friedländer and Krause, on the other hand, deny that there is any structural change, and limit the disappearance of ganglion cells to the lateral groups of the ventral cornu. Special importance is attached to the diminution of the dorsal cornu and columns. A disappearance of cells in Clark's columns was also reported. The nerve stump was found reduced in size and about half its fibres diminished by at least a third, with corresponding structural changes. The ventral root is unaltered, while the altered fibres are traced into the dorsal. It is, therefore, concluded that the observed changes are all limited to the sensory fibres and their connections.

Mayser, after eradication of the ischiadicus, detected reduction in the gray matter of the dorsal cornu and some modification of the ventral cornu. Vejas, in 1883, stated that after tearing off the roots of a spinal nerve, the stumps *both* degenerate, and that the ganglion will degenerate after section of the peripheral nerve. Joseph and Kahler, however, very soon after reinvestigated the matter, with results which corresponded fully with Waller's law. Von Gudden and his students have applied the same method to the cranial nerves. When the facial was torn out from the canalis Fallopiæ the root fibres and deeper nidulus disappeared. The root clusters of the eye-muscle nerves were located by the same means. The nidulus of the twelfth was found to atrophy on section of the hypoglossus, though Roller's nidulus was unaltered. Professor Forel applied the same method to the trigeminus and detected great degeneration in the ascending root of the vagus and little in the motor root.

These experiments chiefly relate to young animals, and many of the effects must be ascribed to failure to properly develop on the part of the structures related to the destroyed root. Forel, however, eradicated the facial from an adult guinea-pig, and after one hundred and forty-one days found a total decomposition of the fibres and cells. It must be noted that simple section of the motor nerve root never seems to produce as profound a change as forcibly pulling it out. Forel thinks much depends on the point where the nerve is interrupted. Whether the central portion degenerates or not is largely determined by the relative size of the severed part to the remaining part.

Nissl claims to have observed histological changes in the cells of the facial nidulus twenty-four hours after the eradication of the nerve. These changes consist in partial decomposition of the chromatin figure. On the second or third day the entire cell is affected. On the tenth day many cells have quite disappeared.

In 1890 Singer and Münzer applied the Marchi method to this subject. This method consists in preservation of the tissue in Müller's fluid for three or four days, then dividing into small fragments and leaving six days more, then substituting for Müller's fluid a mixture of two parts of Müller's fluid and one part of one per cent. osmic acid, which is employed for over a week. After washing, hardening is completed in alcohol gradatim, and sections are made in photoxylin. Those portions which have degenerated become intensely blackened, while the normal fibres retain the brown color of the chromic preparation. As a result of this method, Singer and

Münzer decide that Waller's law is correct—that the "ascending degeneration" reported in motor nerves is not a true ascending degeneration such as occurs in sensory nerves.

Bregman, more recently, has applied the same method to the cranial nerves and finds that the motor roots degenerate, but that the degeneration proceeds from the cell outward. Thus Forel's theory is shown to be incorrect, and a genuine trophic influence of the nerve cell is suggested. The degeneration takes place in the same way whether the nerve is sectioned near or far from the point of exit. These pathological phenomena are intimately associated with the physiological results of Gotsch and Horsely. The applicability of Waller's law is not discredited by the fact that even motor fibres may be destroyed by peripheral section, for the source and direction of the changes obey the law that growth and degeneration are governed by the influence of the parent cell. *C. L. Herrick.*

WATER, BIOLOGICAL ANALYSIS OF. Introduction.—Until very recently the examination of drinking-water for sanitary purposes was left entirely in the hands of chemists; but, with increasing accuracy in biological methods and a better knowledge of the living organisms found in water, biological analysis has come within a few years to be considered indispensable in the scientific study of a water. At present neither chemical nor biological analysis alone suffices, but both are necessary, and there is thus no question of the new method superseding the old.

The earliest contribution of importance to biological water analysis was that of Hassall, whose vivid description of organisms and organized detritus found in Thames water in 1850, was largely the means of inaugurating a much-needed improvement in the London water-supply. From this time the examination of water sediments under the microscope began to receive attention. The accurate study of bacteria found in the water was not at that time possible, though it was attempted by Burdon-Sanderson, in 1874, while Pasteur even cultivated pathogenic bacteria from water. Quantitative accuracy first appears in the work of Koch, who examined samples of water by means of his gelatine-plate method, and made a numerical estimation of the water bacteria a comparatively easy matter to all workers.

For several years the advances made in biological water analysis were practically confined to bacteriology, and it was only in 1890 that the ingenious methods perfected by Sedgwick and Rafter enabled the other organized constituents to be studied quantitatively with the same convenience and accuracy as the bacteria.

Qualitative work has lagged behind quantitative, and it is in regard to the nature and significance of the organisms living in water that our knowledge is most deficient. The determination of the species of bacteria, and the relation which they and the other organisms in water bear to public health, are the problems which now engage the attention of workers in this field. The difficulty of cultivating and experimenting with the non-bacterial organisms remains a serious drawback.

With the exception of deep springs or artesian wells, natural waters invariably contain a certain number of organisms; in other words, all surface waters contain organisms. Roughly speaking, the number of organisms present is in inverse proportion to the purity of the water, and hence the importance of quantitative methods. Of aquatic *fauna* and *flora* the bacteria are those most important in relation to public health, owing to the fact that so many of the infectious diseases are known to be caused by bacteria, and that the epidemic outbreak of such diseases is often associated with contamination of water-supplies.

For convenience the subject will be considered under the following headings:

I. Microscopic examination of organisms other than bacteria.
II. Quantitative bacteriological analysis.
III. Qualitative bacteriological analysis.
IV. Pathogenic organisms in water.
V. Bibliography.

(It was originally intended to give diagnostic tables of the bacteria and other organisms found in drinking water, but this has been found impracticable.)

Microscopic Examination:—Organisms other than Bacteria.—Until the convenient and accurate method devised by Sedgwick and Rafter became known, much less progress was made in the examination of the other microscopic organisms as compared with the bacteria. Their examination was conducted, as a rule, in a perfunctory manner, and the possibility of comparison between the results of different observers was very limited. The usual method adopted consisted in allowing the organisms to precipitate in the form of a sediment, of which portions were taken for examination. This sediment was obtained by allowing the water to stand in conical glasses, and be collected from the bottom of these by a pipette at the end of twelve to forty-eight hours.

While this gave a general idea of the nature of the sediment, it gave almost no information as to the amount in which the different organisms were present. Further, those forms which were motile, or lighter than water, were likely to be overlooked. By the Sedgwick-Rafter method all the organisms in a water are strained off by means of a sand filter placed at the bottom of a funnel, through which a given quantity of the water is poured.

The filter is formed by stretching a piece of fine silk bolting-cloth over a perforated rubber cork and forcing it into the outlet of the funnel. Upon this a layer of fine sand, about half an inch in depth, is poured. This sand, having been previously washed with distilled water until the washings are proved microscopically to be free from organisms, is then dried and kept for use. The water to be tested is poured into the funnel and allowed to filter through the sand. As the first 200 c.c. usually comes through rapidly and contains a considerable number of organisms, this amount should therefore be poured back into the funnel. When the amount of water to be examined has run through (500 c.c., as a rule, is a convenient amount) the cork should be carefully withdrawn and the plug of sand (which remains fast in the neck of the funnel) is to be carefully washed out with exactly 10 c.c. of distilled water into a wide test-tube, and shaken up until the organisms entangled in the sand are evenly distributed through the water. 1 c.c. of the washing is then to be withdrawn by a pipette and placed in a special form of cell, which should have a depth of 1 mm. and be 50 mm. in length by 20 mm. in width. The sides of the cells can be readily cut out of soft type-metal at any type-foundry and cemented on glass slides by means of balsam. The capacity of such a cell, when closed in by a large cover-glass, is exactly 1 c.c., and its area is 1,000 square mm.

If one litre be filtered, and 10 c.c. contain the entire sediment, the water is concentrated 100 times, so that the number of organisms found in 10 square mm. of the surface represent directly the number per cubic centimetre. For example—if in the case of the organism Dinobryon, in counting ten squares, we obtain the following results: 0, 1, 4, 0, 0, 2, 0, 1, 0, 0, total 8, we know that this organism is present in an average of 8 per c.c. $\left(\frac{8}{10} \times 1{,}000 \times \frac{1}{100} = 8\right)$. In other words, we divide the total number of organisms found in a given number of squares by the number of those squares, multiply the result by 1,000, representing the proportion which one square bears to the cubic capacity of the cell, and divide by the number representing the concentration of the water.

An error, of course, is multiplied 1.000 times where only one square is examined, and 100 times where 10 squares are examined. To get an absolutely correct estimation of the number of organisms of a given sample, it would be necessary to count the entire 1,000 squares; but I have found that the examination of 10 squares gives sufficiently accurate results. To eliminate a certain personal element, caused by the tendency to overlook

squares containing no organisms and select those containing them, where the distribution of the sediment in the cell is unequal, Rafter has recommended the employment of a rack-and-pinion mechanism, by which the cell is moved exactly one c.c. each time, which forms a valuable addition to the method. The same result can be obtained with any mechanical stage, where movement in each direction is recorded upon a sliding scale.

In the original apparatus introduced, the floor of the cell was ruled into square millimetres, but as this adds considerably to the expense, the ruling is now dispensed with, and, instead, a small disk of metal or black paper is introduced into the eye-piece, having a square aperture cut to correspond exactly with one square mm. on the slide at a given tube length with the objective and eye-piece used. Objective BB Zeiss with eye-piece No. 3 or No. 4, will be found convenient for counting. A high-power lens with a long focal distance is needed for identifying the smaller forms.

To check the results, instead of examining a larger number of squares in the same specimen, I prefer to examine the sediment from two different samples of the same water. If corresponding results are found in each case, the results are evidently to be depended upon, and with careful working I found this usually the case. A certain proportion of the organisms tend to adhere to the sides of the funnel, and these should be washed down with distilled water. It is not advisable to hasten unduly the filtration, one hour being a minimum time for the separation of organisms from a litre of water.

The amount of organized débris and detritus present may also be estimated, and it has been suggested to employ a mental unit by which 20 square microns represent the average area of a single mass of amorphous matter.

Rafter recommends counting the organisms in 20 squares. When 500 c.c. of the water are filtered and washed with 10 c.c., the total of twenty squares gives directly the number per c.c.

The organisms are best registered by genera, under the following headings: (1) Diatomaceæ, (2) Desmidieæ, (3) Chlorophyceæ, (4) Cyanophyceæ, (5) Other Algæ and Fungi, (6) Rhizopoda, (7) Infusoria, (8) Larger animal forms, (9) Miscellaneous and amorphous matter.

A source of error in the system of recording per c.c. is that it is impossible to express numerically the amount in which a given organism is present below 0.5 per c.c., as this number would be given if only a single individual was met with. This difficulty is got over by indicating the occurrence of a solitary organism by the letter *p* (present), to indicate its presence in numbers less than can be expressed quantitatively by the method.

The diagnosis of the organisms in water will probably be found difficult even by those accustomed to microscopic work. To recognize with facility a large number of animal and vegetable forms, presenting few points of distinction, requires special training. Probably those who have amused themselves with dilettante work, making a hobby of the organisms found in ponds and ditches, find less difficulty with the diagnosis than those who have a more accurate, but at the same time more limited, knowledge of biology. The assistance of a skilled botanist or zoölogist is most valuable to a beginner. One of the great difficulties is that no one text-book deals systematically with the diagnosis of the forms likely to be met with in water, and it is necessary to consult a varied and greatly scattered literature.

For sanitary purposes the diagnosis need not be carried beyond the establishment of the *genera*, as we do not know of any cases where particular *species* of algæ, etc., possess any special significance. Though the number of genera to be recognized is large, it bears but a small proportion to the totality of forms described. As a rule, not above 20 different organisms occur in one sample of water, and 200 or 300 genera include the great majority of those likely to be met with. Of course, the more accurate study and determination of species is highly to be recommended, though the results obtained are of scientific rather than of sanitary interest.

Various liquids have been recommended for the preservation and study of the water algæ and infusoria, the most useful agent being a watery solution of osmic acid, of which 1 to 10 drops of a 1 per cent. solution are to be added to 1 c.c. of the water containing the organisms. A gradual addition of the osmic acid prevents the more delicate organisms becoming brittle by exposure to concentrated solution, and at the same time replaces the acid, which is reduced at first by the contact with organic matter. Many forms can be preserved in a 10 to 30 per cent. glycerine solution, which may be lightly tinged with basic aniline or eosin stain. Camphor water, naphtha water, 1 per cent. carbolic or salicylic acid in 25 per cent. glycerine, form preservative media in which the color of the green algæ is preserved; but as a general rule, the trouble of preserving algæ and infusoria in this manner is greater than is justified by the results.

Beyerinck has succeeded in obtaining gelatine cultures of Scenedesmus, Chinella, and a few other algæ in 8 per cent. nutrient gelatine made with decoction of the green scum from stagnant water, and Ogata has isolated certain protozoa and infusoria in this medium.

A fairly large number of observations which we now possess as to the distribution of organisms other than bacteria in certain waters have, it must freely be confessed, not as yet led to any very valuable hygienic deductions, but possibly better results may be looked for in the future. Attempts have been made to trace the association of large numbers of particular organisms with the occurrence of disagreeable odors and tastes in the water, but very little that is definite has been arrived at. G. H. Parker, from an example of 500 samples of water in Massachusetts, of which about half possessed distinctive odors or tastes, found that in 90 per cent. of the waters possessing distinctive odors large numbers of organisms were present, while 90 per cent. of the waters free from strong odors and tastes were characterized by a striking freedom from organisms. As the attempt to associate particular organisms with special forms of odor has led to very discordant results, no specific effects can be set down as the inevitable result of the presence of any one organism.

Sponge spicules have been held responsible for the occurrence of a nauseous fishy taste in waters, largely owing to the fact that they were charged with being the cause of it in one case where a reservoir water was examined by Professor Remson. The presence of large numbers of Cyclops or Daphnia, and the occurrence of Crenothrix, were also thought to account for objectionable flavors and odors in particular waters.

The occurrence of odors and tastes in water does not appear to depend so much upon the *presence* of organisms as to their *destruction in large numbers*, and the putrefactive products from the decomposition of the dead organisms, so that the tastes complained of are probably not due immediately to the organisms found, but rather to the bacteria which decompose them when dead. The presence of accumulations of organisms in reservoirs, supply-pipes, etc., should be studied by comparing samples from different points—the inlet, the reservoir, the outlet, etc.—as they can thus be often located in particular districts.

Sponge spicules appear in abundance only when the spongilla which produce them are being destroyed, that is to say, during the winter months. In the spring and early summer, and during the warm weather, when the sponge growth is most abundant, few spicules are met with. The sponges usually attach themselves to the upper portion of pipes; if attached to the lower side they are apt to be destroyed by accumulation of detritus within their pores (G. H. Parker).

Crenothrix is one of the very few organisms which thrive in the dark; for most other algæ a certain amount of light is necessary to growth. In order, therefore, to secure a water against growth of algæ, filtering basins, reservoirs, etc., should be protected from the light, even a very small aperture being sufficient to admit enough light to allow of considerable growth. On the other hand, access of light is beneficial, as it tends to destroy the bacteria and promote self-purification of the water.

Whether settling basins and filter galleries should be open or covered, is still a question upon which opinion is divided.

The presence of many crustacea, rotifera, and anguillula is regarded as an objectionable feature in a water, though they are present in a number of undoubtedly pure waters, and cannot in themselves be regarded as dangerous.

Pettenkofer and Löwe maintain that algæ, especially Euglena, play an important part in purifying the water, by assimilating the products of decomposition, such as glycocol, leucin, kreatin, and neurin, in weak solutions of which the algæ were found to grow readily.

Extraneous Substances.—Certain organized elements, when recognized microscopically, are indicative of contamination; the presence of meat fibres, squamous epithelial cells, and fragments of vegetable tissue, are to be regarded with great suspicion, as indicating contamination directly by sewage, or by household and kitchen waste. Matters which can be directly traced to the pollution by sewage, form the most objectionable constituent that a water can possibly contain.

Starch.—The occurrence of starch granules in water is a feature which has, apparently, received a wrong interpretation. It is usually stated that starch indicates contamination by food-products, and that partially digested starch, whose granules can be identified with corn, potato, etc., is a direct proof of contamination. The writer was considerably surprised to find that the water of the Ottawa River (a stream so large as to render contamination of its total volume out of the question) habitually contained starch granules. These were present at all seasons of the year in numbers varying from 0.3 per c.c. to 3 per c.c., and water of the Montreal supply derived from this source, collected from districts where the circulation in the mains was defective, even contained as many as seven granules per c.c. As this was the only suspicious feature of the water, it was difficult to reconcile such large quantities of starch with the fact that chemical and bacteriological examination pointed to a remarkable freedom from contamination.

Further study of the characters of the starch granules showed that they corresponded exactly in form, size, markings, and polarization to corn-starch. The introduction of corn-starch from the waste of factories could not be seriously imagined, as no such establishments are to be found along the course of the river, and on the other hand, the St. Lawrence water was never found to contain starch, although several large starch factories exist on its banks. In any case, the aim of a starch factory is to save its refuse, and not to throw it away, and, as a matter of fact, the profitable working of a starch factory depends largely upon the careful saving and selling of the waste. What appears to be the correct explanation of the presence of starch in Ottawa waters was suggested by Dr. G. P. Girdwood, of Montreal, namely, that it was derived from the bark of the white pine, of which 3,000,000 to 10,000,000 logs are sawn every year in the Ottawa districts, the sawdust being thrown into the river and accumulating there in quantities sufficient to produce obstruction to navigation.

An examination of the bark of the white pine showed it to contain numerous starch granules, which, as will be seen from Figs. 655, 656, 657 correspond closely both to the starch found in the water, and to corn-starch. The somewhat greater tendency to a rounded outline found in the starch in the water, compared with that in the fine bark, is probably due to the effects of soaking, and the change due to maceration of white pine starch, as shown in Fig. 658, where the outlines simply become rounded, distinguishes it from the maceration effects of corn-starch, where the granule becomes brittle and splits up into segments, as shown in Fig. 659.

The derivation of starch from aquatic plants natural to water was also a source to be borne in mind, but the writer was unable to find any water-plants which contained granules corresponding to those found in the Ot-

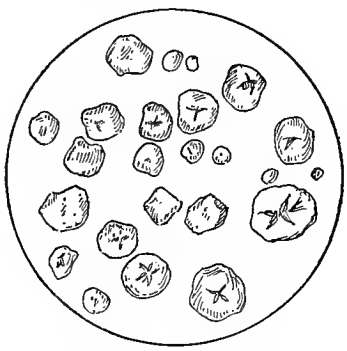

Fig. 655.—Corn-starch. × 200.

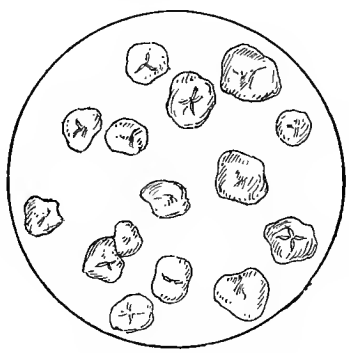

Fig. 656.—Starch from Bark of White Pine. × 200.

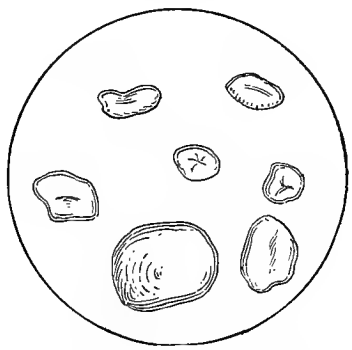

Fig. 657.—Starch Grains from Montreal Water. × 200.

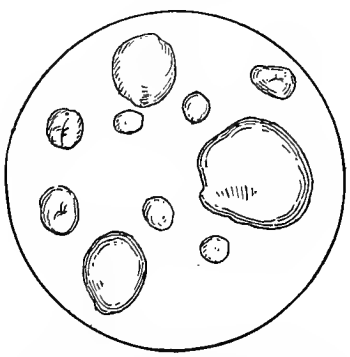

Fig. 658.—Starch from White Pine after Maceration. × 200.

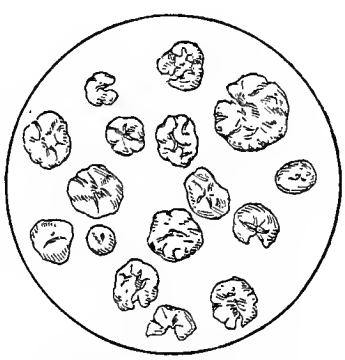

Fig. 659.—Corn-starch after Maceration. × 200.

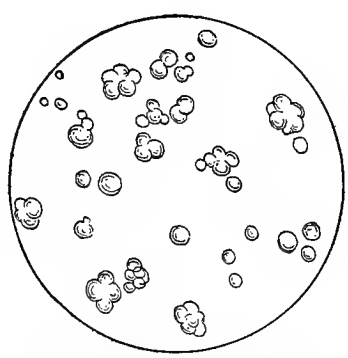

Fig. 660.—Starch from the Yellow Water Lily (Nuphar). × 200.

tawa water. The only two plants likely to produce starch in sufficient quantities to enable its presence in the water to be detected, are the Yellow (Fig. 660) and White Water Lilies *Nuphar Nymphæa*, and the Wild Rice or Water Oats (Fig. 661), in both of which the granules are not only considerably smaller, but of a different shape and outline from those found in the Ottawa.

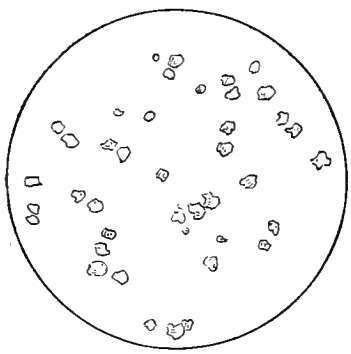

FIG. 661.—Starch from Wild Rice. × 200.

The rhizome of the sweet flag (Fig. 662) also contains numerous starch granules, considerably smaller than those of corn. As an aid in distinguishing starch corpuscles from these different sources the following table of dimensions will be found useful:—

Starch granules from.	*Size.*
Water sediments	11.4 to 28.0 μ
White pine bark	8.0 to 28.0 μ
Corn	5.7 to 27.0 μ
Sweet flag	6.0 to 13.0 μ
Wild rice	5.7 to 13.0 μ
Nymphæa (white water lily)	1.9 to 7.6 μ
Nuphar (yellow water lily)	3.8 to 13.3 μ

(After Professor D. P. Penhallow.)

The presence of starch in a water may thus be accounted for without necessitating the assumption of sewage or industrial pollution. Besides the sources mentioned above, it is probable that others exist, as the writer

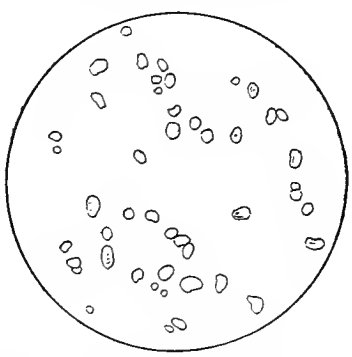

FIG. 662.—Starch from Sweet Flag Root. × 200.

has found starch granules not dissimilar to those mentioned in waters where pollution by sawdust was out of the question. The subject is one requiring further study and observation.

The presence of textile fabrics, etc., is occasionally noted where waters receive the washings of factories, but probably a large number of the observations on this head are due to errors in manipulation, where the cloths used in cleansing the apparatus have been the real source of the fibres. When an examination for fibres is to be made, a large amount of water—several gallons—or in the case of a tap-water, several hundred gallons, are to be strained through a glass wool filter; the filtering substance can then be crushed and examined in a Petri dish. It is rare with these precautions to find any trace of fibres.

Human and animal hairs are said to have been found, both in the water and in ice, but rarely by experienced observers; and the observations probably often rest on erroneous grounds.

A fecal origin of contaminating substances is not established with certainty by the detection of vegetable kitchen refuse. These fragments of starch do not always give the iodine reaction. If fragments of boiled starch-grains are found in a water it points to a contamination by kitchen refuse.

The detection of particles of meat fibre in a water is of more significance, as meat is not digested to the same degree as starch, and small muscle fibrils are always present abundantly in stools. Both raw and cooked muscle-fibres present, under the microscope, distinct striation and sharp ends, and are of a grayish color. When, however, a muscle has been partly digested, it appears as golden-yellow, glistening masses, with rounded outline and blunted angles. The striation may be either preserved or entirely absent. The arrangement in bundles is sometimes clearly seen. The masses burst upon pressure. When seen in a bright microscopic field, the yellow coloration by bile-pigment is often very marked, and may be retained after three or four weeks' standing in frequently changed water (Gaertner). The detection of such particles in a water, as, for instance, was accomplished by Snow, in the case of the Southwark and Vauxhall Company in London, is sufficient evidence to establish with certainty that contamination with fæces has taken place.

Intestinal epithelium, fat crystals, mucus, connective tissue, elastic fibres, etc., have scarcely ever been detected in water.

PARASITIC ORGANISMS IN WATER.—*Malaria.*—That malaria prevails only in damp, ill-drained regions is a fact of such general experience, that there can be no doubt that the plasmodium malariæ is, for its development, dependent in some way upon water. The entrance of the parasite into the human system appears to be accomplished by inhalation of miasmatic vapors rather than by drinking the water. A number of forms allied to the *plasmodium malariæ* are found in the amphibia (Danielewsky), and recently Coronado claims to have succeeded in cultivating the plasmodium of Laveran in water from a malarious stream.

Filaria sanguinis hominis appears to be connected with damp regions, but probably the infection is accomplished by the aid of an intermediary host (mosquito), and not directly from the water.

The *filaria medinensis* is not infrequently found in the cellular tissue of man. The embryos have been traced to small crustacea. (Cyclops.)

The *distoma hepaticum*, in its embryo stage, infests the small form of water snail (Limnæus minutus).

Distoma hæmatobium, found chiefly in Africa, has proved fatal to man. The ova infest small mussels and water insects, as intermediary hosts, and these are supposed to be ingested by drinking-water.

Parasitic Ova.—The ova of many parasitic entozoa retain their vitality for a long time in water, and some forms, notably the *Bothriocephalus latus*, become, in one phase of their development, free swimming embryos. The direct use of this water by man, for drinking purposes, is not dangerous, but fish (pike) in waters containing the dejecta of patients harboring bothriocephali, develop the cysticercus stage of the parasite, and fish from such waters, if imperfectly cooked, are known to give rise to *Bothriocephalus* in man.

Tænia mediocanellata is not directly produced in man by ingestion of fluids containing the ova, and *Tænia solium* is rarely so, but the intermediary hosts, cattle and hogs, are probably often infected by drinking-water containing the ova.

Echinococcus has never been shown to be transmitted through means of water.

Of the platode parasites, *Distomum* is certainly trans-

mitted by water to cattle, as the disease usually appears where the pastures are unduly damp.

Of the nematodes, a large number of those infesting the lower animals, notably *Filaria*, *Strongylus*, *Pseudalius*, etc., appear to be frequently derived from the water.

Of the nematodes infesting man, only one, *Anchylostomum duodenale*, has been clearly traced to this cause, where, as in the case of the laborers in the St. Gothard tunnel and in certain brick-yards at Cologne, water polluted by the dejecta of persons suffering from the parasite was drunk by the other workmen. Attention to this point eradicated the disease.

The parasites, *Ascaris*, *Oxyuris*, and *Trichocephalus*, are probably occasionally transmitted by drinking-water, though the individual cases are difficult to trace.

Trichina does not appear to have been communicated to water.

The tropical dysentery, which we now know to be due to the *Amœba coli*, is thought to be communicated by drinking-water, though more objective proof is wanting on this point.

Bacteria in Water.—*Distribution.*—Bacteria are always present in surface soil in large numbers, and from thence gain access to the water, where, if they find conditions suitable to their development, they increase.

As the atmosphere near the earth's surface always contains bacteria, a certain proportion must naturally be derived from this source, though, as micrococci and molds, which form a large percentage of the organisms found in air, are rarely met with in water, it is evident that the number derived from the air is comparatively insignificant.

A surprising fact, demonstrated first by Koch and elaborated afterward by Fränkel, is that soil and the water which percolates it, only contain bacteria at points very near the surface; so that soil and soil water, at depths greater than two metres, are almost always practically free from bacteria, although the humus at the surface may contain millions of bacteria per c.c. This is, no doubt, due to the fact that, by its mechanical filtering power, the earth retains the bacteria and withdraws them from the water passing through it. *Deep ground-waters under normal conditions contain no bacteria.*

Most of the water bacteria belong to the class of bacilli. The presence of cocci points to transient conditions by which these organisms have recently entered the water from the air or the soil, and have not yet had time to die out.

This preponderance of bacilli in water was first observed by Koch, and has been confirmed by most observers. Although quite a number of species of cocci have at various times been isolated from some waters, the writer's experience of the large Canadian rivers, St. Lawrence and Ottawa, was that normally only bacilli were present, and that cocci and molds represented a transient contamination (usually indirectly from the air, as when following the melting of snow). Micrococci are chiefly met with in small bodies of water, such as brooks, wells, or aqueducts, and probably show that the water is exposed to minor degrees of soil or dust contamination. The presence of micrococci in a natural water is, therefore, an unfavorable sign, though it does not necessarily indicate harmful pollution.

The depth at which bacteria are present in soil and ground-water varies with the nature of the soil and the locality. C. Fränkel found at times 100 to 600 bacteria per c.c. in ground-water where the soil nearer the surface had been free from bacteria. Loose and sandy soils yield bacteria at a greater depth than denser strata. The soil in cities usually presented a somewhat deeper layer of earth containing bacteria than was found in uninhabited spots, though this difference was not very striking, and the soil beneath streets and houses, or even in the vicinity of sewers, was practically sterile at a depth of 3 to 5 metres.

The soil in grave-yards was found by Beumer and also by Gärtner, to show bacteria at greater depths than would be expected in other localities, and in one instance the ground-water at 2.5 metres contained 27,000 bacteria per c.c. Anaërobic bacteria are practically absent from the deeper strata, so that the exclusion of oxygen does not appear to be an important element in determining the absence of bacteria.

The temperature of the soil, though varying from 2.5° C. in March to 14° C. in August at 1.5 metre, and from 8° C. in March to 13° C. in September, did not appear to influence the number of bacteria present (Fränkel).

Recently, Esmarch has investigated the old graveyard soil in the grounds of the Charité Hospital, at Berlin, and arrived at conclusions corroborative of those mentioned above.

The distribution of bacteria in natural waters is a subject upon which our knowledge is very incomplete, owing to the fact that the number varies in the same locality at different seasons of the year, and the examinations have not, as a rule, covered long periods of time. Also, methods for taking samples are so diverse that it is hard to compare the results of one observer with those of another. In particular, the results of examinations of well waters are so modified by the state of the pumps, by which such samples were usually obtained, as to render them almost valueless. It may be stated generally that the water of shallow wells and surface springs contains the same number of bacteria as surface water, usually several hundreds or thousands per c.c. Deep wells and deep springs contain the same number as ground-water (from 0 to 10 per c.c.), unless extraneous sources of pollution exist. The water of flowing streams usually contains from 50 to 1,000 per c.c., and the water of large standing bodies of natural water, such as fresh-water lakes, from 0 to 10 per c.c. Sea water has not been frequently analyzed, but the results show that it is relatively rich in micro-organisms as compared with fresh water (Russell).

Rain and snow near the surface of the earth invariably contain a certain number of micro-organisms. The average number contained in the rain-water at Montsouris observatory, near Paris, for the three years, 1883–86, was 4.3 bacteria, and 4.0 molds per c.c., which, with a rainfall of 60 c.c., signified that about 5,000,000 germs fall annually for each square metre surface in that locality (Miquel). Melted snow is stated by Miquel to contain fewer bacteria than rain-water. Hail was found to contain 729 organisms per c.c. (Foutin) at St. Petersburg, and on another occasion 705 per c.c. at Baltimore (A. C. Abbott). At points distant from the earth's surface, such as the summits of lofty mountains or several hundred miles out at sea, the air has been found quite free from bacteria. It is considered that bacteria are not carried into the air by the mere process of evaporation, but only where dust is present. Snow usually contains a larger number of micro-organisms than are found in ice (Prudden), molds and micrococci being abundantly represented.

The conditions determining the amount of bacteria in natural waters are varied. Surface soil and dust form the great depot of these organisms, and their increase naturally depends on whether conditions favorable to their development are present or not. Warmth, moisture, and a sufficient amount of suitable nutrient substances favor growth; dryness and cold check the growth of most bacteria, but kill only a few of the more delicate species. The nutriment most favorable to particular species is very diverse. The water bacteria proper find in pure distilled water a medium sufficient to produce millions of organisms per cubic centimetre, in the course of a few days. Some forms, again, only flourish when a certain amount of proteid, such as peptone or albumin, is present; while, on the other hand, the group known as nitrifying organisms only grow in saline media from which albuminoids are absent. Some grow best in acid, others in alkaline media. Certain bacteria form products favorable to the growth of their own or other species, while others produce bodies having inhibitory powers which render the water infertile and incapable of supporting bacterial life (Miquel). The phosphorescent group and some forms peculiar to sea-water require the addition

of more sodium chloride to their culture media. Some grow only at low temperatures, 0° to 10° C., while others grow only at temperatures higher than that of the body, 40° to 60° C.

Fortunately, as far as we are aware, none of the pathogenic bacteria are capable of developing in water to any considerable extent, and as, even in impure water, the other forms present tend to destroy the disease-producing germs, unless a water is exposed to repeated infection, dangerous conditions tend to disappear. On the whole, the general tendency of the results of bacterial life in water is to purify it and to remove noxious substances.

The number of bacteria in a water affords an excellent indication of its cleanness, and, for this object, affords an even more delicate and reliable index than chemical analysis. Although it is hardly possible to state arbitrarily what degree of purity may be represented by special numbers of bacteria to the cubic centimetre,* which has been accepted by common consent as the standard unit of comparison, the following scale, suggested by Miquel, is very convenient to bear in mind:

MIQUEL'S SCALE OF PURITY OF WATER.

Exceptionally pure water contains	0 to	10 bacteria per c.c.
Very pure water contains	10 to	100 bacteria per c.c.
Pure water contains	100 to	1,000 bacteria per c.c.
Poor water contains	1,000 to	10,000 bacteria per c.c.
Impure water contains	10,000 to	100,000 bacteria per c.c.
Very impure water contains	100,000 and	upward bacteria per c.c.

By employing the words *clean* and *unclean* the scale is made to represent better our ideas as to the sanitary value of such results, since, as Miquel admits, a water classed as "pure" or "very pure" here would have to be branded as dangerous if any part of the small number of bacteria happened to be pathogenic germs. Still, to express the idea of relative cleanness, this scale answers very well.

According to Koch, water habitually containing above 100 bacteria per c.c. ought not to be employed for drinking purposes, and in filtered water the presence of more than 100 bacteria per c.c. is sufficient evidence that the filters are not working properly.

General meteorological conditions have an important influence in modifying the number of bacteria in water.

The *temperature* of the water or air, contrary to what might be expected, has very little effect upon the number of bacteria present. In waters which range at different seasons between 0° C. and 20° to 22° C., the number of bacteria never rises proportionately to the increase in temperature, and the maximum number usually occurs at a time when the temperature is lowest. The writer found, in the case of the Ottawa and St. Lawrence Rivers: (1) That the maximum numbers of bacteria per cubic centimetre were met with in the early spring and at the onset of the winter; (2) that no gradual rise in the number of bacteria accompanied the steady increase of temperature during the early summer; (3) that the number of bacteria during the three warmest months was lower than at any other period; and (4) that the number during the winter did not fall materially below the average for the entire year. These observations, made upon rivers of enormous size, where local contaminating causes were reduced to a minimum, correspond closely with those published by Miquel, who found that in the rivers near Paris the greatest number of bacteria was met with during the winter. In Miquel's observations it is interesting to note that the maximum numbers were found in February and the middle of December—seasons corresponding closely with April and November in Canada, when the difference in climate is taken into account. It is not generally known that in the winter the temperature of large rivers is 0° C., even at the bottom of the stream; thus cooling the whole body of water to the freezing point, even when the current is almost imperceptible. This was observed in the water of the St. Lawrence by Professor Goodwin, at Kingston, Ontario, and in the Ottawa and St. Lawrence at various points by the writer. (Figures 663 and 664.)

ICE.—With *temperatures below the freezing point* the case is somewhat different. Ice always contains far fewer bacteria than the water from which it is formed. The results of different investigators on this subject vary widely. Fraenkel found that the number of bacteria in natural ice supplied at Berlin ranged from a minimum of hundreds to a maximum of thousands per cubic centimetre, while ice artificially prepared from distilled water was practically free from bacteria. Prudden found that the physical characters of the ice played an important part in determining its bacteriological purity. Clear ice always contained a smaller number than ice with air-bubbles, and the latter again less than the surface ice, which contains snow. This snow ice, he maintains, should never be used for drinking purposes. By experimentally freezing water containing various species of bacteria, Prudden found that some germs possessed greater resistance than others. With typhoid bacilli, for instance, about ninety per cent. were at once destroyed by freezing, but a certain proportion withstood one hundred and three days' freezing. Repeated freezing and thawing were found more efficacious than uninterrupted freezing alone, five alternations of thawing and freezing sufficing to destroy all typhoid bacilli. From this it seemed that the crystallizing process of freezing acts mechanically in injuring the bacteria, although Prudden, strange to say, found that when the temperature of water was reduced below the freezing point, and freezing prevented by coating the surfaces and sides of the vessel with oil, an even more energetic germicidal action was obtained than by repeated freezing and thawing (moist cold acting, apparently, in a manner analogous to moist heat). Bordoni-Ufreduzzi found that while about ninety per cent. of the bacteria in water were instantly destroyed by freezing, no further reduction in number took place, even if the ice were kept frozen for several months.

All observers agree that the freezing of an impure water does not render the ice fit for human consumption, and the general result of the investigations has been to show the superiority of artificial ice supplies over the natural ones, except when the water of the latter is exceptionally pure. Heyroth, however, found that the artificial ice supplied in Berlin often contained large numbers of bacteria, a condition traceable sometimes to the fact that impure water was originally used for its manufacture; at other times to contamination of the ice, during or after the process, by unsanitary conditions of the machinery, store-houses, etc. He urges the necessity of such establishments being placed under sanitary supervision.

A recent investigation into natural ice supplied in Paris from impure ponds and streams, showed in all cases such dangerous impurity as to cause its use for purposes of alimentation to be prohibited.

The Massachusetts State Board of Health, as a result of an extended series of investigations of the rivers and ponds of Massachusetts during the winter, arrived at conclusions similar in the main to those of Prudden. It was found that the ice contained, chemically, less organic matter than the water from which it was derived, and a notably less number of bacteria. Chemical investigations were made as to the effect upon the water of being frozen over, and it was found that this appeared to exert an unfavorable influence upon the natural processes of self-purification; so that winter water is, if anything, somewhat inferior to that obtained from the same source during warm weather. The lower portion of a cake of ice contained fewer bacteria than ice of the same transparency near the surface. In this connection it must be remembered that the numbers of bacteria, as obtainable by the gelatine plate method, only represent one phase of aquatic bacterial life. The nitrifying organisms, which are the agents by which the final and most important steps in the oxidation process is accomplished, appear, from chemical analysis, to be incapable of working at temperatures below 13° C. Though the biological side of the question

* A cubic centimetre contains approximately 15 minims, or a quarter of a teaspoonful.

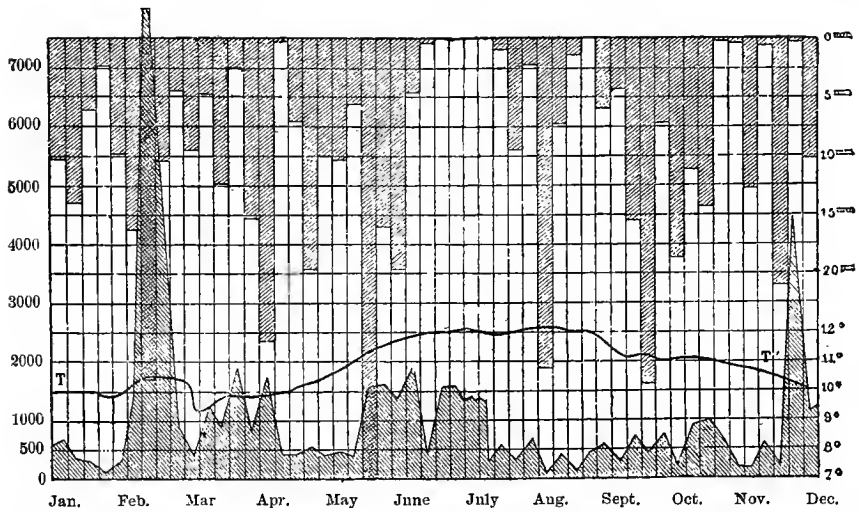

FIG. 663.—Diagram Showing the Relation between Rainfall and Bacteria in Water during 1889. Montrouge reservoir, Paris (Miquel.) By mistake a rainfall of 12 mm. in the second, third, and fourth weeks of July has been omitted. The truncated columns give the rainfall, the pointed ones the number of bacteria per c.c. TT', temperature.

an area of over half a million square miles, much of which is uninhabited country where no meteorological stations exist. Hence the local rainfall, as observed at Montreal, did not correspond as closely to the fluctuation in number of bacteria as did the water-level. The increase evidently depends upon the washings of alluvial soil, and not on the direct access of rain, as in the greatest increase, that of the spring, the rise of river-level is mainly due to a general melting of snow and relatively little to rainfalls.

In Miquel's diagram of a water obtained from a comparatively small water-shed, the local rainfall coincides accurately with rises in the number of bacteria.

has not yet been worked out, it is clear that a lowering of the temperature in water is not by any means an unmixed blessing, as a water is not only not directly improved by cooling, but is even prevented from purifying itself.

ICED WATER.—The evidence adduced shows the advisability of cooling water by other means than the direct introduction of ice, which may contain sufficient bacteria to pollute the water. Contamination of drinking-water by ice is to be prevented either by obtaining a pure natural supply in the first instance, or by manufacturing it from pure natural or distilled water under suitable conditions. When this cannot be done, care must be taken that the ice used in coolers is not put directly into the water, but into a separate cooling chamber. In hot, dry climates an admirably cool and refreshing water is obtained by allowing it to stand in vessels of porous earthen-ware,* enough evaporation taking place through the sides of the vessel to keep the water at from 10° to 12° C., even in the hottest weather, without the employment of any ice at all. The practice of drinking ice-water habitually can hardly in any case be considered to rank among our national virtues, though it is stated on good authority that where serious gastro-intestinal disturbances have been traced to the drinking of iced water, either the water or the ice was found, upon analysis, to be impure.

Barometic pressure appears to exert no influence upon the number of bacteria found in water.

Rainfall and melting of snow appear to be the chief factors affecting the number of bacteria in natural waters. In the writer's experience of Canadian waters, seasons of heavy rainfall were attended by marked increase in the number of bacteria. This accounts for the increase in bacteria noticed just before the onset of winter, a time at which all the rivers become full. The water-level of the river was found to be a better index than the observed rainfall, as the watersheds of the Ottowa and St. Lawrence cover

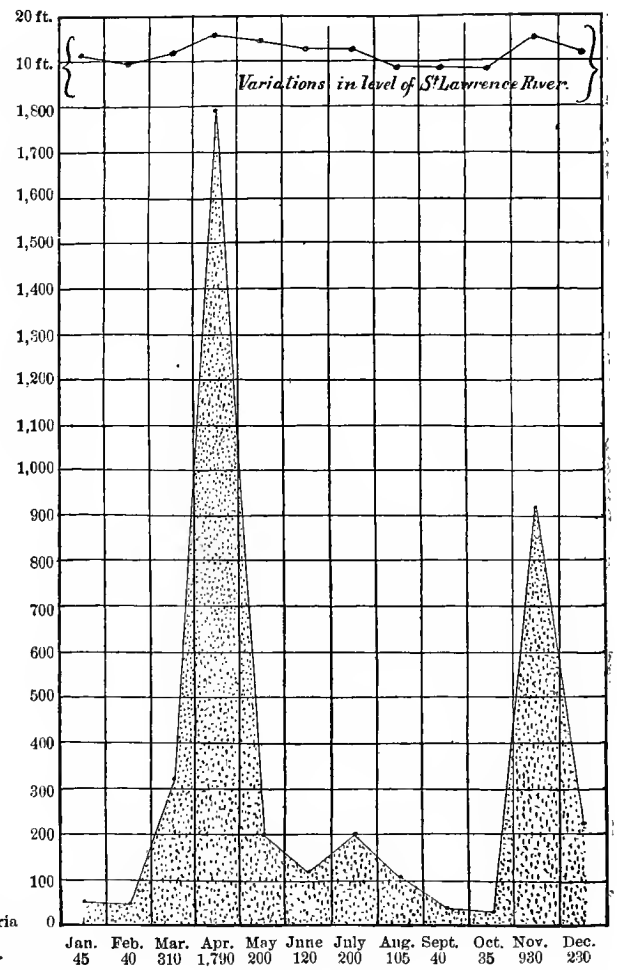

FIG. 664.—Diagram Showing Average Number of Bacteria per c.c. in Montreal Water, during 1891. (Johnston.)

* Darlington has stated that water cooled in this manner soon becomes offensive, probably owing to infection by bacteria remaining in the pores of the earthenware. This was especially noticeable in water which was boiled previously to being placed in the jar. He recommends the use of glazed jars covered with moist cloths.

Influence of Seasons.—From the preceding it will be seen that the variation in the number of bacteria in a water is chiefly determined by the degree of its exposure to contamination by substances containing large numbers of micro-organisms, but above all, by the washings of soil. Seasonal variations in the number of bacteria vary with the different climates. In analyzing the statistics bearing upon this point certain precautions require to be taken, which have obliged the writer to discard a large number of otherwise valuable observations as being open to too great sources of fallacy. In particular, the elaborate weekly analyses of the Spree at Berlin are nearly valueless for general statistics upon meteorological influences, however important they may be from a local hygienic point of view, or in showing the efficiency of the filtration methods employed. In Plagge and Proskauer's observations, as well as those of G. Frank, the difference between the numbers obtained in various months was far less than that obtained in individual observations during the same month. For instance, with weekly analyses, the average numbers of bacteria (per c. c.) found in unfiltered Spree water, in each month in 1884–5, was as follows:

1884.

July.	Aug.	Sept.	Oct.	Nov.	Dec.
1,064	1,440	2,496	3,251	3,466	811

1885.

Jan.	Feb.	March.	April.	May.	June.
864	685	1,843	1,698	381	6,190

showing an apparent falling off in number during the winter, with a minimum in May. In the following year the result obtained was:

1885.

	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.
Min...	4,400	2,640	1,800	960	1,204	5,520	2,700	1,100	1,250	1,010
Max...	7,980	110,740	11,900	9,200	4,840	31,500	9,000	29,000	20,000	100,000
Av....	6,190	56,690	6,850	5,080	3,020	17,010	5,850	15,050	15,625	50,505

It is evident here that the variation between the result of different collections in the same month may not only be ten times as great as the maximum range of the monthly averages, but in each month the minimum single observation falls lower than the minimum average for the ten months. It is clear that small streams like the Spree are quite unfitted for the work of furnishing data for general application. The work is further vitiated in a number of valuable memoirs by the fact that no statement is made as to the variations in the numbers of bacteria found in individual samples collected at the same time. Work of this kind should always be done in duplicate, and the full details given for purposes of control.

Bacteria per c.c. in Seine water, taken at:

Season.	1888. Months.		Pont d'Ivry.	Pont d'Austerlitz.	Marne at St. Maur.
Winter.	December. January. February.	.....	14,350	41,536	70,990
Spring.	March. April. May.	.....	47,234	66,084	20,204
Summer.	June, July. August.	.....	6,080	13,666	6,683
Autumn.	September. October. November.	.....	55,700	45,940	38,029

Information of far more value has been obtained from the examination of larger streams, and the results of Miquel from the Seine and Marne waters are probably a truer index of the influence of seasons on bacteria in water. From certain peculiarities in his methods the number of bacteria given by Miquel is greater than would be indicated by the gelatine-plate process.

Here it is seen that the minima occur in the summer and the maxima during the winter.

Analogous results were obtained by Smith in the water of the Potomac, and it may be inferred that this condition fairly represents the behavior of large streams, under natural conditions. Griffith found in the water of the river Witham, at Lincoln, the following means: Winter, 5,097; spring, 11,300; summer, 11,092; autumn, 7,980. It must be remembered that the summer is in England a season when much rain falls.

Although, as a matter of observation, the number of bacteria in natural waters does not seem to diminish notably during winter, there can be no doubt that the continued low temperature of the water not only checks the natural increase of bacteria in water, but actually tends to destroy their vitality. In water allowed to stand at temperatures of 18° to 22° C., a great increase in the number of bacteria takes place within the course of a few days, so that water containing less than 100 per c.c. will usually be found to yield about half a million per c.c. after three or four days. At lower temperatures the increase is less marked, but even at 6° C. a marked increase in certain species has been noted after a few days (Bolton).

On the other hand, in water kept at 0° C. the same observers observed a marked diminution, especially among the liquefying forms, as is seen from the following figures (the numbers in parentheses indicate liquefying forms):

Days at 0°.	Bacteria per c.c. (before.)	Bacteria per c.c. (after.)
1....	148 (14)	126 (6)
1....	150 (11)	115 (2)
2....	123 (14)	69 (0)
2....	158 (15)	101 (0)
3....	129 (9)	29 (0)
3....	156 (11)	33 (2)

It appears, therefore, that the influence of cold, when sufficient to lower the temperature of the water to 0° C., must tend to greatly diminish the number of bacteria present, so that any marked increase observed in winter is to be ascribed to conditions tending to introduce bacteria into the water from without. That in natural waters no marked diminution in number occurs in the colder months, may also mean that *some more powerful restraining influence than low temperature is held in check during the cold period.* The results by the Massachusetts State Board of Health show that the nitrifying processes in water cease when the temperature falls below 14° C., and are only resumed when it again rises. In the same reports it is repeatedly shown that when nitrification was in full progress the numbers of bacteria in sewage, etc., were being markedly diminished, though the idea that nitrification is an agency by which bacteria can be destroyed is not formulated. Consideration of the fact that a marked fall in the number of bacteria always occurs during the warm months, when nitrification can be shown to be most active, seems to justify the view that the nitrifying process in some way tends to restrain bacterial growth in natural waters, sewage, etc., and that the removal of this restraining or destructive influence in cold weather compensates to some extent for the reduction effected by cold, so that the bacterial death-rate, so to speak, remains stationary.

Though the number of bacteria is nearly as great in natural water in winter as in summer, the species are different. This was brought out by a comparison of the principal forms met with in Ottawa water, during the summer and winter, respectively. During the summer, one species, the bacillus fluorescens liquefaciens,

formed about thirty to forty per cent. of all the colonies; but during the winter this organism was only present in the proportion of two per cent.; and the bacillus aquatilis, and some allied organisms, scanty in summer, formed fully twenty per cent. of all colonies in winter.

Light.—It has long been known that bacteria grow best in the dark, and recent experiments have shown that direct sunlight has strong germicidal powers over many bacteria. The experiments of Buchner and others show that both liquid and solid cultures of typhoid bacilli and bacillus coli communis were killed by exposure to direct sunlight for half an hour. Buchner suggests that this action may have an important bearing upon the diminution of bacteria in standing bodies of water, and suggests that settling basins should be shallow and lined with some white material, in order to obtain the full benefit of the bactericide action of light. Proof as to the depth to which the sun's rays can exert any bactericidal action in various waters is not yet forthcoming, and in the case of brown peaty waters it is unlikely that this action is sufficiently pronounced to account for the small number of bacteria usually found in these waters. On the other hand, some grounds exist to show that a reservoir or settling basin may possibly be better left open than covered in, contrary to the generally accepted opinion.

Motion and Rest. *Motion.*—Although there is some discrepancy between the results of individual observers, it appears clearly established (Cramer, Miquel, Gärtner) that agitation of a water exerts no influence upon the number of bacteria in it. For instance, Miquel found that on taking a sample of water from the Vanne, which contained originally 28 bacteria per c.c., and dividing it into two portions, one of which was constantly shaken at the rate of two hundred and fifty shakes per minute, while the other was left at rest, at the end of twenty-four hours the flask which was shaken showed 71,000 bacteria per c.c., and the one at rest 80,000 per c.c. Another sample taken from the Marne, which showed at first 65 bacteria per c.c., increased to 43,000 per c.c when shaken, and 31,000 when at rest. No significance attaches to these slight variations. The motion which water undergoes in passing through supply mains does not seem either to increase or lessen the number of bacteria present (Wolffhügel, Proskauer).

Rest.—A state of rest in natural waters exercises a very marked influence in diminishing the number of bacteria. In fresh-water lakes formed by the expansion of large rivers, the lake water always contains far fewer bacteria than that of the streams entering it. In the Ottawa River, which has an average width of about half a mile, an expansion occurring above Ottawa is called Lake Deschênes, and another, about one hundred miles lower down, is known as the Lake of Two Mountains. The width of these lakes is over two miles, and their average depth thirty to fifty feet in most places. A quite perceptible current passes through them, though its velocity is less than one-sixth that of the river proper. Above the Lake of Two Mountains the river water never contained less than 30 to 60 bacteria per c.c., while in the lake it only averaged 5 per c.c., the maximum being 14 per c.c., and a majority of the samples yielding no colonies whatever by the gelatine-plate method. The water of Lake Deschênes contained from 0 to 20 bacteria per c.c.; whereas the river about five miles lower down contained 120 to 200. In Lake St. John, which forms the head-waters of the Saguenay, the average of four large rivers entering was 240 per c.c., and the lake water contained from 0 to 16 bacteria per c.c. The River Saguenay, which forms the outlet, was found to contain 50 to 60 per c.c. The Spree, which enters the Lake Havel a few miles below Berlin, with water containing 190,000 bacteria per c.c., on leaving it contains only 9,200 per c.c. (Frank).

It is thus clear that the state of rest in a natural water does not lead to any of the objectionable features which we are accustomed to associate with the idea of stagnation, but is, on the contrary, one of the most powerful agencies by which the self-purification of water is secured. The statement, formerly current in text-works on hygiene, that motion, as found in running water, was a valuable aid in purification does not seem to rest on any definite observations. It is possible that, as water in running rapidly over the bed of a stream must be brought into intimate contact with the material forming that bed, if the ferments necessary to excite nitrification lie at the bottom of the stream their influence upon the water will be thus aided by the current, but that the agitation of the water alone is of any particular benefit, has not been supported by a shadow of proof. In several Canadian rivers, whose course was marked by rapids and waterfalls, samples were taken at points above and below, without showing any alteration in the number of bacteria present which could be ascribed to the action of the waterfall or rapid. It is of interest also, in this connection, that chemical analyses, made a few years previously in the same localities, failed to show any improvement in the water consequent upon the "aëration" which was suffered to take place in rapid currents. The term, aëration of water, is one which seems to have come into existence through a total misconception of the real nature of the processes by which the oxidative and nitrifying phenomena in water are carried on.

How are we to account for the disappearance of bacteria from natural bodies of water at rest? Undoubtedly the simple sedimentation or sinking of the bacteria themselves, or of the suspended particles to which they are attached, plays an important part. Water is found to free itself, to a large extent, of suspended organic matter, in passing through these natural "settling basins," and it is reasonable to suppose that the bacteria tend to sink to the bottom. This could only apply to non-motile forms, and the majority of organisms found in water have independent motion. Experiments by Wolffhügel, Cramer, and Hueppe, of allowing water to stand in tall jars or tubes, showed that in some cases an apparent sinking of the bacteria to the lower strata really took place, while in others it did not. Gärtner experimented with motile and non-motile organisms in a similar manner, using pure cultures instead of unsterilized water, and found that in no case was anything corresponding to natural sedimentation obtained.

A point upon which too little stress appears to be laid is that, under natural conditions, the apparent sedimentation *is accompanied by a great reduction* in the number of bacteria present, while in the experiments an increase was usually observed. If the bacteria, or a large proportion of them, really sink to the bottom of standing bodies of water their numbers with increasing depths would certainly show a uniform increase. This is not the case. A few observers have at times noted that the number near the bottom of reservoirs, ponds, etc., is greater than at the surface (Currier, Wynter-Blyth, Cramer and Fol); but on the other hand, the results of the majority of observations show that this is the exception and not the rule. The writer was able, by means of a special apparatus, to examine the water at different depths in the Montreal reservoirs, and in some Canadian lakes and ponds, and found that in almost every instance the number near the bottom, at depths of twenty-five to fifty feet, did not exceed that at or near the surface. A progressive increase with the depth was never observed. The only instance in which the water at the bottom of a pond was found to contain notably more bacteria than were present at the surface, was that of a mill-pond, where the bottom was extremely foul and full of débris.

In the case of the Spree at the Havelsee (when the river above Berlin contained 8,950 bacteria per c.c., which number rose to 190,000 below the city and above the lake; while after passing through the lake the number fell to 9,200, showing that the water had been freed from the same number of organisms by which it was polluted in passing through the city), these polluting forms were not the bacteria peculiar to water, but those inherent to sewage and household water, street drainage-soil, and presumably pathogenic forms; and it is highly probable that those forms not natural to water would disappear more rapidly than the water bacteria proper.

Gärtner sums up the influences which may be supposed to act on the water in this instance as follows:

1. Sinking of non-motile organisms and spores of motile bacilli.
2. Spontaneous sinking of bacteria attached to suspended matter.
3. Artificial precipitation by substances used to purify the water.
4. Dying out of forms other than the water bacteria.

The precipitation of obnoxious substances from water by artificial means is a subject which will be referred to elsewhere (p. 1011). Apart from that, the above explanation seems too much dependent on passive and mechanical agencies to meet the facts of the case. That a constantly flowing stream of water, highly polluted, can in this way undergo such phenomenal improvement in passing through a shallow little lake about six miles in length, seems hardly credible, unless some more active agencies are in operation.

What calls for special comment is that in spite of the precipitation constantly going on, as revealed by the physical clearing of the water, the deeper layers of the water contain practically no more bacteria than those near the surface. Further, as this condition remains constant year after year, it seems inevitable that something connected with the sediment itself, or with the bed of the stream, is the agency most active in maintaining a pure condition of the water. If we suppose that some biological or chemical factor is present in the water (and most abundant at the bottom) by which bacteria coming within range of its influence are destroyed, we have an explanation of the fact that water near the bottom of a mass of water, where sedimentation is constantly going on, often contains fewer bacteria than water near the surface.

It seems more rational to seek the explanation of the self-purification of waters more on biological or chemical grounds, and less on mechanical grounds.

What is the nature of the agency which causes bacteria to disappear so rapidly from standing bodies of water? This question can only be answered imperfectly at present. Our positive information on this subject is due chiefly to Miquel, who studied biologically the behavior of pure and impure waters on being allowed to stand. As has already been stated, all waters, on standing in vessels or flasks, show a marked and rapid rise in the number of bacteria present, consequent upon the multiplication of the germs contained in them. Thus, a sample of Montreal water, which immediately after its collection gave fifty-eight colonies when sown in gelatine, increased on subsequent examination as follows:

	Per c.c.
After 2 hours	96
" 6 "	168
" 8 "	390
" 10 "	3,200
" 12 "	15,460
" 24 "	62,000
" 48 "	480,000

This increase of bacteria in waters standing *under artificial* conditions has received more or less attention at the hands of almost everyone who has worked at biological water analysis. The phenomenon has been thoroughly investigated by Bolton, Wolffhügel, Frankland, Cramer, Hueppe, and Miquel, and all observers agree in stating that after a gradual rise to many hundred thousand (usually one or more millions) bacteria per c.c. the number gradually subsides with repeated examinations, until, in samples taken some months or years after the first examination, bacteria may be almost absent. Miquel alone has given anything like a rational explanation of the causes determining the secondary decrease in number following the primary increase. He considers it likely that the bacteria are poisoned by their own products, and so prevented from further increasing. With that vivid scientific imagination characteristic of the great French scientists, he calls the process "auto-infection" of water, and considers it analogous to the processes observed in infectious diseases. Starting from the point of view that it is the products of bacterial life which check the further increase of bacteria, when it has reached a certain point, Miquel formulated the view that this substance would be more abundant in waters which were strongly contaminated, than in those which were pure: and therefore that water originally pure would possess less power of resistance to this auto-infection than impure water.

The observations published by Miquel certainly bear out his view, though, so far as I am aware, they have not been controlled in the work of other observers. Miquel found that the waters of the Vanne, St. Laurent, and the Dhuis (which he selects as relatively pure waters at the time of examination, since the number of bacteria they contained was well below 1,000 per c.c.) showed an early and rapid rise in the bacteria curve when allowed to stand, followed by an early and rapid fall, as indicated in the diagram.

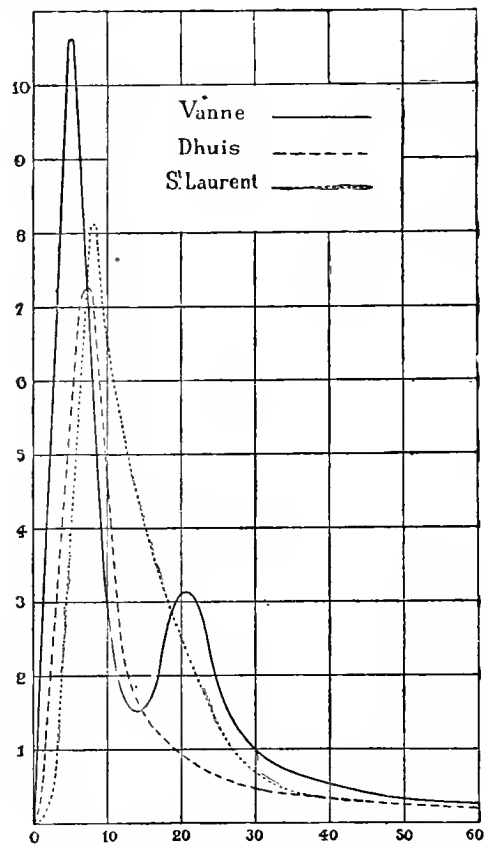

FIG. 665.—Auto-infection of Pure Waters. (Miquel.)

The ordinate lines denote a scale in units of 100,000 bacteria per c.c., and the abscissæ mark the days.

On the other hand, water of the Marne and Ourcq, which are impure waters, containing 60,000 per c.c., show a much more gradual rise, which only becomes well marked by the time that the number is falling in purer waters, but which is much more persistent. This capacity of resistance in impure waters is thought by Miquel to depend upon certain substances analogous to the defensive proteids or bactericide substances now known collectively by common consent as alexins. At the same time it must not be overlooked that the bacteria found in impure water, especially that contaminated by sewage, do not belong to the class which rapidly increase in water, and no information is given by Miquel as to which species gave rise to the increase.

The curves taken by the impure waters of the Marne and Ourcq are shown in Fig. 666, and for comparison

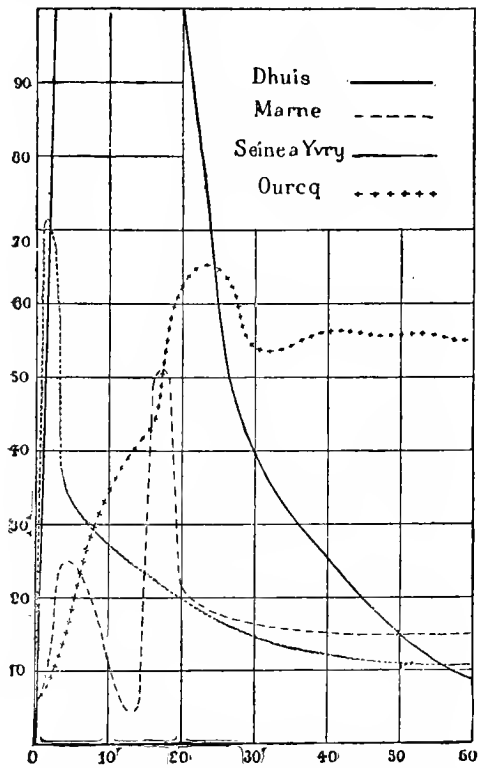

FIG. 666.—Auto-infection of Impure Water (Miquel).

curves are shown of the relatively pure waters of the Seine and Dhuis, at a time when through temporary contamination the bacterial richness was about the same as the permanently impure water. All the cultures were kept at a temperature of 30° C. The scale is in units of 1,000 bacteria per c.c.

It must be admitted that M. Miquel is rather unfortunate in his selection of types of pure water. The average number of bacteria present in the water throughout the year is stated to be as follows: Vanne, 800 per c.c., Dhuis, 1890, Seine at Ivry, 32,500. These waters certainly do not strike one as being particularly pure, especially when we consider that the best of them, the Vanne, at times contains as many as 14,000 bacteria per c.c.

Miquel does not rest his assumption of the presence of a bactericide or restraining substance in water on the above grounds alone, but has endeavored to isolate the substance. By introducing cultures of bacteria capable of developing in water, into various water samples, he found that, while at first this led to an increase in the number present, later on no such increase took place; the water thus having become, as he expresses it, *immune* or capable of resisting the process of auto-infection. That this immunity was not solely dependent upon the *abstraction* of substances furnishing nutrition to the bacteria, was shown by the fact that, after boiling, it again became susceptible to auto-infection, and afforded a good medium for the growth of water bacteria.

Acting on the assumption that the substance rendering the water immune or *infertile* was destroyed by boiling, M. Miquel tried to free the water from its bacteria by filtration, and by distillation *in vacuo* at the temperature of 30° C. By means of the ingenious apparatus shown in Fig. 667, samples of water were evaporated at this temperature from the dish *V* and the vapor, condensing upon the surface of the flask *B*, through which a current of cold water was kept circulating, dropped as water into the sterilized bottle *F*, in which, by reason of its narrow neck, very little evaporating surface was offered. The interior of the bell jar, and the outer surface of *B*, were sterilized previous to use.

The water collected in *F* in this manner, when obtained from samples of impure water, was found to be, not only sterile and free from bacteria, but *infertile* and incapable of nourishing them, a fact considered by Miquel to establish the existence of a restraining substance in solution in this water. Miquel and Wada published several experiments upon water of this description, in which it was found that bacteria introduced into it were found to disappear after the lapse of a few days, while in control experiments, where sterilized distilled water was employed, a growth of from one to six millions per c.c. was noted.

No statement has been made as to the chemical composition or properties of the substances which render water infertile. The presence of substances of this nature in natural waters would appear to afford a most rational explanation of the great reduction of bacteria in large bodies of natural water. That the formation of these substances is connected in some way with the bed of the stream is rendered probable by the fact that, though sedimentation must apparently be constantly going on, the lower strata of water do not show more bacteria per c.c. than that near the surface—possibly because the restraining substances are more abundantly present near the bottom. It is difficult to avoid associating the formation of these products in water in some way with the nitrifying organisms which, we know, form a sort of film at the bottom of standing water, but in the absence of any direct experimental evidence on this point we are not in a position to form any definite conclusions.

The aëration of natural waters depends upon the amount of dissolved or suspended air or oxygen present. Apart from purely mechanical causes, this is regulated by the circulation currents going on in the water as a consequence of heating and cooling. The oxygen furnished by the aquatic plants is essential to a normal condition of the water. At great depths and in stagnant waters, the amount of dissolved oxygen has been shown to be very small, and this must have a modifying influence upon the number and kind of bacteria present. It would be expected, *prima facie*, that in deeper waters *anaërobic* bacteria would predominate, but in the recent examination of the deep water of the Gulf of Naples by Russell, such was not found to be the case. The distribution of anaërobic bacteria in water has as yet received but little attention, and requires far more careful study, since anaërobic bacteria were long since shown by Pasteur to be active putrefactive agents.

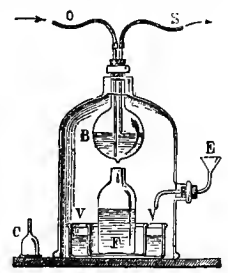

FIG. 667.—Miquel's Apparatus for Obtaining Infertile Water by Distillation at 30° C.

An increased number of bacteria, observed at times near the surface of waters, has been thought to be due to the greater abundance of oxygen there.

The cycle of bacterial life in natural waters has recently been studied by Migula, Karlinski, and di Mattei, keeping up as far as possible the natural conditions, but maintaining a low temperature and a constant current in the samples, and in one instance by lowering a sterilized vessel into a natural spring and allowing it to remain there while the tests were being carried on. Under these conditions the increase of water bacteria (auto-infection) was comparatively trifling.

Relation of Bacteria in Water to the Amount of Nutrient Substances Present.—Gärtner, after an exhaustive review of the available literature on this subject, comes to the conclusion that no constant relation exists between the number of bacteria in a water and the amount of nutrient material it contains. According to Naegeli,

the chemical composition of bacteria includes not only carbon, hydrogeu, oxygen, and nitrogen, but also sulphur, phosphorus, potassium and calcium, and other inorganic elements. The nitrogen and carbon can only, be stated, be taken from pre-existing organic carbon and nitrogen compounds. Bolton found that certain bacteria (Micrococcus aquatilis and Bacillus erythrosporus) were capable of unlimited development in water in which organic matter was not present in quantities sufficient to be estimated by chemical tests. He reckoned the weight of twenty million of these bacteria to be only $\frac{1}{100}$ of one milligram. Bacteria vary greatly in regard to the amount of organic matter required to enable them to develop: some requiring, apparently, none at all, while others (notably the pathogenic microbes) only increase when an appreciable quantity of organic matter is present. Cramer found that by diluting nutrient gelatine with sterilized distilled water, so as to bring the amount of organic matter in three samples to $\frac{3}{100,000}$, $\frac{1}{100,000}$, and $\frac{1}{1,000,000}$, and introducing water containing 312 bacteria per c.c. into each, the increase in bacteria was to some extent directly proportionate to the amount of organic matter present; but that even the most attenuated solution contained 3,256,000 bacteria per c.c. at the end of four days. The extent to which bacterial *cannibalism*, so to speak, takes place under these conditions has not been determined. Bolton found that the presence of 6.7 parts of nutrient material per 100,000 was necessary for the increase of typhoid bacilli, and 40 for the cholera vibrio. Of all substances peptones are the most potent in inducing bacterial growth; after these come albumin and sugar, then leucin or tartrate of ammonium with sugar, then albumin, and ammonia salts (Naegeli). The importance which organic matter bears to bacterial increase in water depends chiefly upon whether the bacteria contained in it are of a kind which requires the presence of these substances for their development. From the above it follows that waters most rich in bacteria are not necessarily those which give the highest amount of organic matter upon chemical analysis.

Chemical Changes Produced by Bacteria in Water.—It is difficult to determine exactly the part played by bacteria in the chemical phenomena observed in water. We know that, generally speaking, the bacteria produce metabolisms similar to those resulting from animal aquatic life, changing albuminoids into extractives, and tending to absorb and combine with free oxygen. While resembling plants in possessing the property of assimilating nitrogen from ammoniacal compounds (Cohn), they are unable to obtain their carbon from carbonic acid. Moreover, the anaërobic forms do not liberate free oxygen.

Nitrification.—Although the bacteria found in water are capable of splitting up nitrogenous bodies into derivatives which are ultimately oxidized, they are themselves incapable of completing the process, and appear to deal only with the preliminary stages. The main oxidation processes in water may be summarized as the series of steps by which albuminoid and ammoniacal substances are transformed into nitrites and nitrates. In the formation of nitrates or nitric acid out of albumin or protein there are four distinct stages, which may be considered as perfectly distinct: (1) proteid; (2) ammonia; (3) nitrous acid; (4) nitric acid. The chemical nature of the processes known as "self-purification" of water is practically the change of proteids and ammonias into nitrites and nitrates. The former (1 and 2) may be regarded from a hygienic standpoint as relatively dangerous, and the latter (3 and 4) as relatively safe components of a water, in so far as they indicate that unstable compounds have been changed into stable ones, though of course the detection of nitrites and nitrates in a drinking-water indicates in itself the existence of an undesirable contamination. The existence of nitrites and nitrates in water, therefore, though bad in itself, still shows that the oxidation or nitrifying agency is at work in removing the contaminating materials. The principal source of nitrites and nitrates in water being sewage, which always contains large amounts of chlorides, besides albuminoids and ammoniacal nitrogen, the degree of oxidation which has taken place can be inferred from the proportion to the chlorides, since the chlorine is an element which does not undergo changes through nitrification.

Though the nitrification phenomena have long been recognized in waters, our accurate knowledge on the subject has been derived from the study of these processes in soil by Gilbert and Lawes, Warington, Schloesing and Münz, Frankland, and especially Winogradsky. It was established by Schloesing and Münz that nitrification must be the result of the action of some organisms, and as the process was so universal in waters, the water bacteria were naturally looked upon as being the possible cause of the phenomenon. It was shown that nitrification in soils could be arrested by agencies capable of checking bacterial life, such as boiling, saturation with chloroform, etc., but for a long time all attempts to isolate an organism capable of producing nitrification were unsuccessful. Frankland, after testing the powers of the bacteria typical of water, found that these were not only incapable of nitrifying, but actually produced a reduction of nitrates to nitrites and ammonia, so that the action of the bacteria not only was not the cause of nitrification, but probably, under natural conditions, helped to mask it.

Heraus, in 1886, though the fact has not been generally recognized, undoubtedly worked with pure cultures of nitrifying organisms, and also showed that a species of bacteria exists which is capable of obtaining its nourishment, and constructing its tissue, from carbonic acid and ammonia. Heraus, however, was mistaken in ascribing nitrifying powers to a number of well-known bacteria, bacillus anthracis, etc.

After years of patient labor, Winogradsky, Warington, and P. Frankland succeeded in 1890, independently of each other, in isolating the nitrifying elements and obtaining them in pure culture. In America, E. O. Jordan had also arrived at the same end by the time the results of the European investigations were published. The method at first employed was that of adding small quantities of soil, which had been shown to possess nitrifying properties, to sterilized fluid containing ammoniacal and earthy salts—phosphate of potassium, sulphate of ammonium, carbonate of magnesium, sulphate of magnesium, chloride of calcium and carbonate of sodium, being used in varying combinations and degrees of dilution. The process was most active at a constant temperature of 30° C., but was observable between 12° C. and 40° C.

At the end of about ten days the ammonia in the solution disappeared and nitrites were abundantly present, with or without traces of nitrates. Later on, the nitrates increased, and in some cases the nitrites entirely disappeared, having been converted into nitrates. Upon adding fresh quantities of ammonia to the solution it was found in the same manner to be converted into nitrites and nitrates.

By introducing small quantities of these culture liquids into fresh sterilized solutions of ammonia and earthy salts the same course of events was observed, and in this way the cultures could be passed through a number of successive generations. It was found, however, that in these secondary cultures the process did not always go on to the formation of nitrates, but sometimes stopped at the nitrite stage. In these cases it was still possible to induce the formation of nitrates, by adding a fresh dose of the original nitrifying earth or some of the earlier cultures.

This observation led to the inference that two separate fermentations were involved, each depending upon the action of a distinct micro-organism. That is to say, that one *nitrous* organism existed, capable of forming nitrites out of ammonia, while the oxidation of nitrites to nitrates was effected by a separate and distinct *nitric* organism. That both were present simultaneously in the earth originally employed, was shown by the fact that this substance was found capable of completing the process when the organisms present in the daughter-culture failed to do so. It was subsequently learned that the nitric or-

ganism does not flourish vigorously until the ammonia has, for the most part, disappeared, and its optimum is reached in solutions containing nitrite without ammonia. The failure of daughter-cultures to produce the nitric fermentation is due to the seeding of the secondary cultures being completed when the nitrous fermentation was at its height and before the nitric organism had had favorable opportunities for growth. In this way the nitric organism becomes gradually climinated from the culture fluids.

Isolation of the Nitrifying Organisms. — The above results were obtained in large part by working with mixed cultures containing not only both of the nitrifying organisms, but also a certain number of bacteria originally introduced with the earth, and which formed the requisite nutrient materials for their existence in the saline fluids employed as culture media. Numerous attempts were made to isolate by the gelatine and agar plate method the nitrifying organisms, but without success, as for some reason these microbes refuse to grow at all in organic gelatinous substances.

Failing this, recourse was had to a much older method, that of dilution of the cultures sufficiently to obtain samples containing the nitrifying organisms, but free from bacteria. By greatly diluting the impure culture fluids with the sterilized nutrient saline solutions, cultures were obtained in sterilized glass-stoppered bottles (carefully guarded against infection from dust, etc.), which, while capable of setting up the nitrifying changes, were found free from bacteria by the gelatine plate process. In this way pure cultures were without great difficulty obtained, which formed nitrous acid in ammoniacal solutions, and though the isolation of the nitric ferment was a much more difficult matter, it was likewise successfully accomplished.

The organisms, when isolated in this manner, were found to exist in the form of a jelly-like layer adhering to the sides and bottom of the glass (Warington), an appearance long familiar to persons engaged in water analysis, but the significance of which was never before suspected. This substance forms abundantly at the bottom of streams and ponds, and though experimental proof of its nature is yet wanting, there can be little doubt that it furnishes the active agent in the nitrification of water under natural conditions.

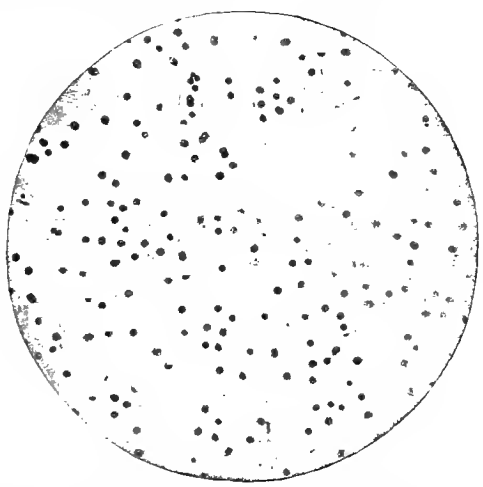

Fig. 668.—Microphotograph of the Nitrous Ferment, B. Nitrosus, × 1,000 (Winogradsky). N.B. The culture does not appear to be perfectly pure, as some short, slender bacilli are seen in the field.

Accounts of the morphological characters of the nitrifying substance under the microscope, as described by different independent observers, show a remarkable unanimity. By all, the organisms are described as small oval rods 1.5 μ in length and 0.5 μ in width: in addition to which, rounded disk-like bodies occur having a diameter of 1.5 μ to 2 μ. The fact of two morphologically distinct organisms being described is what we might expect from the fact that two different fermentations exist. Winogradsky has shown that in solutions in which a purely nitrous fermentation was going on, the larger

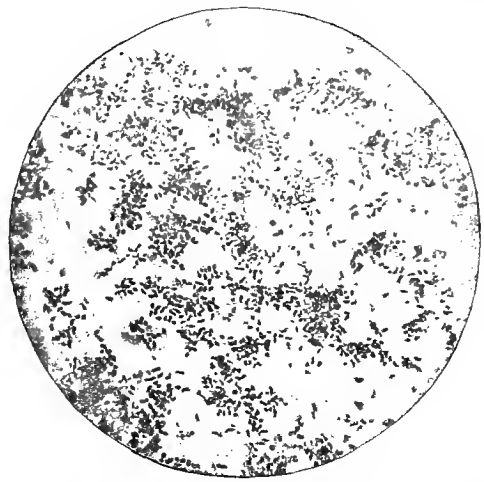

Fig. 669.—Microphotograph of the Nitric Ferment, × 1,000 (Winogradsky).

round bodies were alone present (Fig. 668), while in the purely nitric fermentation the smaller rod-shaped organisms alone were found (Fig. 669).

We have, therefore, nitrous and nitric periods of fermentations, each perfectly distinct and presided over by a separate organism, though under natural conditions both processes go on simultaneously, and the nitrous period is merely transitory. The nitrifying organisms are stained feebly by all the aniline dyes. They do not stain by Gram's method. The staining is best accomplished by allowing an extremely dilute, almost transparent solution of malachite green to act on a cover glass specimen (dried and fixed in the usual manner) for at most half a minute. The cover glass is then washed and stained with an equally dilute watery solution of gentian violet. The nitro-organisms are stained intensely by this means, and the intervening gelatinous substance remains colorless. The use of mordants, etc., is liable to lead to a granular precipitate and to staining of the intercellular mass.

Although the nitrifying organisms were undoubtedly obtained in pure cultures by the dilution of liquids, their ready isolation and accurate study were first made possible by a most ingenious plan, employed by Winogradsky, who obtained an inorganic gelatinous substance by the use of soluble silica (water glass) as recommended by Kühne, in which the organisms grew readily. The details of this procedure are described under Methods (p. 1017).

The exact relation in which these organisms stand to the bacteria proper is not yet definitely settled, but they have the general morphological characters of bacteria, and probably might be included under the group of pleomphic bacteria. Although the nitrous organism is of a distinctly rounded form, I shall provisionally refer to them here as Bacillus nitricus and Bacillus nitrosus, respectively, as the name of nitromonas, which has been applied to them, has the disadvantage of confusing them with the animal genus Monas. Winogradsky has suggested that they should be considered as a new *genus*, "*Nitrobacterium*," but has not yet brought out any convenient nomenclature to distinguish the nitric and nitrous species. A point of special interest in connection with these remarkable organisms is that, like plants, they are capable of assimilating their carbon directly from CO_2 or the inorganic carbon compounds. This physiological peculiarity certainly makes it necessary to distinguish them from the bacteria proper.

The process of nitrification has been carefully studied in connection with sewage filtration by the Massachusetts State Board of Health, it being found that when nitrification set in a very marked decrease in the number of bacteria took place.

Of the remaining chemical changes induced by the bacteria of water, we know, unfortunately, very little. As already stated, many of the water bacteria are capable of reducing nitrates to nitrites, but to what extent this takes place in natural waters we are at present unable to state. It is also possible that saprophytic organisms producing definite fermentations under artificial conditions, may sometimes act in a similar way under natural conditions, provided the needful food-supply, temperature, etc., are forthcoming.

The life processes of the anaërobic bacteria in water, have not yet received accurate study. As a rule, anaërobic bacteria are very scantily represented in water, forming less than five per cent. of the total number of species met with in pure water. In impure waters, on the other hand, the numbers appear to be relatively larger. Miquel found fourteen per cent. of anaërobic bacteria in the water of the Seine at the Chaillot pumping-station. The proportion of anaërobic to aërobic bacteria is probably regulated by the amount of dissolved oxygen in the water. Stagnant water should, in the writer's opinion, be considered as one in which the process of oxygenation is materially below the normal. Such waters are favorable to putrefactive changes by the anaërobic bacteria, and therefore, in all cases where stagnation is suspected a numerical estimation of the anaërobic forms, as well as the aërobic, is of special importance. Owing to the imperfection of the methods of anaërobic culture this matter has been almost uniformly neglected in water analyses, as far as quantitative work is concerned; but, with improved methods we may soon hope for more exact information on the subject.

Various forms of the saccharine alcoholic fermentations have been artificially produced by bacteria obtained from water, but we have no evidence to show the extent to which these fermentations take place under natural conditions.

Winogradsky, some years ago, described two specific chemical changes due to the action of certain bacteria. These were, (1) the oxidation of ferrous oxide in water containing traces of iron, leading to the deposit of ferric oxide in the protoplasm of a certain species of leptothrix, which constitutes the slimy, reddish scum and sediment so often found in ferruginous waters; and (2) the oxidation of sulphides, in sulphuretted mineral waters, into sulphuric acid by the action of a genus of Beggiota. (*Thiothrix.*)

Petruschky has attributed the alkalinity of certain waters to the preponderance of fluorescent bacteria, which he found to produce alkaline fermentation.

The nature of the inhibitory substances shown by Miquel to exist in his infertile waters, has not yet been demonstrated, as they were obtained in water which had been distilled at 30° C.; they are volatile and possibly aromatic in nature.

The general tendency of the changes in water due to biological causes may be outlined in the following table:

Agent.	Nature of Action.	Original Substance.	Resultant Product.
Plants.....	Reducing.	CO_2, NH_3, HNO_3.	Oxygen; proteids.
Animals.....	Oxidizing.	Albuminoids.	CO_2, Extractives.
Bacteria.....	Oxidizing.	Albuminoids.	Ammonia.
Bacteria.....	Reducing.	Nitrates.	Nitrites.
Nitrobacteria...	Oxidizing.	Ammonia, Nitrites.	Nitrites, Nitrates.

It must be understood, however, that the general tendency is toward oxidation and that plants indirectly aid in oxidation by liberating the necessary free oxygen.

Contamination of Waters.—From a sanitary standpoint the most important sources of contamination of water-supplies are those arising from the influence of human habitation and industry, so that, as a general rule, the degree of contamination of water is directly proportionate to the amount of population in relation to the area of the water-shed and the volume of water. In densely populated districts watered by small streams, the pollution of natural waters is usually sufficient to unfit them for drinking purposes without previous purification by artificial means. The contaminating substances are divisible into three classes: 1, the waste of industrial establishments; 2, household waste; and 3, sewage proper, containing excrement. The chief danger lies in the last class, and is owing to the risk of spreading infectious diseases. Other household and kitchen refuse is less dangerous because less likely to contain the germs of disease, but from its greater bulk is likely to produce a more obvious state of pollution in the water, and to render it unwholesome for drinking, even though less liable to spread specific infectious diseases. Factory waste, such as flows from dye-works, and other establishments where chemicals are employed, though the least dangerous of all, is likely, from its abundance and disagreeable physical characters, to impair the quality of the water.

The degree of danger to drinking-water supplies from any sources, depends less upon their actual extent than upon the degree to which they are susceptible of being controlled and regulated by the sanitary authorities. If factories can be compelled to obviate, by precipitation or other means, the objectionable features in their waste water when this enters some source of drinking supply; if the household waste is separated from the more dangerous parts of the sewage, and the latter dealt with separately by precipitation or filtration upon a sewage farm, it is obvious that the contamination of water passing through a town, even when of large size, must be much less than that created by a smaller town where the sewage and drainage are not properly looked after. The great safeguard against contamination of water-supplies, both small and large, lies therefore in the direction of keeping, as far as possible, sewage and drainage from directly entering the water.

A recent statement by von Pettenkofer that the bad effects of sewage rapidly disappear from water, has met with general dissent.

The effects of the drainage of towns upon water was well shown in Berlin, in 1881, where the number of bacteria per c.c., which above the city was 82,000, rose to 1,800,000, 4,480,000, and 10,180,000 in consequence of its passage through it. (Koch.) These numbers have been considerably reduced in consequence of proper supervision having been exercised, so that now, even in the worst places, the number of colonies in Spree water does not exceed a few hundred thousand per c.c. In Paris a similar deterioration was observed in the water of the Seine by Miquel, who showed that, while the water above the city only contained 300 bacteria per c.c., upon entering the city this number rose to 1,200, and further on, after receiving sewage, to 200,000 per c.c. The most marked change was noted below the floating wash-houses, which line the banks of the river in places, as the river water below one of these actually contained 26,000,000 bacteria per c.c., or over four times the number found in the sewers themselves.

This pollution of the water is not only dangerous, in that it indicates a dirty condition to be present, but still more because that condition is due to a cause which might be associated with the germs of infectious disease. In estimating the degree of danger from a polluted water, the cause of the contamination must be borne in mind. While a marked rise in the number of bacteria might have no special significance if due to the washings of a heavy general rainfall carrying alluvial soil into the water, a much slighter rise, distinctly traceable to sewage, would indicate a far greater danger.

In the case of rural districts it is necessary to see that wells and springs are placed where the drainage and washings from privies, cesspools, barnyards, etc., cannot possibly enter them. And the water-shed of a tract of country supplying water to a neighboring city should be carefully inspected to see that no nuisances of this de-

scription exist in dangerous proximity to tributary streams or aqueducts. A recent commission, appointed to overlook the Croton water-shed, which furnishes the water to New York, stated that over four thousand nuisances of this description existed.

Probably the most important duty in protecting water from contamination by cities and towns is the separation of the dangerous parts of the sewage, and their disposal by means of a sewage farm. This has now been carried out in the case of most of the larger European cities, usually by means of large collecting cesspools of iron, from which the contents are pumped out at regular intervals into iron tanks and carried out to the sewage farm. A complete duplicate system of drain-pipes would be still better, but as the bulk of the fecal matter is not excessive it can readily be handled by the simpler means of pumping into portable closed tanks. When this is carried out the improvement in public health, especially as regards freedom from typhoid, is very marked. The death-rate from typhoid in Munich, falling from 100 to 300 per 100,000, down to 10 to 20 per 100,000, being probably largely attributable to this cause, though an improved water supply was introduced at the same time.

Artificial Purification of Water.—It may be laid down as an axiom that a water-supply should be, if possible, taken from a source which would render it above suspicion; but where this cannot be done, then the next best thing is to purify it artificially before consumption.

The means employed to purify waters biologically are: 1, sedimentation; 2, precipitation; 3, filtration; 4, sterilization, or in some cases a combination of several of these.

1. *Sedimentation.*—The beneficial effects upon natural waters due to standing, have already been pointed out, and a marked improvement can also be effected in the case of many supplies by the construction of proper settling basins and reservoirs, in which the process of sedimentation is allowed to take place before the water is distributed. As it was shown that, in all probability, the great reduction in the number of bacteria taking place in natural bodies of water at rest is due, not simply to the mechanical action of gravitation, but to biological causes, in which the nitrifying organisms possibly play an important part, care should be taken that the floor of settling basins consists of material capable of inducing nitrification. For this, sand or gravel beds are perhaps the best, but in any case the sediment falling from the water itself probably furnishes the requisite materials. The idea that the beds of settling basins and reservoirs should be formed of cement and washed clean at frequent intervals is founded on a totally erroneous idea of the agencies by which water is purified, since, undoubtedly it is this very sediment, which hydraulic engineers are desirous of removing, that is the chief agency by which water is purified.

As to whether reservoirs, etc., should be covered or not, is a question depending upon whether the degree of exposure to contamination by dust is sufficient to counterbalance the benefits from access of sunlight. The requirements for an ideal settling basin are, therefore, (*a*) a bottom containing nitrifying material, (*b*) a situation protected from dust but open to sunlight, (*c*) sufficient depth to secure the benefits of gravitation of the suspended material, but not enough to interfere with the circulation and oxygenation in the deepest parts, (*d*) separate inlet and outlet, (*e*) sufficient capacity to allow that the daily consumption does not exceed ten to twenty-five per cent. of the volume of water which it is intended to settle, (*f*) provision for cleaning occasionally.

In some reservoirs it has been noted that an increase of bacteria takes place subsequent to standing. This is especially noticed in filtered waters, and seems clearly due to the absence of the conditions conducive to nitrification. The beneficial effects of even partial settling were well shown in the case of the Montreal lower reservoir, containing eighty million gallons (daily consumption of water from reservoir being ten to twenty per cent.), which showed on the average less than one-fourth as many bacteria as were found in the aqueduct supplying it, in a series of examinations extending over an entire year. The benefit of settling is most marked in the case of those waters which have naturally good keeping powers, or where much inorganic matter is suspended. The growth of algæ, in some reservoirs and filtering galleries, causes considerable trouble, and more so in open than in covered basins.

2. *Precipitation* has until now been chiefly employed for the chemical purification of sewage, especially to remove and obviate the waste of factories. Artificial experiments with bacteria, on a small scale, by Krüger and others, gave somewhat unsatisfactory results. It was found that by means of such precipitants as lime and charcoal, the number of bacteria could be reduced by about ninety per cent., but that subsequently an increase took place. Wiebe and Wahl found that by the employment of the "Röckner-Rothe" apparatus, sewage containing 1,686,000 to 5,245,000 bacteria per c.c., only contained at the end of the process 34 to 178 per c.c. These results, brilliant as they seem, are more applicable to the purification of highly contaminated bodies like sewage than to ordinary water. The natural taste of the water also suffers by this treatment, and its increased hardness unfits it for certain purposes.

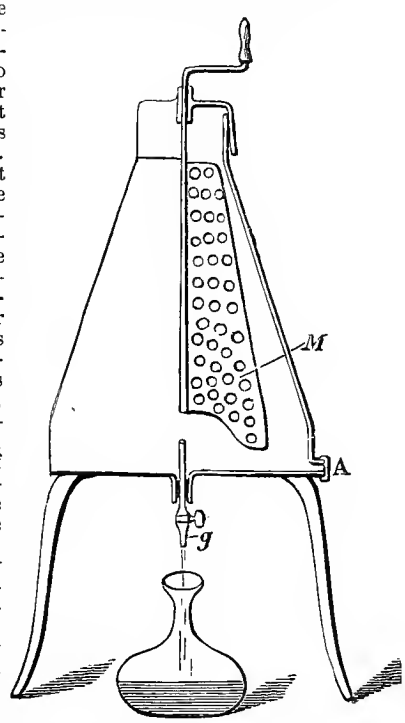

Fig. 670.—Babes's Apparatus for Precipitation by Alum. *M*, mixer; *g*, glass tap and tube; *A*, aperture for cleaning.

Of many other precipitating agents, probably, fragments of iron and minute quantities of alum are the most reliable and free from objection.

Babes has recently strongly urged for precipitation in households the use of alum, having found that by mixing alum with the water to be purified, in the proportion of 1 to 6,000, or 1 to 10,000, and stirring thoroughly, when the mixture is allowed to settle for a few hours a perfectly clear water can be decanted, having a pleasant, refreshing taste, and not only containing no bacteria at first, but remaining free from them even if allowed to stand in open vessels for several days. This water is found to be chemically free from alum, since the latter, when precipitated, forms an insoluble compound with the suspended matter. A simple and cheap form of apparatus, recommended by Babes, is shown in Fig. 670.

The chemical nature of the changes which occur here have not yet been explained. The most remarkable feature in connection with it is the tendency of the water to remain infertile, or in other words, to preserve its powers of self-protection against infection from without. This simple plan may be destined to come into extensive use in replacing the ordinary household filter, which, too often, is simply an abomination, tending in many cases to promote the objectionable features which it is designed to remove.

The great objection to all the customary modes of filtration is the increased susceptibility of the water to subsequent contamination, and it seems that a move in the

right direction is made by adopting a method which furnishes a water as capable of resisting auto-infection as natural waters are under natural conditions. In the absence of any experimental proof we must refrain from speculating as to whether this retained power of self-purification is due to the fact of the nitrifying elements being left intact, or to the retention in solution of the volatile protective substances whose existence in water has been established by Miquel. The behavior of pathogenic bacteria in water thus purified, would be worthy of study. Similar results can be obtained by the use of small quantities of chalk and sulphuric acid, or of sulphate of iron, but the quantities required are somewhat greater, and the decanted water is not always clear.

By means of suitable apparatus to secure thorough mixing and subsequent settling, these methods have been applied with considerable success to large water-supplies. Naturally, it is necessary to control their working by bacteriological tests, a matter too often neglected by the engineers and civic officials intrusted with the care of water-supplies; and the neglect of this scientific supervision is probably more to blame for failure of the methods in actual practice than to any inherent defects in the methods themselves.

Electricity.—Fermi has tested the action of electricity, and found that a marked diminution in the bacteria and other impurities of contaminated waters can be effected by means of an electric current. The mode of action appears largely dependent upon precipitation induced.

It has been suggested to employ electrolysis of saline solutions for the purpose of precipitating the organic and organized matter of the New York water supply (Edson).

3. *Filtration* is the means most commonly employed for cleansing impure water both in households and in large supplies. We have seen that, while the soil at the surface of the earth contains millions of bacteria per cubic centimetre, that taken at a depth of two metres is usually nearly or quite free from organisms, and that ground-water rarely contains any considerable numbers. As water is constantly percolating through the soil and setting up minute capillary streams, which extend in directions depending upon the forces of gravity and capillarity, it is remarkable that more bacteria are not carried to the deeper layers; and the fact that such is not the case is only to be explained by assuming that the soil itself is constantly acting as a vast universal filter, separating and retaining the innumerable bacteria at the surface, without permitting them to penetrate.

When sand is employed for filtration it is found that, in a properly working filter, most of the bacteria are retained in the upper few inches, but that when clean sand is employed a considerable number of bacteria pass through it and can be detected in the filtered water of the effluent. The number of bacteria which pass through depends largely upon the rate of flow, as determined by the pressure of water permitted. After a few days this number becomes much less, until few or no bacteria can be detected in the filtered water. Strange to say, this increased filtering power appears due to the mechanical action of the sediment itself, which, though swarming with bacteria, mechanically obstructs the pores of the filter in a manner not obtainable by the finest sand procurable. A properly acting filter is therefore neither more nor less than a dense bed of bacteria and slime, which so obstructs the pores of the sand as to prevent the passage of organisms. This obstructive substance is less composed of living than of dead and degenerated micro-organisms.

The efficiency of filtration can be readily estimated by comparing, by means of the gelatine-plate method, the number of colonies developing from a given quantity of unfiltered and filtered water.

The bacteria which appear in the effluent of filtered water are not, as a rule, the residue of those which entered, but, rather, are organisms which have been washed away from the deeper parts of the filter (Bertschinger), though it has been proved by working with cultures of easily recognized organisms, such as B. prodigiosus, that a certain proportion actually pass through and appear in the effluent (Fränkel).

The degree of efficiency of a filter in removing bacteria has been represented diagrammatically by Piefke as shown in Fig. 671, where the ordinate lines represent different levels in the bed of filtering sand; a, b, e, d, having a depth of 30 c. m. The distance from the abscissa h i, represents the number of bacteria retained in the water, and the curve k y l showing this number is seen to be reduced $\frac{5}{6}$ in the first 10 c. m. of sand, and $\frac{1}{10}$ in the second 10 c. m. The efficiency of the filter cannot be considered satisfactory until the curve k y l reaches the abscissa line h i, an effect which was usually attained at the end of fourteen days in the case of the filter at Berlin, upon a model of which the observations were made.

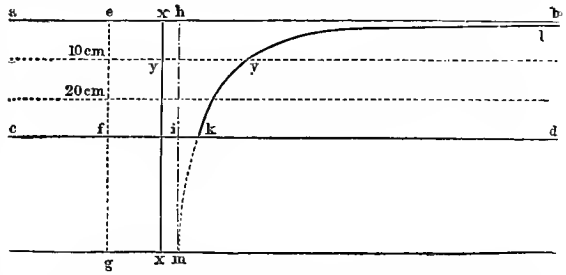

FIG. 671.—Diagram Expressing Efficiency of a Sand Filter (Piefke).

A sand filter which is working properly should yield a filtrate almost free from bacteria. As the bacteria which exist in the filtrate are not the same individuals which entered the filter, it is not quite correct to express the working of a filter in percentage, except with the reservation that the numbers given only show the relation between the two waters as regards richness in bacteria. In a good filter the bacteria in the filtrate only average, as a rule, ten per cent. or less of those in the unfiltered water: so that ninety per cent. of the total number of bacteria present disappear. This holds good of relatively pure waters containing only about 100 to 1,000 bacteria, but when the original water is notably bad in quality, and contains from 1,000 to 10,000 bacteria or upward per cubic centimetre, the beneficial effects of filtration become much more striking, so that ninety-five, or even ninety-nine per cent. of the number originally present may be removed. From this it follows that sand filtration is better fitted to render a poor water moderately good than to bring an already fairly good water up to the first-class standard. In other words, the numbers in the filtrate will be the same whether the original water contains 1,000 or 100,000 per cubic centimetre.

The extent to which a filter purifies water depends partly upon the construction of the filter bed, and partly upon the rate of flow. As a rule, the extent to which bacteria are removed is in inverse proportion to the rate at which the water passes through. It can be readily understood that the slimy masses of dead bacteria which clog the pores of the filter, are more likely to be washed out if the stream is rapid and the pressure great; while the living bacteria are more likely to pass through if the rate of flow is increased. Piefke and Fränkel were able, with a sand filter 30 mm. deep, by reducing the rate of flow in from 100 mm. per hour down to 30 mm. per hour, to reduce the number of bacteria in the filtrate from 60 or 100 per c.c down to 10 or 15 per c.c. (The rate of flow is calculated by the length of a column of water which would pass through a filter bed of corresponding area in a given time, and is for convenience reckoned usually in millimetres per hour.) The rate of flow which may be permitted in a given filter, depends also on the quality of water, as that containing a large number of bacteria requires to be filtered more slowly in order to attain the best results. Thus, while in the case of the relatively pure water of Lake Zürich it was found that a reduction of the bacteria to $\frac{1}{80}$ in the filtrate could

be attained with a rate of flow of 300 mm. per hour; with the water of the Spree, at Berlin, the same degree of improvement could only be attained by reducing the flow to 100 mm., or even 50 mm., per hour.

Previous sterilization by dry heat of the sand employed was not found at Berlin to improve the quality of the water furnished during the early period of filtration, but rather the contrary, and it was always necessary to reject the filtrate obtained during the first few days. Coarse sand was found more efficacious than fine, provided its grains were sharp. Previous to filtration the water should be allowed to stand for some time—one to two days—in settling basins, by which means the coarsest impurities and a large proportion of the bacteria are removed, and, the work of the filters being lessened, they do not require to be cleaned so often.

By the time a filter has begun to yield a good effluent the rate of flow has already begun to decrease, and the yield of filtered water becomes gradually less. The quantity may be increased somewhat by increasing the pressure, and several ingenious forms of apparatus have been contrived which regulate the pressure and keep the flow constant, acting upon the same principle as the governor of a steam engine. Ultimately the amount of the effluent becomes very small, and the filter is then said to be "dead" and requires to be cleaned.

In cleaning filters it is found that the surface of the sand is covered with a thin greenish-brown membranous pellicle from $\frac{1}{8}$ to $\frac{1}{16}$ of an inch in thickness (*Schmutzdecke*), beneath which the sand is found to be quite clean. Consequently, when this is removed with shovels or scrapers after the water has been run off, the filter is again rendered fit for use. (Piefke-Sedgwick.) It is this membranous layer which acts as the true filtering membrane.

The length of time during which a filter may be used without cleaning varies from two to three weeks in the summer to as many months in the winter. The entire bed of sand does not require to be renewed above once a year. After a filter ceases to furnish a pure water, its sand must then be removed and replaced by fresh.

According to Koch, chemical examination of water affords no indication of the efficiency of filtration, as the matters to be removed are suspended and not dissolved. He states that the effluent of each filter bed should be examined daily bacteriologically. The presence of over 100 bacteria indicates that something is wrong with the filter. The examination of the mixed effluent of all the filter beds may leave a dangerous defect in one or more individual filters undetected, as the total mass of water may not show the contamination. (Ztsch. f. Hyg., xiv.)

While the action of filters in removing bacteria from water, as tested by the state of the filtrate immediately after passing, is usually very satisfactory, there is a great tendency to subsequent growth of bacteria in the filtered water. On this account it is not well, as a rule, to store any very large quantity of water after filtration, but it is preferable to use it as soon as possible. The water during its purification is not rendered infertile, but its susceptibility to auto-infection is increased by the removal of the protective substances. Hesse, Wolffhügel, Riedel, and others have studied this phenomenon without very clearly explaining the causes which promote it. The chemical changes in water undergoing this deterioration seem to escape our present methods of observation. The curve seems in most cases to be that taken by pure water. For instance, an increase to 2,310,000 bacteria per c.c. in filtered water has been noted in the first thirty-six to sixty hours after filtration, subsiding to 2 per c.c. at the end of forty days (Dupont). That this increase forms an actual source of danger is highly improbable, as the organisms can only be the harmless water-bacteria, but at the same time it would obviously be better to obtain water in which no subsequent increase took place, and which resembled more in this respect natural bodies of water.

In stating that biological as well as mechanical processes are concerned in filtration through sand, it must be understood that the biological element is not simply the obstruction of the pores of the filter by the bacteria masses, but that chemical changes also take place in the water during filtration, which can be ascribed to biological agencies; and it is possible that the intelligent employment of these may effect future improvements in filtration. It must be borne in mind that a natural process of filtration is constantly going on in the soil, and so successful is this natural filtration that the ground-water is practically free from bacteria, and, with scarcely any exception, from all the organisms. This filtration is constantly going on, and yet the soil loses none of its filtering power. On the other hand, in the system of filtration employed for the water-supplies of London and Berlin there is a constant tendency for the filters to get out of order. The sand has to be cleaned and renewed at short intervals, and at first the water which comes through is too impure to be used for drinking purposes. Further, as the filtering material consists, practically, of a mass of dead and living organisms, it is evident that an objectionable element must be present in the filter before it begins to work efficiently, and that this element increases steadily until the filter becomes unfit for use.

Contrasting that natural filter, the earth, with the imitations employed by the water companies, we are at once struck with the fact that the former appears able to keep itself in order and does not deteriorate by use extending over a number of years, while the latter has to be kept in order artificially by constant watchfulness and attention, and becomes, even under the most favorable circumstances, inefficient at the end of a few weeks. It certainly seems worth while to study out the causes which produce such a vast difference between natural aud artificial filtration, and to see whether we might not take a lesson from nature and learn to filter as she does.

The first striking difference is that, while in artificial filtration the water supply is continuous, in natural filtration it is intermittent, depending upon the occasional falling of rain. Another difference is that in soil, under natural circumstances, the water is placed under conditions similar to those in which the nitrifying influences (organisms) work in the soil. Water percolating through a natural soil is constantly in the presence of the nitro-bacteria, and constantly having its ammonia changed to nitrites, and its nitrites to nitrates, or in other words, it is placed in a position to receive natural self-purification. When a water is purified in this way, under natural means and by natural agencies, it can be readily understood why this process should be continual and progressive, and why it should be able to look after itself without constant watching and manipulation, by changing and cleansing beds of sand, and so on. The reason for these self-contained powers of regulation is simply that the nitrifying organisms are the active agents, and as they live and increase through having material given them to nitrify, the more work they have to do, within reasonable limits, the better they are able to do it, provided always the surroundings are such as do not tend to check their action or destroy their vitality. Now, the one thing of all others which interferes with nitrification is a too great supply of albuminoid matter, which is not yet converted into ammonia or amides. Keeping this in view, it is easy to see that in the average filter the conditions present must, under nitrification, be very difficult, while under conditions resembling those which obtain in soil nitrification is facilitated and goes on by itself.

If the great purifying agency in water is nitrification, it seems unfortunate that, while attempting to purify water, we must commence by imposing conditions which render nitrification difficult or impossible. It would appear very desirable to adopt some method similar to that which goes on in the soil with such satisfactory results, rather than to insist upon trying to strain the water continuously by methods which give less satisfactory results and require so much attention. It might not be going too far to supplement Piefke's aphorism, that filtration is a biological process, by the statement that in the continuous sand filtration processes we adopt a method more liable to hinder than to favor it, and fail to take advantage of the natural methods by which the effect of

the biological agencies in filtration could be assisted and heightened.

The desirability of adopting, if possible, a system of intermittent filtration has led to numerous experiments being made to determine the nature of the water obtained by this means, and how much per day may be safely filtered through a given area of sand in order to obtain the best results. Frankland, in England, and the Massachusetts State Board of Health in America, have published the results of their investigations.

It is well known that the subsoil drains of sewage farms, which form a system of effluents to the filter beds, contain as a rule remarkably few bacteria, these having been removed by the soil. At Lawrence, Mass., a system of filter tanks was established for the purpose of obtaining accurate quantitative results in sewage filtration. These were filled with sand to a depth of three to five feet above a layer of rocks or cement; and some yellow loam was placed at the surface. The sewage was applied intermittently in small quantities at a time, and the observations upon the effluent were continued over periods of from two months to three years without changing or removing the filtering material. It was found that, by proper care, the filter at the end of three years' constant (intermittent) use was in perfect order, free from disagreeable odor, and capable of yielding an effluent containing few bacteria, only about .001 per cent. of the number in the original sewage, and which for the most part contained only 0.3 to one per cent. of the ammoniacal and organic nitrogenous matter present in the sewage.

These observers attributed these very satisfactory results to biological causes, namely, the burning or oxidation of the bacteria and organic matter by the agency of living organisms present in the sand. The conditions necessary to produce disappearance of the bacteria and nitrification were a temperature above 40° C. and an abundance of oxygen in the pores of the filter. By pouring or spreading the material to be filtered on the surface of the sand at intervals, the introduction of a constant supply of fresh oxygen was assured. The efficiency of nitrification in a filter was indicated not only by loss of albuminoid and free ammonia, but by increase in the nitrates. The reduction in the number of bacteria was generally directly proportionate to the completeness of nitrification, being less marked during the winter months, when the ammonia of the effluent averaged fifty per cent. that of the sewage, than in the summer, when it fell to between 0.2 per cent. and three per cent. The amount of sewage filtered averaged 50,000 gallons per acre daily. The reduction of bacteria during incomplete nitrification was always considerable, one per cent. surviving passage through the filter, but when nitrification became complete, a marked reduction appeared at once, so that only 0.08 to 0.03 per cent. appeared in the effluent.

Similar methods of intermittent filtration were experimentally tried with the water-supply of Lawrence, Mass., and the results obtained were quite analogous to those with sewage. It was found that, (1) the reduction in the number of bacteria corresponded closely to the completeness of nitrification; (2) that with suitable temperatures and a proper supply of air in the pores of the filter, marked nitrification was attained during the warmer months; (3) that even when nitrification was partially arrested during the cold weather, the improvement in the quality of the effluent, when compared with that of the inlet, was *fully as marked as could be expected from continuous filtration under the most favorable circumstances;* (4) the filter at the end of two years' constant (intermittent) filtration did not show any signs of deterioration; (5) the organisms other than bacteria were almost completely removed from the water; (6) the water of the effluent upon standing did not show that tendency to an increase of its bacteria by auto-infection characteristic of waters filtered by the ordinary continuous method. (For details, the admirable special reports of the Massachusetts State Board of Health for 1890 should be consulted, the work being reported with a care and thoroughness which leaves little to be desired.)

From the above experiments we have seen that it is possible, experimentally, to imitate successfully the natural filtration as it takes place in the earth, with the result of obtaining filters which gain, instead of losing, in purifying powers after years of use, and which yield a water comparable to the natural ground-water. The only drawback to the employment of this method in actual practice is that a much larger filtering surface is needed, or in other words, with plant of the same capacity a smaller yield of filtered water is obtained than by continuous filtration with periodical changing and cleansing of the sand.

To obtain the best results by the intermittent method, the quantity of water treated should not exceed 500,000 gallons per acre, per day. The filtration of the London, England, supply of 190,000,000 gallons per day, is obtained with a filtering area of 109¾ acres, giving 1,700,000 gallons as the average daily yield per acre, or more than three times what could be expected of the intermittent method. Even when it is considered that, of the total filtering area of London, over ninety per cent. has to be cleansed in the course of a month, and that a large proportion of the total area is always lying idle, it will be clear that for the quantity of water delivered by the intermittent system, the filter beds would require to have at least four times the area needed for continuous filtration.

What is expected of a filtering system is that it shall remove *all dangerous ingredients from the water*. That this is not done in actual practice has been shown experimentally by C. Fränkel, but that a dangerously polluted water, after thorough filtration, becomes a fairly safe one for a drinking supply, is a matter of universal experience. The extent to which filtration of a water removes the dangerous elements was shown by the appearance of a typhoid epidemic in Berlin during the winter of 1889. Owing to an unusually severe and prolonged frost, eight open filter-basins became useless, and the whole water-supply of that district had to be forced through five covered filtering galleries. Owing to the necessary increase in rate of flow, from 100 mm. per hour to 300 mm., the purification of the water became very incomplete, so that the filtrate contained for several months from 2,000 to 3,000, and at one time over 4,000, bacteria per c.c., instead of only 50 to 100 per c.c. The effect upon public health was that *in the portion of the city receiving this water* over three hundred deaths from typhoid occurred within a period of three months, at a season when usually but little typhoid was to be expected. The remainder of the city remained free from excess of typhoid during this period. As soon as it became possible, through the appearance of milder weather, to cleanse the filters, the number of bacteria in the water fell to 0 to 500 per c.c., and the typhoid mortality fell to its normal limits. A more striking proof of the occurrence of typhoid from drinking-water could not be asked for, though unfortunately the hygienic laboratories of Berlin made no special effort to ascertain if typhoid bacilli could be detected in the water during the period of the epidemic.

Koch has shown that the absence of cholera from Altona during the Hamburg epidemic in 1892 was due to an efficient filtration of the water, which was originally worse than that of Hamburg. In the winter of 1892–1893, when some of the Altona filter beds became frozen, cases of cholera began to appear.

A filtered water, though better than the same water before filtration, is not to be compared in hygienic value with a water obtained from a source which lies beyond the reach of pollution. In Vienna the most careful filtration of water obtained from the Danube still left the city with a most unenviable record for typhoid, while with the adoption of a supply from the neighboring highlands,* the mortality from this cause immediately decreased, although no other sanitary improvements of note in the drainage, etc., were carried out at the time. In Munich, formerly notorious for typhoid, although

* Unfortunately it appears that this supply is not enough for the needs of the city, a water famine being occasionally threatened in dry seasons.

Professor Pettenkofer has strenuously opposed all attempts to attribute the improvement to this cause, the procuring of a supply of pure mountain water was followed by such a falling off in typhoid that the disease has now become a rare one there. As extensive improvement in drainage was at the time carried out, the improvement is less clearly due to the change in water-supply than in the case of Vienna.

With the constant increase in population the problem of obtaining water for large cities like London, Berlin, Paris, and New York, becomes more difficult. The question becomes practically narrowed down to carrying water from immense distances, or utilizing the ground-water obtained by means of artesian wells. The former plan is most favored by many English scientists, who are seriously considering the relative feasibility of drawing the London supply from the mountain district of North Wales, at a distance of 180 miles from the metropolis, at a cost of over £11,000,000, or from the lakes of Cumberland and Westmoreland at a cost of over £13,000,000. The main objection urged is not that the engineering difficulties are too great, but rather that in diverting the daily amount of 230,000,000 gallons, estimated as necessary for the needs of London, from another part of the kingdom, they are depriving the cities of the North of England of their natural water-supply. In Germany, on the other hand, the utilization of the ground-water by means of artesian wells seems to find more favor. In Paris no comprehensive scheme for improving the water-supply has yet been matured, but, as in France water is not much employed as a beverage, the question appears to be considered less pressing than would be indicated by the frequency of such diseases as cholera and typhoid.

The present water-supply of New York from the Croton Aqueduct is anything but an ideal one, and the constant presence of from 2,500 to 40,000 bacteria per c. c. in the city supply seems to urgently call for filtration.

Chicago, with the whole of Lake Michigan to draw from, has succeeded in contaminating the water about the city intake so as to render it almost unfit for drinking purposes; but here the question is relatively simple, as by the construction of sewage farms, on the one hand, and the lengthening of the conduit, on the other, a pure supply should be available.

Household Filters.—The question of rendering an impure water drinkable by means of a small domestic filter is one which has not yet received a satisfactory solution. Most of the filters on the market are capable of physically purifying water and making it clear and palatable. Unfortunately, as these filters do not efficiently remove the bacteria, the last state of the water is too often worse than the first. The ordinary carbon, gravel, pumice, sand, glass, and asbestos filters yield a filtrate which usually contains more bacteria than the water from which it was derived, while, if the water originally contained many organisms, they appear in undiminished quantities. The benefit from such filters is purely æsthetic in character, and the filtered water is not one jot improved, from a hygienic standpoint. The failure of filters of this class to remove bacteria from water is due to the following causes: (1) the filtering substance is incapable of retaining bacteria; (2) the receiving chambers form a suitable spot for the subsequent autoinfection of the water; (3) particles of sediment are washed off by the current and appear in the filtrate; (4) the construction of the filters does not permit of their being readily cleansed or sterilized; (5) nitrification does not occur.

As a rule, the ordinary household filter, working in the usual way, shows innumerable bacteria in the filtrate, even when the water appears clean and appetizing. As the first thing we demand of a filter is that it shall remove from the water any germs which may cause disease, it is evident that none can be considered to meet this condition unless the bacteria are almost entirely removed. Recent improvements in construction have done much to remedy this deficiency, and a few filters are now procurable which yield a water free from micro-organisms.

The oldest and best known form is the Pasteur-Chamberland bougie filter, which is made of a hollow chamber of porous porcelain, which is made to fit into a tube attachable to any water-tap. The water percolates through the porcelain, and collects in the central cavity, from whence it drops into the vessel used to collect it. This arrangement is shown in Fig. 672.

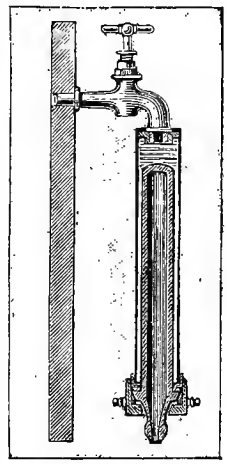

Fig. 672.—The Pasteur-Chamberland Filter.

When a pressure of water is not attainable, the filter may be made to act as a siphon by attaching a rubber tube about 6 feet long to the outlet, and after placing the bougies in a bucket of water, sucking the tube until it becomes filled with water. An arrangement is shown in Fig. 673, by which 3 bougies are simultaneously employed to filter the water from a pail. This simple plan is adapted to meet the requirements of travellers, soldiers on the march, etc.

That a Chamberland filter in proper working order will yield a filtrate absolutely free from bacteria is the universal experience of those who have taken the trouble to test it. There is no doubt whatever that under proper conditions this filter is absolutely germ-proof. There are two drawbacks which prevent it from being an ideal filter: (1) it will only furnish germ-free water for a limited period, usually varying from 3 to 8 days, rarely over 2 weeks, and (2) the amount which can be filtered through it is small. This latter objection is overcome by having "batteries" of 4, 10, 20 or more filter bougies arranged in one pressure chamber, when the water is required for schools, etc. Each bougie will, under moderate pressure, furnish one-half to two gallons per day. In practice, the outer surface of the bougies should be cleansed with a brush at the end of about a week, and should be sterilized by boiling in water, or in a steam sterilizer. One common cause of failure of these filters is the presence of cracks or flaws in the porcelain, through which unfiltered water passes, and such cracks are liable to be produced during sterilization, unless it is carefully done. Under ordinary circumstances, the filtrate at the end of a week has begun to show bacteria. Their presence is usually explainable as due to their having grown through the pores of the filter, but is probably frequently caused by the organisms of dust, etc., lodging at the mouth of the filter and spreading upward into the central reservoir. If

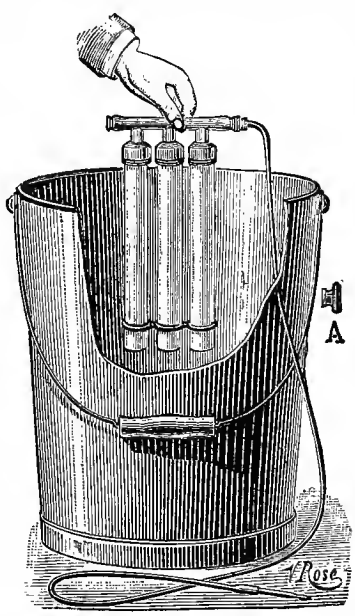

Fig. 673.—Pasteur-Chamberland Filter with simple siphon tube attached.

cleansed and sterilized every week and carefully looked after, the Chamberland filter can be depended upon to furnish water free from bacteria. It has the great advantage of being compact, and having all its parts readily accessible for cleansing and sterilization.

A number of so-called porcelain filters, made on the same pattern, are far inferior to the Pasteur-Chamberland.

It has long been sought to combine the advantages of the Chamberland filter, of furnishing a germ-free water and being readily cleansed and sterilized, with a more abundant supply of the filtrate. Recently several filters have been placed on the market, which profess to attain this, and while none of the rapid filters are absolutely germ-proof, several are capable of accomplishing about what may be expected of sand filtration on a large scale, and give an abundant supply of water from which most of the bacteria have been removed. In some of the best of these, asbestos fibre and infusorial earth are employed as the filtering medium, and an arrangement is made by which the filter can be readily cleansed, and afterward sterilized, by passing steam through it, which is certainly a scientific and thorough method.

Breyer reports very favorable results from the use of an asbestos membrane filter, which yields for several days an absolutely germ-free water under a pressure of between ½ and 1½ atmospheres. The filtering material contains three million pores per square mm. of surface. In practice it is best to renew the filtering material every forty-eight hours. This filter is also found capable of filtering considerable quantities of water, about thirty cubic metres being obtained per square metre of filtering surface, in twenty-four hours. The cost of operating is mainly that of renewing the asbestos.

Nordmeyer and Bitter found that with filters of infusorial earth, a germ-free water was furnished for about a week; the apparatus could readily be sterilized by steam.

It would be out of place here to discuss the individual merits of particular manufactures, but it may be generally stated: (1) That ninety per cent. of all the styles of household filters sold are absolutely unreliable, and do not fulfil their claims, and with the remainder good results can be obtained only by proper management; (2) in all filters, cleansing and sterilizing is necessary at intervals of about once a week; (3) the filter which can be most readily cleansed and completely sterilized is the one to be preferred; (4) all filters which have a receiving chamber, where the filtered water is allowed to stand indefinitely, should be discarded as dangerous.

Sterilization of Water by Heat.—The experiments of Pouchet and Currier have shown that most of the bacteria met with in water are destroyed at temperatures considerably below the boiling point. Currier found that cultures of cholera, typhoid, diphtheria, and pathogenic cocci suspended in water, were killed instantaneously by boiling, or in 15 to 30 minutes at 70° C. Only one species was found which required boiling for an hour to destroy it. Miquel found that in water heated to 45° for 15 minutes, about 75 to 90 per cent. of the bacteria were killed: at 55° about 92 or 93 per cent. were destroyed: at 65° about 95 per cent. Less than 1 per cent. withstood the heat of 100°. This held good of several samples of river water. In other observations the bacteria were almost completely destroyed by ten minutes' heat of 80° C. From this it is evident that in water which has been boiled any pathogenic bacteria present will have been destroyed; hence this treatment of water affords the greatest security in times of epidemic. On the other hand, it has certain disadvantages: boiled water has an insipid, flat taste, and is not refreshing; further, in boiled water which is allowed to stand exposed for some hours an enormous number of bacteria develop, so that it is preferable to boil the water immediately before use. Enthusiasts for hydro-therapeutics appear to find great comfort in drinking hot water, claiming that it is more refreshing than cold. To persons of this way of thinking, the sterilization by boiling would, of course, be highly satisfactory. To ordinary individuals boiled water can only be rendered palatable by aërating, either with air or with carbonic-acid gas, by means of some of the various apparatus designed for the purpose. On shipboard, where water has to be stored in tanks for a long period, it becomes often very foul; and in some cases there is no doubt, very dangerous to health, especially in times of epidemic on board. The greatest safeguard against water contamination at sea is to obtain it by means of condensation. Distilled water obtained by means of condensation apparatus, is now used altogether in the American and German navy, and it has been found that the employment of this system has materially benefited the health of the ships' crews. The condensation apparatus is combined with an aërating process, so that the water is palatable and refreshing.

When large supplies of sterilized water are required for use by a number of people, for instance in case of epidemic in a small town or village, the boiling of the water by individuals is an obvious disadvantage. An apparatus has been devised and constructed by Rouart and Geneste-Hercher for sterilizing the water at a high temperature, namely, 115° to 130° C. The construction of the apparatus, which is simply a special set of coils of pipe, between which hot air is passed, with subsequent cooling and filtering of the water, will be understood from Figure 674

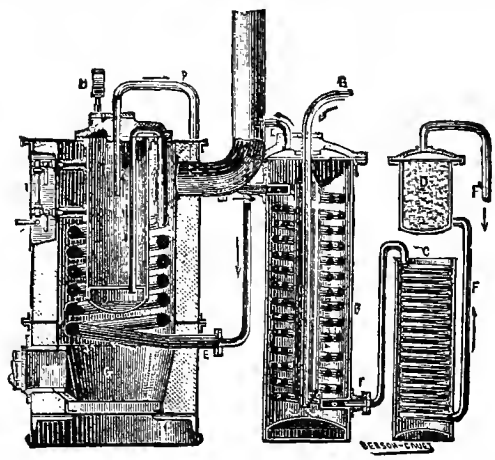

FIG. 674.—Geneste-Hercher Apparatus for Sterilizing Water at 130° C.

With this, for each pound of coal, about ten gallons of water can be sterilized. The municipalities suffering from epidemics are in this way able to furnish temporarily water free from suspicion to large numbers of the inhabitants.

Voller, after investigating water-sterilizing apparatus made by Heaton and Hennike, Burgdorf, Siemens, Strebel, and Jones, found that the Hennike apparatus furnished 180 litres of sterilized water per hour, and the others 25 to 40 litres. The fuel employed was gas, of which 6.11 cbm. were required per 1 cbm. water by the Hennike and 7.50 to 11.60 by the others. In all these apparatus the sterilized water in the process of cooling is made to warm the water about to be sterilized.

Disinfection of Water.—The addition of disinfecting substances to drinking-water has, owing to the poisonous and acrid nature of our most reliable chemical disinfectants, not come into use; however, when proof has been afforded that a well is polluted it is advisable, in addition to cleaning, to thoroughly disinfect it. In the case of tubular wells this is best accomplished, according to Fränkel, by first pumping as dry as possible, then removing the pipe and pump, and placing them for two hours in two per cent. carbolic-acid solution, afterward cleansing with a brush and pouring in several gallons of five per cent. crude carbolic and sulphuric acids. The pumping is to be resumed and continued till no trace of carbolic acid can be detected (tested by the phenol reaction, on addition of perchloride of iron). Fränkel considers the common method of disinfecting by chalk not

adapted for tubular wells. Ordinary wells cannot be completely disinfected by this method.

Peroxide of hydrogen has been added to drinking-water in order to purify it by disinfection. The addition of small quantities of permanganate of potash is also recommended. This acts as a precipitant only, the water being subsequently cleared by agitation with coke.

Mineral Waters.—The examination of natural mineral waters by Malpert-Neuville, Poncet, Roman, Collin, in France; Reinl, in Austria; and Minges, in America, have shown that, taken with proper precautions at the source, these waters are almost free from bacteria. When bottled, however, a rapid increase takes place, so that at the end of twenty-hour hours over 500,000 microbes per c.c. may be met with. Analogous results were obtained by Fränkel, who examined samples of artificially prepared seltzer water. The carbonic acid, with which these waters are saturated, tends to act as a germicide, and where proper cleanliness is used, the bacteria per c.c. in bottled mineral waters should not exceed 250 per c.c.

Carbonic Acid.—The action of carbonic acid on water bacteria has been shown by Leone and Fränkel to be a destructive one. Of the anaërobic bacteria but few exist whose growth is not hindered by the presence of carbonic acid. In spite of the tendency of carbonic acid to destroy bacteria, aërated waters often contain large numbers of bacteria, and in the manufacture of these care should be taken that the apparatus, etc., are kept clean, and that a pure water is employed.

METHODS.—*Procedure to be Adopted with a Sample of Water:*

A. Estimate the number of bacteria per c.c. by gelatine-plate method.

B. Identify as far as possible the different organisms obtained by culture in this method, and the proportion in which they occur.

C. Describe any new species met with.

D. Examine the sediment by the Sedgwick-Rafter method.

The directions given here are intended for those who are familiar with the ordinary processes in bacteriology; information on which is found under the headings "Micro-organisms," Vol. IV., and "Bacteriological Technology," in the present Supplement.

The object of special methods for water analysis is chiefly to guard against certain sources of error. There is no work in which mistakes can more readily be made, and wrong inferences drawn. Methods which, while not absolutely accurate, afford little chance for making a serious mistake, are to be preferred to more delicate methods capable of misapplication. Rapid and simple methods enable the observer to make a larger number of individual observations than more complicated and precise ones, and the ultimate precision obtained through a large number of simple observations is usually more correct and reliable than that obtained by a smaller number of complicated ones.

The greatest safeguard against error lies in the duplication of all work, and the comparison of the results so obtained. Thus, at least two observations should always be made, and each of these should be done in duplicate, and, to check them, the whole process repeated. If corresponding results obtain throughout, the observation is reliable. The importance of using expeditious methods is therefore clear.

As the biological characters of a water are different at various seasons, various points, various depths, etc., it is necessary that, where possible, the observations should deal with the water in all its different phases, in order that the extent of its variations may be learned. The biological work is, for convenience, divided into bacteriological examination, and examination of the other microscopical organisms, such as algæ, infusoria, organized and unorganized *débris*.

Loss of time between the collection and examination of samples is fatal to accurate results. This is especially true of the bacteria, but also of the other organisms. The interval between the collection and plating for bacteria should be, if possible, only a few minutes, and certainly less than an hour. For the other organisms the examination should be completed within one or two days of the time of collection.

The Collection of Samples is a matter which, where possible, should be done by the analyst himself and not deputed to others, except where the conditions of the water are such as make it a mere matter of routine. The points to be attended to are: 1, To get samples characteristic of the whole body of the water, for which purpose it is always best to obtain as many different specimens as possible; 2, to take them under such precautions as render the occurrence of contamination from the hands, dust, etc., out of the question. For work other than bacteriological, a glass-stoppered bottle containing one or two litres is on the whole the most convenient. Especial care must be taken that it is so thoroughly cleansed that, when rinsed out with distilled water, no organisms are found in the washings. The stopper is only to be removed at the moment when the sample is being taken. In the examinations carried out by Boards of Health the bacteriological examination is often made from water taken in this way, and transported to the laboratory for analysis. In this case the bottles require to be sterilized by heat before use. Although this, with proper precautions, gives fairly accurate results, and is better than omitting the bacteriological examination altogether, it is far preferable that separate samples be collected for bacteriological work in smaller bottles, that a large number of these be taken, and that the cultures be made at the time and place of collection, if this is more than a few minutes' journey from the laboratory.

For bacteriological samples the use of test-tubes, or Erlenmeyer's flasks, is usually recommended, the directions given being that after plugging with cotton wool and sterilization these should be covered by a rubber cap, which is only to be taken off at the time of collection of the sample. The contact of the rubber cap and the wadding with the fingers is to be avoided, and the bottle is to be immersed before removal of the stopper, and the sample taken some distance below the surface, holding the bottle or tube in such a position that it is not exposed to washings from the hands and arms, or other sources of contamination. It is well to discard the original plug of the bottle, and replace it by a fresh one. A good plan is to use sealed tubes, or Sternberg's bulbs drawn out to a fine point, which can be broken under water, and can be sealed again if transport is necessary. For making cultures the ends are broken off. This, as far as freedom from contamination is concerned, leaves little to be desired, but the trouble in making and sealing a bulb for each sample is considerable and requires to be done in the laboratory.

An ingenious method, adopted by Miquel, makes it possible for samples to be taken in this way at any required depth below the surface, by the apparatus shown in Fig. 675, where the pointed end of the sealed flask is curved and broken at *A*, by means of a string, at the required depth. This has been further improved by H. L. Russell, who inserts a sterilized rubber stopper into the test-tube, through which is passed a piece of bent glass tube, sealed at the end and broken by the descent of a lead weight running along a wire, as shown in Fig. 676.

The writer has found it convenient to employ, for a collection of samples, dropping bottles of about 50 c.c. capacity, which are fitted with pipettes that serve as ground-glass stoppers. For collecting purposes these are placed in a special frame, as shown in Fig. 677, and the stopper raised at the required depth by pulling on the string or wire attached to a movable cross-bar; the apparatus being sunk by the weight of the box forming the base of the frame which is filled with shot. This apparatus is modified from one introduced in 1885 by Wynter-Blyth and invented by Mr. A. F. Strafford ("Proc. Roy. Soc., Edin., 1885–1886"). The modifications consist merely in a more convenient method of holding the bottle and stopper. For working at depths of less than fifty feet this apparatus leaves little to be desired; at greater depths it is difficult to manipulate the lines at-

tached to the cross-bar and sinking-frame. The bottles, when opened under water, fill in the course of ten to fifteen seconds, and can be withdrawn and replaced by others. Ten samples of water can be taken, at a depth of ten to twenty feet, in this manner, in less than a quarter of an hour. The writer at first used to seal the ends of the pipette stoppers, but latterly he has employed some which are graduated, the rubber cap being placed in position after sterilizing, and in this way the necessity of a separate set of sterilized pipettes for making the cultures is done away with. Where it is not necessary to take the samples at any considerable depth, a simple lead sinker may be employed, attached by a wire or string to the neck of the bottle, which is then immersed by using a fishing-rod and line, a method very convenient for obtaining samples from the banks of streams, from bridges, from steamboats in motion, etc.

An apparent objection to this apparatus is that the attachments to the collecting-bottle for opening and closing it being external, are liable to contamination, though the uniformity of the counts obtained shows that it does not actually occur. Dr. George H. Nuttall suggested a most ingenious idea by which the springs for closing the bottles were to be placed inside it. A method also suggested was filling a bottle with sterilized mercury and allowing it to escape at the required depth. (Bertin-Sins.)

Transport.—The bottles used for collecting samples should be secured from contamination of all sorts previous to use, and when the water samples have to be kept for more than half an hour previous to making cultures, they should be cooled to about 0° C. The writer found it convenient to place the bottles in a tin box, the lid of which is furnished with a handle and lock. The box can be surrounded by ice in an external jacket, or the lid converted into a tray in which ice is placed, a tube carrying off the water which collects. In this way security from contamination and cooling of the water are secured. Refrigerating boxes for the transport of samples have been devised by Pfuhl, G. Roux, and others, in which the samples enclosed in a water-tight box are surrounded by a non-conducting substance, usually sawdust, and packed in ice. According to Miquel, the number of bacteria developing from samples of water kept even at 0° C. for several hours, is sometimes considerable, and on this account the transport of samples for long distances is undesirable.

G. Frank has recommended the shipment of a small box containing the materials necessary for making cultures at the spot of collection, together with printed cards of instruction by which the cultures can be made by persons without technical skill, such as sanitary inspectors, or the laity generally. This, however, must be regarded as a poor substitute for skilled manipulation, and the choice between shipping samples of water or allowing the cultures to be made by unskilled hands, is but a choice of evils.

Quantitative Bacteriological Analysis.—It will be understood that the cultures are to be made, where practicable, on the spot where the samples are collected, with the least possible loss of time. The bottles containing the samples are first shaken thoroughly to insure the uniform distribution of the organisms throughout, and to break up any bacteria masses or clumps that may be present. By always giving one hundred violent shakes to every sample of water, very uniform results are obtained. Instead of using plates, roll tubes, or Petri dishes, the cultures may be made in small, flat-sided glass vials, such as can be obtained from any apothecary. The "Blake" vials, holding two to three ounces, are most convenient. These, when cleaned, plugged, and charged with 5 to 10 c.c. of flesh-peptone gelatine, should be sterilized on two or three successive days, just as with gelatine tubes. Before use their gelatine should be melted by placing them in a pan of tepid water at a temperature not above 40° C. Labels can be placed on the necks of the bottles, and it is convenient to employ for this purpose gummed paper cut into long strips, which are nearly torn across after having been written upon.

With a graduated pipette, ten to twenty of which should be kept ready for use in a small tin box (where the graduated pipettes do not form part of the stopper), a quantity of water, say 1 c.c., should be measured out and dropped into one of the bottles containing gelatine; ½ c.c. is put into a second bottle, and a smaller quantity,

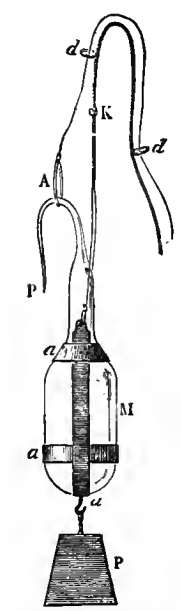

Fig. 675.—Apparatus for Collecting Samples at Desired Depths (Miquel).

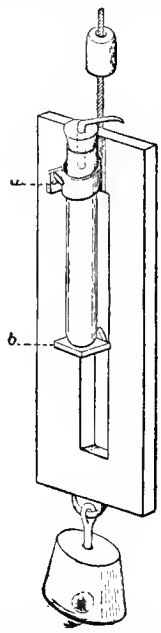

Fig. 676.—Apparatus for Collecting Water Samples at Great Depths (Russell).

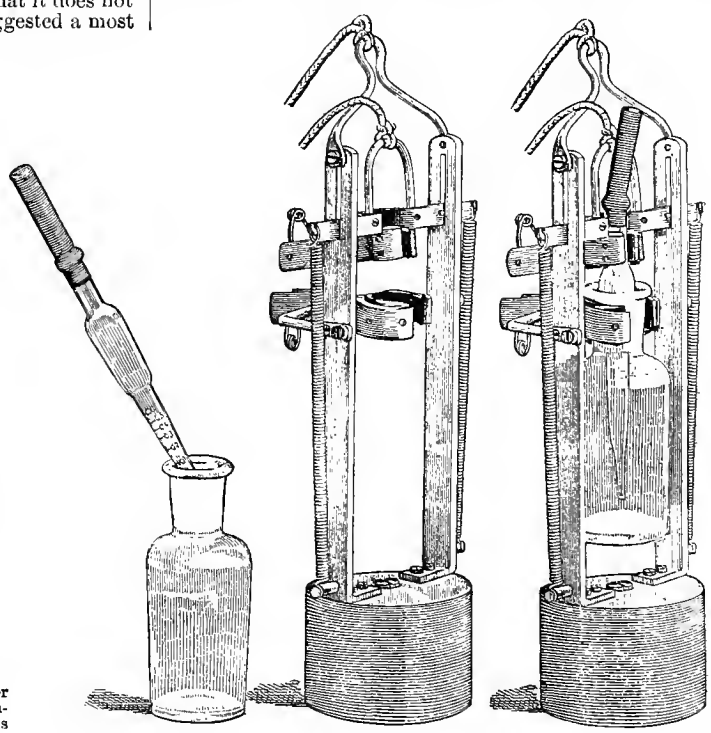

Fig. 677.—Apparatus for Collecting Samples of Water below the Surface (Johnston).

either $\frac{1}{10}$ or $\frac{1}{20}$, into a third bottle. The bottles are then gently shaken, so as to secure uniform distribution of the germs, and then to be laid on their side till the gelatine stiffens. The hardening of the gelatine is materially hastened by laying the bottles upon a flat lump of ice. Before making the cultures the cotton-wool stoppers should be loosened by turning them half round, so as to make sure that no gelatine has stuck to the wool. It is convenient to use pipettes holding 1 c.c., graduated to $\frac{1}{10}$ c.c., and these should preferably discharge drops of $\frac{1}{20}$ of 1 c.c., so that one drop equals $\frac{1}{20}$ c.c., and two drops equal $\frac{1}{10}$ c.c.

By employing various fractions of a cubic centimetre in the same sample a valuable control is secured, as the accuracy of an observation will depend upon the extent to which the numbers of colonies correspond to the amount of water introduced. Thus, in a water containing 100 bacteria per c.c. (that is to say, yielding 100 colonies by the gelatine method per c.c.), a whole cubic centimetre should yield 100 colonies; a half cubic centimetre, 50 colonies; $\frac{1}{10}$ cubic centimetre (2 drops), 10 colonies, and the $\frac{1}{20}$ cubic centimetre (1 drop), 5 colonies. If this proportion is materially altered—for instance, if the smaller fractions give higher counts than the larger ones—we are warned of a mistake somewhere. The fractioning method has the further advantage that, where the water contains more bacteria than was anticipated, and the colonies are so close set, or the liquefaction so rapid, that the culture made with an entire cubic centimetre cannot be accurately counted, the smaller fractions will still give countable plates. For accurate work care should be taken that the number of colonies developing on any one plate does not materially exceed one hundred.

The smaller fractions usually give counts proportionally higher than the larger ones; for instance, where 100 colonies grow from 1 c.c., about 60 may appear from $\frac{1}{2}$ c.c., and 12 or 13 from $\frac{1}{10}$ c.c. This is owing to the fact that, in the thickly sown plates, crowding of the organisms may cause a single colony to be formed in some cases from the fusion of two or more distinct centres of growth. In densely set plates smaller colonies can often be seen lying within the larger ones. For this reason the number shown by the greater dilutions is more accurate, and the multiple of this number representing cubic centimetres preferable.

To exclude the personal or subjective factor as much as possible, the average of the different plates should be taken and used for record, but at the same time it is most important that the maximum and minimum should also be noted, as *the difference between these*, when recorded, furnishes a permanent indication of the accuracy of the work. The statement of average numbers only is therefore to be deprecated.

When the bacteria in the water are represented by many thousands, as is the case with impure waters, the water should first be diluted before making the cultures. This is done by adding 1 c.c. of the water to be examined to 100 c.c. of sterilized tap-water, mixing thoroughly by shaking, and taking of this mixture 1 c.c. and its fractions for making the cultures. The results must, of course, be multiplied by one hundred. Where the numbers run into hundreds of thousands or millions per c.c., it is necessary to make a second dilution by taking 1 c.c. of the diluted water and adding it to 100 c.c. of sterilized water, multiplying the number of colonies by ten thousand. In addition to this, as a control, the number of colonies may be also estimated by dividing 1 c.c. or less of either the dilutions or the original water among a series of cultures. As a general rule, it may be stated that the system of dilution is more reliable than that of trying to take very minute fractions with a fine pipette.

Gabritchewski recommends, in the case of highly polluted water, the employment of capillary pipettes of extremely fine calibre for making the dilutions, so that direct measurements can be made of $\frac{1}{100}$, or even $\frac{1}{1000}$, of a cubic centimetre! The fluid is driven out by means of a finely graduated screw compressing a rubber tube, as shown in Fig. 678.

This plan is possibly preferable to dilution, when much field work is to be done, with water polluted to an extreme degree. As these capillary pipettes save space, by doing away with the necessity of providing a supply of sterilized water, a larger number of examinations could be made and time saved. On the other hand, it is not possible actually to measure out such extremely minute quantities of water with certainty, owing to the disturbance due to capillary attraction, which tends to make the drops so large that quantities representing .01 c.c. can only be reckoned upon when the water is dropping at that rate from a burette for some minutes together. Dilution with sterilized water is more accurate and reliable than that of capillary measurement, and it may also be mentioned in this connection that the polluted waters do not tend to undergo the rapid changes on keeping which characterize pure waters (Miquel), and therefore slight delay before plating is not so objectionable as in the case of the latter.

A source of error, not generally known, appears to lie in the fact that the number of colonies developing from a given quantity taken into the dry pipette is less than when the process is repeated a second time. This I consider due to the fact that bacteria tend to adhere to the sides of the pipette. My observations have become more uniform since I adopted the practice of rinsing out the sterilized pipette with the water, and refilling it before making the examination.

The cultures are to be kept in a dark place, at a temperature of, as nearly as possible, 20° to 22° C. The influence of temperature upon the uniformity of results is very great, and in the winter a warm room should be selected, or an incubator kept by means of a small flame at the desired temperature. In the summer, if the room be too hot, the same result may be obtained by allowing a stream of water at a temperature of 20° C. to flow through the incubator. Kinyoun and others, working in the Southern States, have adopted a simple plan of placing the cultures in a tin box covered with linen cloth, which is kept constantly moist, and the evaporation from which secures the desired temperature. For field work, or on journeys, a small portable refrigerator may be employed, consisting of a double-walled tin box with a tray of ice, from which the water can escape by means of a tap.

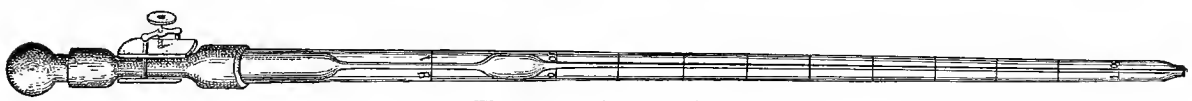

Fig. 678.—Capillary Pipette (Gabritchewski).

The colonies begin to appear at the end of about forty-eight hours, and their number should then be noted. In doing this the use of a powerful hand lens is necessary to distinguish the smaller colonies; the counting is facilitated by ruling parallel lines with ink, or by means of a writing diamond, on the exterior of the bottle, two longitudinal ones usually sufficing. The culture bottles should be placed upon a black background to bring the colonies into sharper relief. The side to which the gelatine has adhered should be placed uppermost.

To prevent the possibility of mistakes in enumeration, and to relieve the mind of the strain of constant attention to a monotonous series of numbers (a constant source of worry and irritation), the use of an automatic tally, such as is used by drovers for counting the animals in their flocks, or by officials for checking the number of passengers on ships, is highly to be recommended, as the counting then becomes automatic, and the mind is left free to attend to other details, such as the appearance of the col-

onies. Further, by employing a tally, the interruption by one's friends no longer becomes a thing to be dreaded.

When the number of colonies in a plate is very great a definite portion of the surface only may be counted, and taken as an average of the whole.

The colonies should be counted upon successive days, and any increase noted. When no further increase occurs, say at the fourth or fifth day, the number may be adopted as correct. This maximum number is usually obtained at the end of three to five days, about fifty per cent. appearing at the end of forty-eight hours. It not infrequently happens in the later days of growth that the number apparently decreases slightly instead of increasing, a circumstance which is explainable by the tendency to confluence of colonies, and which indicates that the maximum development has been reached.

While estimating the total number of colonies, the proportion of the more striking and important species should also be noticed. To do this without loss of time properly ruled pages are essential, and this is readily obtained by the use of a rubber stamp, giving parallel lines. I have come to employ altogether small scribbling-books of convenient size, about four by five inches, and to number each sample serially. The employment of serial numbers greatly facilitates labelling. Duplicates of the same sample can be indicated by employing letters, thus: 360, 360 A, 360 B, indicate three duplicate samples from the location from which sample 360 was obtained. The fractions are indicated on the labels and in the notes by placing the dividend beneath the number of the samples; $\frac{360}{2}$, $\frac{360}{10}$, and $\frac{360\ A}{2}$, $\frac{360\ B}{10}$, etc., represent the fractions $\frac{1}{2}$ c.c. and $\frac{1}{10}$ c.c. The numbers of the examinations contained in each book can be shown on the outer page, so that the whole series of a prolonged analysis is always ready for reference and indexes itself, so that any of the examinations can at once be referred to.

Instead of making cultures in the glass vials here described, which satisfactorily replace the more expensive "Petruschky" flasks—and which I find to have been recommended by Schill and others—Petri dishes or Esmarch tubes can be made use of. Esmarch tubes have the disadvantage of requiring time and attention in rolling, just when time is most valuable and can least be afforded. The liquefaction of the colonies in them is a disaster, and the counting is somewhat difficult.

Petri dishes, though more convenient for counting, and requiring less time, do not offer perfect security against admission of germs from the air, where repeated countings are made on successive days. They also require double the amount of apparatus, as the gelatine tubes are also necessary. Further, a variable number of organisms remain in the tube, and do not appear in the plates. The necessity of labelling separately both the tubes and dishes, with the possibility of pouring the wrong tube into a plate, by mistake, is also an objection. The use of the original plate method of Koch with the moist culture chamber jar, offers too great possibility of contamination from the air. In such cultures the presence of moulds is very frequent, and Koch himself always allowed six foreign colonies as a minimum for each plate.

Arloing has contrived a complicated mechanical apparatus by which the growth from drops of water, being delivered exactly in the centre of the square of gelatine, can be distinguished from those due to air contamination, where the colonies are equally likely to fall on other parts of the square. As far as I know, the method has never been adopted by any other person, and presents no especial advantages.

The only point in which the use of common glass vials is inferior to other methods is that, in a blurring from the thickness of the glass, microscopical characters of the colony are less delicately shown than in the thin Petruschky flasks. This disadvantage is more than compensated, in the case of field work, by the readiness with which glass vials can be packed, and by the ease with which they may be set up on end before use, and laid down afterward, or packed one above the other. Moreover, the blurring of the colonies can be remedied by removing the Abbé condenser before examining them, and using a simple mirror illumination, or by the use of a correcting lens for the objective. I have become so pleased with glass vials that I now employ them almost exclusively for gelatine-plate cultures in pathological and bacteriological work.

For counting the colonies several devices have been suggested. The original plan of Wolfhügel called for the use of a square plate of glass, upon which cross lines were drawn, each enclosing an area of one centimetre square. The plate is placed beneath this, and a dark background of slate is used as a relief. A lens mounted on a tripod is used to magnify the colonies. Running diagonally from opposite corners of the plate are two lines of squares, subdivided by finer cross lines into nine divisions, for convenience when the colonies are densely set. It was usual to count only six squares and average the result. This well-known apparatus is not much used at present, as the use of glass plates has been abandoned in most laboratories.

Personally I found it more convenient, in working with Petri dishes, to use a simple school slate, upon which cross lines were scratched, so as to form squares of 1 c.c. or subdivisions of these. A complicated and somewhat

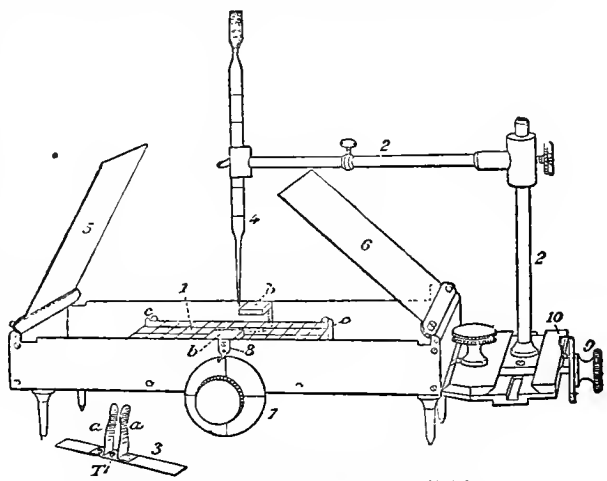

Fig. 679.—Apparatus for Plating Water Cultures (Arloing).

expensive apparatus for Petri dishes has been devised by Heyroth. The illumination by means of a mirror I have not found satisfactory. Petri employed a somewhat similar apparatus, when he first introduced the use of culture dishes. For studying the finer details of cultures in plates the Petri dish is highly satisfactory.

G. Roux recommends photographing the colonies, by allowing the plate or flask to stand over a sensitized albumin paper, which is subsequently developed and fixed, and gives an excellent reproduction both of the number and appearance of the colonies. This method was previously recommended by others. It has the advantage of effecting considerable saving of time, and preserving the proof of the exact nature of the culture.

Certain other methods for the quantitative analysis deserve mention. Some French bacteriologists have shown a tendency to depreciate the gelatine-plate method and to employ the fluid cultures, especially peptone bouillon. Quantitative results by bouillon cultures can be obtained by means of dilutions. Miquel recommends the addition of extremely small drops of water, $\frac{1}{100}$ to $\frac{1}{1000}$ c.c., to small quantities of bouillon, contained in Pasteur's flasks. To avoid the contamination of air, and facilitate manipulation, a burette is used. A portable field outfit, devised by Miquel, is shown in Fig. 680, and contains, in addition to the bouillon flasks, fifteen flasks for making gelatine plates (*p*).

Single drops of the water, pure or diluted, 1 to 100, 1 to 1,000, 1 to 10,000, 1 to 100,000, with bouillon, are

sown in each flask, and the series of flasks is then placed in an incubator at 30° to 35° C. for twenty-four hours, and the number of flasks showing turbidity is noted. As Miquel has found that one-fourth of the bacteria in a water, under these conditions, are capable of producing turbidity at the end of twenty-four hours, the proportion of flasks showing turbidity multiplied by four, and again by the dilutions which the proportion of one drop delivered from the pipette bears to 1 c.c., will give the number of bacteria per c.c.

For example, take one drop of a water representing $\frac{1}{100}$ of a c.c., dilute this with bouillon into fractions of 1 to 100, 1 to 1,000, and 1 to 10,000 of ten flasks, and seed ten flasks from each of these dilutions; if the flasks seeded with the 1 to 100 dilution all become tur-

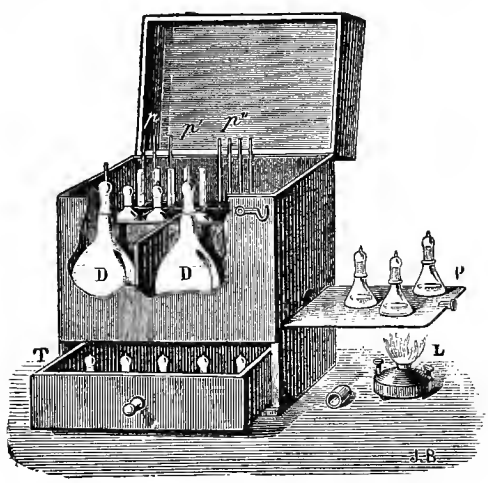

FIG. 680.—Miquel's Portable Outfit for Field Work, with Flasks and Graduated Pipettes. The conical bottles contain nutrient gelatine.

bid in twenty-four hours, and of those seeded with 1 to 1,000 three become turbid, while all of the 1 to 10,000 remain clear, it is evident that as $\frac{3}{10}$ represents one-fourth of the number presumably present . ·. $\frac{3}{10} \times 1{,}000 \times 100 \times 4 = 120{,}000$ bacteria is the number per c.c. The great source of error lies in the enormous degree of dilution, by which an error is multiplied over one thousandfold. Thus two bacteria getting by accident into one of the drops in the 1 to 1,000 solution, in the case cited, would have lowered the result to 80,000 per c.c.

Miquel only employs this as a preliminary (*approximative*) method, keeping the water at a temperature of 0° C. till the following day, when a further large series of flasks are seeded to determine more accurately the number present. A certain degree of patriotic enthusiasm for things French would appear indispensable to rate the practical value of this highly ingenious and scientific above the gelatine-plate method.

Without underestimating the value of M. Miquel's discovery that water contains far more bacteria than are revealed by gelatine plates, it must be remembered that the value of enumeration lies in comparative rather than absolute standards of measurement.

Miquel insists that his method is a very simple one, but except in France it has never come into general use. It certainly has the advantage of recognizing a large number of bacteria which grow poorly or not at all on gelatine at room temperature.

Another method suggested by Miquel consists in the employment of papers saturated with nutritive media, which are moistened with the water in question, and after remaining in a moist chamber for some time are treated with a solution of indigo and sulphuric acid, by which means the number of colonies are recognized by the appearance of the bluish spots. This has never come into general use, and even Miquel, while deprecating the employment of the gelatine method, appears nevertheless to use it himself.

QUALITATIVE BACTERIOLOGICAL ANALYSIS.—Until recently but little systematic study has been attempted of the various species isolated from water. The number of the different forms met with, and the difficulty of distinguishing and identifying them, or of determining from published descriptions whether the forms described by one author correspond with those of another or not, has retarded progress in this direction.

The determination of the nature and properties of the germs found in water has been called "qualitative" analysis, and is distinguished from quantitative, where the number present forms the chief consideration. From a hygienic stand-point great benefit should be expected, *a priori*, from qualitative work in bacteriological water analysis. In particular the recognition of pathogenic bacteria would appear to be of great importance, since it is the presence of disease-producing germs which creates the dangerous element of water. On the other hand, the actual results of work in this direction have been far from satisfactory, partly because, owing to the number of other forms, the recognition of the few pathogenic germs is extremely difficult, as they are sparsely distributed, and minute quantities of water only can be examined by the ordinary methods employed.

A further difficulty is caused by the great resemblance borne by a number of common water bacteria to pathogenic ones, notably the typhoid bacillus, of which almost the exact counterpart can be found in most samples of drinking-water by careful search.

Considerable improvement has lately been effected in the direction of the more ready and certain isolation of pathogenic bacteria in water, consisting of: 1. Culture methods, by which the growth of the pathogenic microbes is favored, while the growth of other bacteria is prevented. 2. Methods enabling larger volumes of water to be employed. 3. More exact study of the characteristics of water bacteria, and comparison with pathogenic forms in parallel cultures.

Our classification of bacteria is still far from perfect. The great advance, due to the introduction of the gelatine-plate method, and the readiness with which a number of species can be recognized by it, have led to its too exclusive use. A further evil attending this one-sided work has been a separation of groups which are, on the whole, closely connected, simply on account of their liquefying gelatine or not. An attempt to place the classification on a broader basis has been made by Miquel, whose scheme is given in the following table:

MIQUEL'S SYSTEM OF CLASSIFICATION (MODIFIED).

A. Cocci.
B. Bacilli.
C. Spirilla.
D. Other forms.

A. Cocci. 1° Aërobic and Facultative Anaërobic.
2° Anaërobic.

A. 1° Aërobic. α Develop at 20° C.
β Develop at 20° to 40° C.
γ Develop above 40° C.

A. 1° α. I. Pathogenic.
II. Zymogenic (specific ferments).
III. Chromogenic.
IV. Saprogenic.

A. 1° α I. a. Liquefy gelatine.
b. Do not liquefy gelatine.
c. Do not grow in gelatine.

It will be noticed that qualitative and quantitative analyses have been treated here somewhat as if no intimate connection existed between them. The reason for this is simply that, owing to the immense amount of time required for biological water analysis, and the number of pressing duties which simultaneously engage the attention of those working at it, it is all but impossible to carry them on simultaneously without assistance. It looks, indeed, as if the thorough analysis of a drop of water would soon demand the attention of a number of indi-

viduals, just as it formerly was said to require ten men to make a pin. To combine quantitative and qualitative biological analyses of water, when done thoroughly, requires so much time that it is seldom called for, several months of uninterrupted labor being necessary for the complete analysis of a single sample, to the exclusion of all other work. An outline of such an analysis, given by Miquel, is appended here.

It is to be hoped that in the future, with continual improvements in our methods, some such satisfactory results will be ultimately arrived at by more speedy means, and that analyses of this sort will become the rule instead of the exception.

COMBINED QUANTITATIVE AND QUALITATIVE ANALYSES.

Bacteriological Analysis of Seine Water, August, 1890 (Miquel).

Quantitative analysis: bacteria per c.c.		397,500
Growing on gelatine	312,400	
Growing only other media	85,100	
	397,500	
Aërobic bacteria	334,000	
Anaërobic bacteria	63,500	
	397,500	
Growing at 20° to 40°	368,000	
Growing at 40° to 50°	26,500	
Growing at 55° to 70°	3,000	
	397,500	
Qualitative Analysis:		
Pathogenic species per c.c.	16,900	
Zymogenic species per c.c.	95,000	
Chromogenic species per c.c.	125,000	
Indifferent species per c.c.	110,000	
Undetermined species per c.c.	50,600	
	397,500	
Of the chromogenic species		125,000
Yellow species	68,000	
Orange species	2,500	
Green species	2,200	
Red species	35,600	
Violet species	500	
Blue species	1,500	
Intermediate colors	14,700	
	125,000	
Of the yellow species sub. group		68,000
Citron colonies	Bacterium xanthidenm.	
	M. citreus conglomeratus.	
Greenish colonies	M. chlorinus.	
	Sarcina ventriculi.	
Brown colonies	Spirillum tyrogenum.	
Yellow colonies	Sarcina lutea.	
	B. cavicida.	
	B. hyacinthi.	

The writer finds it convenient, in connection with the quantitative analysis, to note the proportions in which some of the commonest and most easily recognized species are present, the results being tabulated, as shown in the accompanying record of an analysis of Ottawa River water:

Ottawa River at L'Original, May 1, 1891.	1	1/2	1/10	A	A/2	A/10	B	B/2	B/10	Per cent.
May 3	92	67	8	104	51	11	86	45	10	127.5 per c.c.
May 4	120	65	13	130	63	11	90	48	10	
May 5	122	67	13	140	65	12	liq.	....	12	
May 10	....	....	13	....	....	14	....	....	12	
B. fluorescens liquefaciens	24	10	....	....	....	....	....	....	....	23
B. arborescens	14	....	....	....	....	....	....	....	....	12.5
B. janthinus	2	....	....	....	....	....	....	....	....	2
B. nubilis	6	....	....	....	....	....	....	....	....	3
B. megatherius	1	....	....	....	....	....	....	....	....	1
B. aquatilis	3	....	....	....	....	....	....	....	....	3

QUALITATIVE METHODS.—*Microscopic Examination.*—The examination of a drop of water under the microscope, by simply placing it on a slide and covering it with a cover-slip, was formerly considered to be a highly scientific operation and one yielding valuable results. In discussing this primitive method, Dr. Cahen, of Nancy, goes so far as to say that it constitutes the best means of performing a bacteriological analysis of water; a statement which, being made in 1886, was certainly considerably behind the times.

The bacteria can be advantageously studied by, after evaporating, fixing a drop of water on a cover-glass. Most works giving directions for bacteriological analysis of water recommend that, in each case, several drops of water should be placed upon clean covered glasses and allowed to evaporate beneath bell-jars or glass covers to protect them from the dust. They are then to be fixed by passing through a flame in the usual manner, and stained by a watery solution of an aniline dye, either fuchsin, methylene blue, or gentian violet being selected. The object of this method is, of course, to insure the detection of the forms which do grow poorly or not at all in the culture media. It has been generally ignored by bacteriologists as being unsatisfactory. The better way of attaining the same results is to filter some of the water (several cubic centimetres, 50 to 100 generally suffice) through clean sterilized sand, and to obtain with a sterilized platinum needle or loop a little of the sediment retained, smear that upon a cover-glass, and stain. Few bacteriologists carry this out, although the advantages are obvious.

The staining fluids employed for examining bacteria of water are the ordinary aniline stains as used in other departments of bacteriology, and no special details need be given here. The best methods of staining the nitrifying organisms consist in the employment of extremely dilute solutions of gentian violet, followed by equally dilute solutions of malachite green. The employment of Gram's method is, of course, advantageous for ordinary purposes with the use of a counter-stain, such as fuchsin or saffranin for the organisms which are decolorized by it.

The microscopic study of water bacteria consists chiefly in the examination of the colonies in plate cultures. For determining the different species present this is one of the most valuable means at our disposal. The appearance of colonies under a low power (should be one inch or half-inch objective [AA or BB Zeiss]) is very important. Details of the appearance at different stages of growth should be carefully noted; the size, shape, color, structure, the appearance of the border of the colonies, the presence of motion among their granules, the formation of internal markings, the appearance of the edge in the surrounding gelatine, etc., are the points which afford the chief means of distinction.

In addition to this, dried cover-slip preparations should be made of the organisms of different colonies by fixing in the usual way and staining. The examination can be made, either in water, or after drying and mounting in balsam. The use of an oil immersion-lens is necessary.

For recording observations graphically, camera lucida drawings can be employed, or preferably, when practicable, micro-photographs. Though the latter alone are recognized as possessing scientific accuracy, and being free from subjective errors of observation, a great drawback to micro-photography is to be found in the fact that faithful prints of the negatives are extremely difficult to obtain. When copies have to be multiplied the various photo-gravure and lithographic processes leave much to be desired, and it must be confessed that the great majority of the photographs hitherto published resemble one another to a painful degree, and are rather unsatisfactory. On the whole, the graphic representation of colonies is in a highly unsatisfactory state.

CULTURE MEDIA.—For the culture of water bacteria the ordinary nutritive media, both liquid and solid, suffice. Of these a large variety have been suggested by different authors, and are constantly being added to. For marine species, salt water is to be employed, instead of fresh, in making up the solutions.

Nutritive Gelatine.—Of the various formulæ suggested, that of Miquel is the only one presenting a striking deviation from the ordinary formula. He uses peptone, 20 grammes; table salt, 5 grammes; wood ash, 0.1 gramme; water, 1,000 c.c.; to this bouillon 100 grammes of gelatine

must be added. The reaction should be faintly alkaline, and as the wood-ash and peptones are usually decidedly alkaline in reaction, the addition of a few drops of a weak solution of tartaric acid is necessary. I have found some difficulty in obtaining this medium free from turbidity, and prefer to use a nutritive gelatine made by adding ten per cent. of gelatine to the classical Loeffler bouillon, obtained by boiling an infusion made from one pound of can beef to a litre of water, with ten grammes of peptone and five grammes of salt added per litre and carefully neutralizing. It is preferable that, instead of trying to vary the nutritive media, a well-known medium should be employed, as by this means the results of different observers are more likely to correspond. Slight variations in the composition of a medium are productive of considerable modifications in the appearance of the colonies, so that the same organisms may be described as different species. For this reason it is well to refrain from using the convenient and economical method of making bouillon from meat extracts, the addition of sugar, etc. It is convenient to have on hand two kinds of gelatine, one faintly alkaline and the other slightly acid, growth on acid gelatine being a valuable means of distinguishing certain species.

In some cases a modification of the gelatine may be necessary in order to study forms which do not grow in the ordinary medium; thus Pohl found, in the examination of swamp waters, that the addition of carbonate of ammonia to the gelatine, in the proportion of 0.5 to 1 per cent., favored the development of certain species, especially putrefactive forms, and certain spirilla. The addition must be made after the gelatine has been sterilized, and subsequent boiling must be avoided, as this interferes with the coagulation of the medium.

Drossbach recommends the employment of vegetable albumin, starch emulsions, etc., for obtaining pure cultures of certain spirilla, which do not grow in the ordinary gelatine. The infusions are first diluted in sterilized water, and drops of the diluted material spread upon the nutritive substance, which is then partially dried beneath a vacuum pump: the growth remains entirely confined to the surface, and contamination from deeper colonies is not to be feared. This modification of the dilution method appears likely to furnish material aid in certain cases.

Agar.—The agar medium, employed in the cultivation of water bacteria, is simply that made by adding one to two per cent. to the Loeffler bouillon. It is better to avoid the addition of glycerine or sugar, as this interferes somewhat with the normal development of color in the chromogenic forms.

Potato.—The most convenient form for potato cultures is that recommended by Bolton and Globig, where small cylindrical blocks are placed in sterilized test-tubes. Attention should be given to the reaction of the potato, which should be faintly acid, as the production of color and the form and appearance of the colony are modified considerably when the reaction is alkaline or neutral. New potatoes have usually a neutral reaction, older ones an acid one. To insure a clean white surface in the potato blocks, they should be soaked for several hours in a stream of running water before sterilizing, in order to remove a juice which subsequently turns brown and discolors them.

Serum.—Serum from the blood of the ox is the most commonly used form. Pleuritic or hydrocele effusions also yield a satisfactory medium. By preparing the serum tubes in the way recommended by Hueppe, of first coagulating them at a temperature of 67° to 75° C., and then raising the temperature to 95° C. for half an hour, repeating the sterilization at 95° on two successive days, this medium can be prepared with less trouble than almost any other. As a rule, water bacteria do not grow well upon serum.

Bouillon.—The ordinary slightly alkaline beef-peptone bouillon of Loeffler is now generally recognized as the standard. For the sake of the uniformity, modifications of this solution are, therefore, not to be recommended. For testing the chemical changes produced by bacteria the employment of Dunham's peptone solution is preferable to the use of Loeffler's bouillon, as it is quite colorless, and the detection of delicate color reactions is not interfered with by the presence of yellow pigment in the original solution. It is prepared by dissolving 1 per cent. of peptones (Witte's peptone is the most uniformly colorless) with 0.5 per cent. of common salt, and should be neutral.

To recognize acid and alkali formation add 0.5 per cent. of coralline solution in the strength of two per cent., which gives a faint rose tint that becomes bleached if acids are produced, and intensified if alkalies are formed. Phenol-phthalein solutions give a purple-red with alkali, and are bleached by acid. A number of such cultures should always be made simultaneously, as the result may vary in individual tubes, and control tubes, not inoculated, should always be placed with them, as occasional changes occur from the absorption of ammonia or carbonic acid, etc., from the air.

The formation of indol, characteristic of certain organisms, is tested by the occurrence of a rose-purple tint in Dunham or ordinary peptone bouillon, when a few drops of concentrated sulphuric acid are added to a culture kept twenty-four to forty-eight hours in the incubator. This reaction requires the presence of nitrites as well as indol, and therefore, if it does not appear upon the simple addition of sulphuric acid, one or two drops of 0.02 per cent. solution of sodium nitrite should be added. Some bacteria produce nitrites from simple peptone solutions, while others do not. The test is open to the fallacy that volatile ammoniacal compounds are formed in the air where gas is being burned, and when absorbed into water are changed into nitrites, so that the presence of nitrites in a bouillon does not indicate that they are formed by the action of bacteria, unless control tubes, which have not been inoculated, remain free from them.

Petruschky recommends the employment of a whey obtained from milk, and colored with litmus (Lakmusmolke) for testing these reactions, but the media are more difficult to make than Dunham's solution.

Milk.—The growth of some of the organisms in milk is highly characteristic, and should always be studied; the presence of coagulation or not, the time at which it occurs, etc., should receive attention. Besides plain milk, milk to which litmus is added is also a valuable reagent.

Reduction of Nitrates.—This reaction is characteristic of a large number of water bacteria, and is stated by Frankland to afford a valuable means of diagnosis between otherwise identical forms. It is best studied in a solution containing 0.5 of calcium nitrate, 0.5 of inverted sugar, 400 c.c. each of solutions of 1 per 1,000 phosphate of lime, 0.2 per 1,000 sulphate of magnesia, and 0.1 per 1,000 chloride of calcium, 400 c.c. of which mixture, with 1 gramme of peptone and 15 grammes of calcium carbonate, are added to 4 litres of distilled water. To estimate the amount of nitrate reduced to nitrite is a somewhat complicated process, and can only be satisfactorily done by reducing the terms of ammonia and employing Nessler's test. A more simple and ready means of obtaining the same result would apparently be the employment of the phenyl-hydrazin test, but for some reason or other this test does not give reliable results in the presence of peptones (in the writer's experience), although a slight reduction can be made out. The fault appears to be due to some influence produced by the peptone. The working of the test is complicated by the possible absorption of ammonia or nitrates from the air; precautions should therefore be taken against this by cultivating in stoppered bottles kept in a pure atmosphere.

Water.—The power or not of multiplying in plain water is characteristic of a number of water bacteria, and distinguishes them from other allied forms. Sterilized tap-water is to be preferred as a culture medium to distilled water, as the latter seems to exert an injurious influence upon some organisms, possibly by promoting osmotic changes.

Flagella of bacteria are stated by Strauss to be stained by mixing the material thoroughly with a drop of carbol-

fuchsin diluted with four times its bulk of water, and examining directly under a cover-glass. This method gives good results with the cholera vibrio, but not with the typhoid bacillus.

The most reliable stain for flagella is Loeffler's method. See article "Bacteriological Technology."

Relation to Temperature.—A simple method of roughly establishing the temperature relations of an organism is to make three sets of cultures in bouillon, potato, and agar, and keep one at the room temperature, say 20° C., another near 30° C., and the third at 37° C. The rate and abundance of growth being noted in each case. This shows roughly the optimum, or most favorable temperature, as compared with the others, and in the case of water bacteria the cultures at 37° C. usually remain sterile. Subsequently, more accurate and elaborate tests can be made, and the thermal death-point noted, by exposing cultures to various temperatures for fixed lengths of time.

Relation to Oxygen.—The greater number of bacteria found in water belong to the strictly aërobic organisms, and cease to grow visibly when their supply of oxygen is cut off. The most simple method of testing this is that suggested by Koch, of making a streak culture upon gelatine, which has just become solid, upon a plate or in a Petri dish, and laying upon it a thin plate of mica, which should be sterilized in a flame immediately before use. With strictly aërobic organisms no visible growth occurs, though by the microscope a number of minute colonies may sometimes be seen, which are enabled to grow to a certain extent by the oxygen or air enclosed in the gelatine. If the colonies do not grow visibly, they are certainly neither anaërobic nor facultative anaërobic, and it is therefore unnecessary to study further their capacities in this direction.

The employment of the deep culture is also a simple method of showing the necessity, or otherwise, of oxygen to the bacteria. A stab culture is made in a gelatine tube, and another tube of liquefied gelatine or agar is poured above this. The culture is thus prevented by the upper gelatine from the access of air, and if truly aërobic no growth occurs. These tests are open to the fallacy that small quantities of air are apt to be absorbed by the gelatine, even if boiled just previous to use, which suffice to insure a slight growth even in aërobic forms. A better method is that (of G. Roux) where the air is excluded by a mixture of vaseline, 98 parts, paraffine, 2 parts, for cultures at room temperature, or of vaseline, 90 parts, white wax, 8 parts, and paraffine, 2 parts, for cultures kept at body temperature. Previous to inoculation the tubes should be boiled, so as to drive out all oxygen, and then cooled. The same result can be attained by pouring a layer of sterilized oil over the upper surface of the medium in the tube. In inoculating the cultures it is best to introduce the seed by means of a sterilized capillary glass tube. Where the anaërobic bacteria are to be studied, exclusion of oxygen can be obtained either by absorbing the oxygen in the tubes or plates by means of alkaline pyrogallic solution (Buchner), by passing in hydrogen gas (Fränkel), or by exhausting with the mercury pump (Schotelius). Hesse has recently introduced a simple method, which was also partly anticipated by Marchmann, in which hydrogen gas is passed in under mercury. The methods of Kitasato with flat flasks or rolled tubes, which are filled by means of a rubber stopper, perforated by sealed glass tubes; or the method of Botkin, where the plates are placed under a bell-jar, sealed by vaseline or glycerine at the bottom, are all more or less inconvenient. In isolating anaërobic bacteria it must be remembered that a large number of aërobic germs are present in the original water inoculated, so that it is necessary to purify the first culture by plating it a second or even a third time under anaërobic conditions before the aërobic organisms are completely got rid of.

The cultures of anaërobic bacteria is made much easier by the addition of some reducing substance, such as glucose, 2 per cent., or formic acid, ½ per cent., to the medium, as this lessens the amount of free oxygen present at the commencement (Kitasato).

Gas Production.—The formation of bubbles of gas in gelatine or bouillon cultures is an important biological character. Anaërobic and semi-anaërobic organisms tend to produce gas, and do so most readily when sugar of some sort is present. Its peculiarity offers a ready means of distinction between typhoid bacilli and most other members of the colon group, as the former do not, and the latter do produce gas in saccharine bouillon.

For testing the formation of gas, Theobald Smith recommends the use of Einhorn's saccharometer tubes. These are filled with bouillon containing one to two per cent. of grape-sugar and sterilized. After inoculation they are placed in the incubator, and at the end of twenty-four hours marked gas production occurs, and bubbles collect at the closed end. The distinction between typhoid and colon bacilli by this means is declared by Smith to be absolute, the typhoid variety never producing gas, while the colon invariably does so. Dubief, in asserting that both organisms produce gas, appears to have been in error; the production of gas is checked when the medium becomes too strongly acid, but proceeds again upon neutralizing. The writer has found the test a reliable one, and remarkably uniform in its action.

Rate of Growth.—The property of growing rapidly or slowly should be noted in the description of an organism, and it is better, as far as possible, to give some absolute standard, such as the diameter of the superficial and deep plate colonies, etc., at a certain time after inoculation. In most descriptions the only statement made is that an organism grows rapidly or slowly, which does not convey a very clear idea, though it is better than nothing. When it is stated that an organism grows rapidly, it is meant that colonies attain their maximum development within a few days or a week. In organisms which grow slowly, little growth is visible during the first few days, and the colony takes several weeks to mature and assume its most typical form.

Metabolism.—The chemical changes produced by water bacteria are, as yet, but little understood.

Liquefaction of Gelatine—Peptonization.—Evidence of this action depends upon the formation of a peptonizing ferment, which, when isolated, or when the cultures containing it have been sterilized, is capable of liquefying gelatine, independently of any bacterial growth. Though striking and characteristic of certain forms of bacteria in plate and tube cultures, the liquefaction of gelatine is a minor biological property. It was, at one time, supposed that the liquefying colonies were the putrefactive ones, whose presence would therefore form an objectionable feature in the water. This view is no longer held, as it is known that many putrefactive organisms do not liquefy gelatine, while many which do not tend to cause putrefaction possess this power.

Other Chemical Products.—The water bacteria are capable of forming a large number of chemical products which belong, usually, to a class of the alcohols, especially the higher alcohols, the aromatic compounds, indol, etc., extractives, amides, and other ammoniacal combinations; lactic, butyric, succinic, and proprionic acids. The subject is too large to be entered upon here, and we do not know to what extent the products which characterize the water bacteria in artificial media are formed under natural conditions.

In some cases the products of certain compounds are highly characteristic of particular organisms, and form a valuable means of diagnosis; for instance, the absence of indol in bouillon cultures of typhoid was stated to distinguish it from bacillus coli. The presence of indol reaction in bouillon cultures of the cholera vibrio is also considered a valuable diagnostic point, though a number of other allied forms also produce it. Bacillus fluorescens putridus produces a strong trimethylene odor resembling that of pickled herring. A form of bacillus fluorescens liquefaciens, studied by the writer, produced a strong cyanogen odor in gelatine cultures, but the vapor evolved gave a reaction somewhat different from that of cyanogen gas.

A group of organisms, chiefly marine, form phosphorescent products; this luminous substance being in some species produced most abundantly in cultures kept at very

low temperatures, from 0° to 4° C., and made in media containing two and a half per cent. of chloride of sodium.

Pigment Formation.—The power of certain forms to produce pigment affords a very valuable diagnostic feature. The colors produced are most various and afford a ready means of recognizing the species; unfortunately descriptions of the tint of color are very difficult to convey in words, and thus far no satisfactory way of recording the nature of the pigment has been worked out. In certain organisms, for instance, bacillus prodigiosus, the chemical characters of absorption spectra of these pigments have been recorded, and their solubility in different media noted. Unfortunately, this has not been done in the case of many organisms. In describing a pigment in this manner, besides the color, the solubility in water, alcohol, ether, benzine, etc., should be noted; also the effects of heat and of alkalies and acids. These give a rough insight into the chemical nature of the product. In the case of the yellow pigments, a difficulty is encountered through their being almost insoluble. The fluorescing pigments are particularly hard to describe. The chromogenic bacteria may be roughly classified, from the color they produce, into (1) violet, (2) blue, (3) green, (4) fluorescing (mixed green and yellow), (5) yellow, (6) orange, (7) red, and (8) brown, forming fairly distinct groups. These groups are very difficult to subdivide simply by means of the shade produced, owing to the difficulty of obtaining an absolute standard of color. Probably the only method by which this could be accomplished is the quantitative determination of the spectrum obtained from them by reflected light by means of Abney's disks. This consists of a rotating disk, in which by means of a sector various amounts of yellow, red, green, etc., can be cut off; the resulting shade being expressed numerically in terms of so many degrees red, so many yellow, etc., when a color is obtained corresponding to that under consideration. For studying the color formation the potato and agar cultures are most suitable, as it is produced there most abundantly. The division of bacteria into pathogenic and chromogenic groups is not scientific, since some of the chromogenic bacteria have pathogenic effects.

Pathogenesis.—The testing of the pathogenic properties of water bacteria is a field but little worked in; the methods employed consist in inoculating a large number of the usual animals, rabbits, mice, guinea-pigs, etc., with the organisms. The fact that few of the water bacteria grow well at body temperature probably accounts for the very small number of instances in which the pathogenic characters have been shown to be present. In a few instances bacteria have been found in water which are fatal to the amphibia. Certainly fishes, frogs, and turtles would appear to be more suitable subjects for experiment than warm-blooded animals. Bacteria from the slime at the bottom of lakes, rivers, and reservoirs have often been found to possess pathogenic properties when inoculated into white rats.

In some instances toxic bodies have been isolated from the cultures of water bacteria which are capable of producing poisonous effects. Such organisms have been called "toxogenic" by Vaughan.

Special Methods for Diagnosis of Pathogenic Organisms.—The methods specially recommended for detection of cholera and typhoid bacilli in water have already been described in another part of this article (p. 1029). Certain species and races of bacteria not originally pathogenic, become so by being passed through a series of animals.

Nitrifying Bacteria.—For isolating the organisms producing nitrification the use of special media is necessary. Successful results were first obtained by the dilution method in solutions containing sulphate of ammonia (0.4 p. c.), sulphate of magnesia (0.05 p. c.), phosphate of potash (0.1 p. c.), carbonate of soda (0.6 to 1 p. c.) in distilled water. The presence of even slight traces of gelatine, agar, or other organic substances is sufficient to stop the growth, and therefore the ordinary culture media are quite inapplicable. A suitable solid medium was obtained by Winogradsky by adding soluble silicate of soda, water-glass, which is a thick, syrupy liquid that becomes gelatinous on the addition to it of numerous mineral salts, notably those which were above mentioned as forming a suitable culture medium for the nitrifying organism. The medium is prepared by diluting the ordinary commercial water-glass with three times its volume of water. One hundred cubic centimetres of this are agitated with hydrochloric acid, and the mixture is placed for three days in a dialyzer, care being taken that the acid shall be in excess. At the end of three days, during the first of which the dialyzer is left in a current of tap-water, and the rest of the time in distilled water frequently changed, the solution is ready for use. It should give no turbidity with nitrate of silver, showing the absence of hydrochloric acid. It can be sterilized by boiling, and preserved in a flask stopped with cotton wool; to this is added sulphate of ammonia, 0.4; sulphate of magnesia, 0.05; phosphate of potassium, 0.1; chloride of calcium, a trace; carbonate of sodium, 0.6 to 0.9; distilled water, 100. The sulphates, with the chloride of sodium on the one hand, and the phosphate and carbonates on the other, are to be dissolved and sterilized separately, and the solutions mixed after cooling. For cultures Petri dishes answer very well.

The silicate solution is first evaporated to half its volume, and tested repeatedly as to its powers of gelatinizing by adding to 2 or 3 drops one drop of the saline solution in a watch-glass. The gelatinizing commences in five minutes, and should be sufficiently stiff at the end of ten or fifteen minutes to prevent the disappearance of an impression made upon its surface. After this it is not well to continue the concentration, as this is liable to cause the precipitation of granules and scales of insoluble silicic acid. The silicate solution is then distributed in a small pipette in the Petri dishes, and there is added about one-half or one-third its volume of the saline solution inoculated with the culture material; the two liquids being carefully mixed. At the end of several minutes a slight opalescence indicates coagulation. If desired, the inoculation can be made in the plate immediately after having mixed the two liquids. For streak cultures, inoculation should be made when the coagulation is complete. Carbonate of magnesia may be employed instead of carbonate of sodium, as it yields a somewhat more transparent medium.

The cultures begin to grow in this jelly at the end of from one to two weeks. The plates must be carefully preserved from dessication, and can be studied for from four to six weeks. Although the silicate jelly forms a very unfavorable medium for the development of ordinary bacteria, their growth is not absolutely excluded, and if introduced with the seed material they are not destroyed. They do not form colonies large enough to be confused with the nitro-bacteria, and appear at a much earlier date than the latter. The purity of a culture may be proved by its inability to grow upon ordinary media, and only those which then remain sterile can be considered as nitro-organisms. Though employed by Winogradsky this medium was suggested by W. Kühne.

In the older method of obtaining cultures by dilution a series of stoppered bottles containing the saline liquid was prepared, and these were inoculated from the substance containing the nitrifying organisms. By diluting the original material a thousand-fold or more and seeding a number of flasks with extremely minute portions of the culture, a series of daughter-cultures are obtained in some or most of which nitrification can be detected. By inoculating portions of these simultaneously into fresh saline media and ordinary gelatine media, cultures are ultimately obtained which produce nitrification, but give no growth in gelatine. These are pure cultures of the nitro-bacteria.

Sleskin recommends the following method: 100 c.c of water-glass, dialyzed and reduced to about $\frac{1}{4}$ its volume by boiling (the concentration must not be carried to the point of inducing turbidity), is diluted with sterilized concentrated solutions, (a) of the sulphates, and (b) of phosphate of potash and sodium carbonate. By mixing the different components of the saline solution directly with the silica the danger of turbidity and precipitation

is lessened. By increasing the proportion of the mineral salts a firmer coagulation is obtained, but the power of supporting the growth of nitro-bacteria is somewhat lessened.

Description of Species.—A diary is kept of the cultures made, with the dates, so that a glance at the page will show the work to have been attended to on a particular day, and will afterward serve as a reminder whether it has been done or not. Thus with specimen No. 9 an entry like this was made :

23. VI. 91.	From colony on gelatine plate.	Made. Gelatine plate.
25. VI. 91.	From Plate of 23. VI. 91.	Made. F. P. G. Plate (to test purity). F. P. G. tube. Cell culture. Culture made under mica. Deep tube culture.
30. VI. 91.	From Plate of 25. VI. 91.	3 Agar tubes, at 37°, 22°, 18° C. 3 Potato, at 37°, 22°, 18° C. 3 Bouillon, at 37°, 22°, 18° C. 2 Serum. 2 Milk, at 37°, 18° C. 2 Litmus milk, at 37°, 18° C. 2 Corallin broth, at 37°, 18° C.

In this way a preliminary examination of a new organism can be accomplished in about a week, after which its more detailed study, the accurate determination of its chemical changes, thermal death-point, etc., can be resumed, if desired.

Scheme for Description of a New Species.—Name, habitat, morphology, staining, spore formation, motion, cell culture, gelatine plate, gelatine tube, agar, potato, serum, bouillon, other media, rate of growth, temperature, relation to air, fermentation, pigment formation, pathogenesis.

A great drawback in qualitative work is the difficulty of comparing the results of one observer with those of another. Slight differences in the media employed, irregularities in temperature, and other minor matters of technique make it extremely risky to say whether the forms described in one country or town by one person correspond with those described elsewhere by another. The variability of bacteria and their tendency to form races, in which minor deviations from the standard type become permanent, makes it a delicate matter to decide what constitutes a distinct species. The difference between these varieties of the same species sometimes appears to be greater than that between atypical forms of different species. This variation has been critically studied by Adami, who considers that atypical forms may be looked upon as races when permanent. The value of these variations cannot, however, be definitely settled by individual work; what is needed appears to be a cooperation of different observers, and the comparison of races or varieties obtained from different localities, by which means the personal equation would be, as far as possible, eliminated. A fine field appears to be offered here for collective investigation.

The qualitative study of water bacteria sometimes affords a far more delicate means of detecting contamination than mere quantitative analysis. The writer, in the case of a very foul stream of water entering a large river, was able, at a distance of two hundred feet from the junction of the waters, to predict with confidence that contamination still existed, although the total number of bacteria present per c.c. at that point did not exceed the number met with in the purer water on many occasions, and was not sufficiently large to arouse suspicion. The pure water, however, contained on that occasion colonies of bacillus fluorescens liquefaciens sufficient to form thirty per cent. of the total number of colonies. In impure water the proportion of B. fl. liq. was less than half of one per cent. of the total. Where a high degree of contamination existed the proportion of B. fl. liq. was five to ten per cent., and at two hundred feet out was still below twenty per cent., thirty per cent. being again reached at four hundred feet, where the water was pure. A parallel set of samples, collected for chemical examination, showed undue amounts of nitrates and chlorides at one hundred and two hundred feet, but not at four hundred —a result identical with the bacteriological.

Migula, as a result of over 400 analyses of well and spring waters, obtained statistics of the relative number of species: twenty-one per cent. of the samples only contained one to four species; and one-fourth of these only contained a single species. The remaining seventy-nine per cent. contained five or more different species, and of these fourteen per cent. contained more than ten species. According to Migula a water containing more than ten species per c.c. is to be considered as more or less contaminated by organic impurities. An inverse ratio existed between the number of colonies developed and the number of species present: for instance, in samples where 50 colonies per c.c. develop 4 times only a single species was found; 5 times, 2 species; 6 times, 3 species; 5 times, 4 species; 3 times, 5 species; twice, 6 species; 3 times, 7 species; twice, 8 species; 3 times, 9 species; once, 10 species, and never more than 10. On the other hand, when 10,000 to 50,000 colonies develop per c.c., never less than 4 species were present. According to the usual theory, that only water containing about 50 colonies per c.c. should be considered pure, only one-tenth of the waters examined by Migula would be approved by the simple enumeration of the colonies; whereas, if the presence of ten different species per c.c. be taken as the extreme limit for a pure water, only one-eighth of the samples could have been classified as impure.

Certain species were found characteristic of stagnant waters: Micrococcus ureæ, M. cinnabarius, B. fluorescens putridus, B. erythrosporus, B. fluorescens liquefaciens, B. ureæ, B. mesentericus vulgatus, B. tremelloïdes; while the forms most frequently met with in running water were: M. coronatus, M. radiatus, M. viticulosis, B. luteus, etc. It must be freely admitted that these results of Migula are open to the objection that examinations were made on extremely small bodies of water. The organisms mentioned as characteristic of stagnant waters have also been found by others in large bodies of water of unquestionable purity.

The relation between the number of species and that of the colonies was as follows :

No. of species per c.c.	Number of colonies per c.c.							
	0 to 60.	60 to 100.	100 to 600.	600 to 1,000.	1,000 to 5,000.	5,000 to 10.000.	10,000 to 50,000.	Over 50,000.
1.....	4	7	3	2	1	..	..	
2.....	5	6	4	3	1	..	..	
3.....	6	3	3	4	5	3	..	
4.....	5	5	3	5	3	1	1	
5.....	3	6	11	5	4	3	2	
6.....	2	7	12	8	6	3	1	..
7.....	3	6	9	10	6	5	2	.
8.....	2	5	7	8	16	7	4	
9.....	3	5	6	9	8	9	6	..
10.....	1	4	4	5	4	15	4	9
Over 10..	0	4	2	2	4	9	7	31

Pathogenic Bacteria have been recognized in water by a number of different observers, whose statements may be accepted without reserve. Koch found the cholera germ in the water of a tank in India, where the disease was prevalent among the natives who consumed the water. Rietch found cholera bacilli in the sea-water outside the harbor of Marseilles during the prevalence of an epidemic. G. Roux found tetanus bacilli constantly present in the water-supply of Lyons, and Miquel in the water and sewage of Paris. Septic organisms, and organisms causing specific pathogenic effects when inoculated into animals, have been found in the water and sewage of numerous cities. Vaughan detected a series of

bacteria pathogenic for rats in numerous waters from Michigan.

As pathogenic bacteria all grow at the temperature of the body, by making cultures in bouillon, or by keeping bouillon cultures at these temperatures, the water bacteria tend to be excluded, while the pathogenic forms persist, so that, after a few transplantations the isolation of the pathogenic forms is rendered comparatively easy.

The study of the effects of immersion in water upon pathogenic germs has given valuable results. It has been shown that the cholera vibrio under such circumstances usually dies out in the course of a few days, and is incapable of multiplying in ordinary drinking-water: typhoid bacilli do not show any marked powers of growth in water, but retain their vitality for a considerable time, even three months or more. Tetanus bacilli and the pathogenic micrococci do not lose their vitality and powers of infection rapidly in sterilized water, but do so if the water is impure. Anthrax, when not in the form of spores, soon loses its vitality and powers of growth. Sea water acts injuriously upon the virulence and vitality of pathogenic organisms, notably tetanus bacilli. Under suitable conditions of temperature and nutrition, bacteria are capable of recovering the powers which they have lost by immersion in water.

P. F. Frankland has shown that anthrax bacilli may form spores in water. Many water bacilli possess antagonistic powers over anthrax in water.

Of all infectious diseases, typhoid fever and cholera are the ones having most importance in relation to water-supplies.

Cholera.—The relation of cholera epidemics to drinking-water is a matter about which there has been considerable dispute. Koch advocates the simple and intelligible view that water contamination was the main source of infection in cholera epidemics. At the same time infection by other means, such as contamination of food-supply, cooking-utensils, bedding, clothing, rags, etc., or from soiling of the fingers, was not denied. Pettenkofer, on the other hand, has insisted throughout that epidemic infection cannot take place in this direct manner except when a specially favorable "local disposition" prevails in the infected district. He designates this local disposition as Y; the specific germ as X; and the individual predisposition as Z; all three forming the unknown factors in what he terms the equation of a cholera epidemic. This theory he recently put to the test by swallowing, at Munich, cultures of cholera bacilli obtained from the Hamburg epidemic of 1892; having at the same time taken sufficient alkali to guard against the destruction of cultures by the gastric juice. The same experiment was also carried out by Professor Emmerich, his assistant. The fact of their surviving the operation was claimed by these gentlemen to show conclusively that they owed their salvation entirely to the absence of the element Y, peculiar to the vicinity of Hamburg. Those who have no special object in supporting the claims of the unknown factor Y, will probably be inclined to infer from the fact that both Pettenkofer and Emmerich suffered from severe rice-water diarrhœa, colic, cramps, etc., with abundance of cholera bacteria in the stools, that cholera was actually produced in these cases, and that the mild course of the disease was to be explained by the insufficient dose administered and the absence of previous gastro-intestinal disturbance, or by the microbes having lost their virulence in the process of cultivation. Professor Pettenkofer has apparently done nothing more than afford an additional proof, if one were needed, that the comma bacillus is capable of producing cholera, as a result of his somewhat rash experiment. That cholera bacilli are subject to great variations of virulence was proved by Hueppe and Wood, who showed that their power of producing the poisonous chemical substance to which the symptoms of cholera are due, becomes increased when grown under anaërobic conditions, and furnished with abundant albuminoid nutriment; while in the presence of oxygen, and with a diminished supply of albumin, this organism, becoming more hardy, loses its power of producing the specific toxin. As the cholera bacillus, when occurring in a drinking-water supply, is under the aërobic conditions, its toxic virulence is probably low.

A most convincing argument in favor of the part played by drinking-water in conveying the cholera infection, is the fact that cholera does not become epidemic in cities having a pure drinking-water supply secured from contamination. That the soil water becomes so influenced by Pettenkofer's factor, Y, as to determine the outbreak or not of a cholera epidemic, is a matter lying, apparently, beyond proof. That certain epidemic influences determine the spread of cholera, and that these vary in different seasons for different localities, seems established beyond doubt. That in 1892 cholera did not spread epidemically in England, the United States, and Paris, although isolated cases existed, is a remarkable fact, and seems to show that some epidemic element was wanting. That cholera has never been known to appear epidemically in certain great centres of travel, for instance, Hanover, although isolated cases repeatedly lodge there, is equally remarkable. Whether this immunity is due to the exertions of the sanitary authorities, or whether it depends upon natural peculiarities of the soil, etc., we cannot say; but since it seems clear that, given a good supply of drinking-water, cholera can be prevented from becoming epidemic, there is every reason to assume that labor and money expended in securing good water-supply will not be thrown away.

Special methods for the detection of cholera bacilli can scarcely be said to exist, though the rapid growth at body temperature in bouillon can be taken advantage of (Schottelius), and a preliminary bouillon culture made, from which, at the end of twelve hours, plate cultures can be prepared; the more numerous the plates, the more likelihood of finding the cholera organism.

Koch has lately introduced a ready means of isolating cholera spirilla from water. Peptone and salt are added so as to form one per cent. of each in the water to be examined. This liquid is placed at 37° C., and in a few hours if cholera germs are present they will be found abundantly at the surface. The liquid should be strongly alkaline, one per cent. standard alkali being used.

Strongly alkaline gelatine is also stated to favor the growth of the spirillum. Placing 200 c.c. of the suspected water in the incubator, after adding 10 c.c. of peptone bouillon, favors the growth of the cholera and other spirilla.

The spirillum described by Finkler and Prior has also been found in water.

Recently, C. Gunther has described under the name of vibrio aquatilis, an organism closely allied morphologically to the cholera vibrio, and in which also the gelatine plate presents an appearance liable to be confounded with cholera (*Deutsche med. Wochenschr.*, December 8, 1892).

Weibel (*Centralblatt. f. Bact.*, xiii., p. 117), has also described a vibrio resembling the cholera organism, and Bujwid (*Cent. f. Bact.*, xiii., p. 120) describes two vibrios which also resemble it. Heidel (*Wiener med. Presse*, No. 46, 1892) describes two allied vibrio forms isolated from water.

Koch found, in a large number of samples of water, thirteen spirilla species which somewhat resembled the comma bacilli, but were distinguishable from them without much difficulty.

All the above organisms produce much more turbidity and liquefaction in gelatine plates than the cholera germ. They all give the cholera-red reaction with mineral acids.

Spirillum Choleræ (Koch).—Found in water by Koch, Nicati, Lubbarsch, Loeffler, and Fränkel.

Aërobic and facultative anaërobic, liquefying, motile spirillum. Grows best at blood temperature. Slightly curved rods with rounded ends; 0.8 μ to 2 μ long, and 0.3 to 0.4 μ wide. Sometimes somewhat circular or S-form. Under unfavorable conditions of growth, they form long spiral filaments. Numerous flagella at each end of the rods. In old cultures swollen and distorted involution forms. Spore formation doubtful. Decolorized by Gram's method.

On gelatine plate, at end of twenty-four hours, deep colonies small and white. Grow toward the surface and produce liquefaction funnel, in the shape of an air-bubble, at the bottom of which the colony is seen. Under low power, before the appearance of liquefaction, colonies are white or pale yellow and coarsely granular, with nodular outline. After liquefaction, colony surrounded by a rosy halo, with double contour, caused by the sharp margin of the funnel. A lively motion is seen among the granules composing the colony, and a dark mass of bacteria lies in the centre with a paler periphery. In gelatine tube, slight liquefaction, causing an air-bubble at the top of needle-track at end of twenty-four hours. In forty-eight hours, cup-shaped depression at surface with narrow area of liquefaction half-way down the needle track, and white deposit at the bottom. On agar, a moist, white, glistening growth. On potato, at room temperature, no growth; at 35° C., thin brownish growth. In bouillon, abundant growth, with turbidity at end of twelve hours. Later, membranous surface pellicle. On serum, slight liquefaction. In milk, good growth, without change of medium. Does not grow in acid media. Slight growth (?) in sterilized water, and vitality preserved for several months. In non-sterilized water, dies in a few days. In peptone bouillon, indol reaction; reddish-violet color, upon adding sulphuric acid, at the end of twenty-four hours. Pathogenic for guinea-pigs, when introduced by the mouth, if gastric juice be neutralized. Produces an infective septicæmic condition in animals, with a rapid fall of temperature, when inoculated into the peritoneum.

Typhoid.—Abundant proof has been furnished at various times that typhoid is communicated by drinking-water. The most conclusive proof of typhoid being spread by drinking-water obviously lies in the recognition of the typhoid bacillus in the supply, and this has now been done in over fifty instances by reliable observers, since Klebs first detected what he erroneously took for typhoid bacilli in the sediment of the Zürich reservoir in 1884.

Unfortunately, the value of these observations is considerably lessened by the fact that many waters contain bacilli which very closely resemble the typhoid organism; and further, this organism itself is subject to great variation, and shows a great tendency to the formation of aberrant races.

The typhoid bacillus is one of a group of organisms of which the type is the bacillus coli, and while typical cultures of both of these show well-marked points of distinction, intermediate forms occur where it is difficult to decide to which group they belong.

In the colon group we may include, for convenience, besides the bacillus coli and typhoid bacillus, a large number of allied forms, best known as pseudo-typhoid, some of which are among those described by Weichselbaum under the name of *Bacillus aquatilis sulcatus*. These forms have the common feature of producing gelatine-plate colonies, which in their early stages resemble typhoid, but which can on further study be distinguished from it. The separation of those which subsequently produce a visible growth on the potato, liquefaction of gelatine, fluorescence, or some such appearance, offers no difficulty. Cassadebat has, in a valuable memoir, given the diagnostic tables of what he calls the pseudo-typhoid organisms, including under this head those colonies which resemble typhoid in early plate cultures. As he makes these, however, to include such widely different forms as bacillus fluorescens liquefaciens and bacillus violaceus, it is evident that his use of the term pseudo-typhoid is altogether too loose.

If, instead of including all these heterogeneous species under the heading of pseudo-typhoid bacilli, we restrict the term to those organisms which can only be distinguished from typhoid by prolonged study in parallel cultures, through the occurrence of slightly more coarse and abundant growth, etc., or other minor points, we narrow down the subject materially, and our diagnosis has really only to be made between these and the organisms of the colon group. Among the latter a large number can be readily excluded by their forming visible colonies on potatoes; by not possessing flagella; or by not producing gas in saccharine bouillon.

The presence of motility, the absence of a scum in bouillon cultures, non-liquefaction of the gelatine, and failure to stain by Gram's method, are characters possessed in common by the typhoid, colon, and pseudo-typhoid groups.

The production of acute septicæmia in animals is characteristic of an allied species group, that of the hog-cholera organisms, and distinguishes them from the pseudo-typhoid forms.

The diagnosis between the pseudo-typhoid organisms proper and genuine typhoid forms, is an extremely difficult matter, and up to the present no single universal test has been discovered. It is a striking feature of the literature on this subject that the more carefully and extensively the observations are recorded, the more conservative are the conclusions drawn.

The Germans have taken an agnostic standpoint, and rarely admit that the organisms found in suspected water have been generally typhoid bacilli. The German results in suspected waters have generally, therefore, been negative. The French observers, on the other hand, have gone to the other extreme, and frequently claim to have found typhoid bacilli in drinking-water.

Quite recently, Arloing and Gabriel Roux have promulgated the heterodox view, that no sharp distinction exists between typhoid and colon bacilli, but that the latter, under certain conditions, become transformed into the former and are capable of producing typhoid. This statement, brought forward at the International Hygienic Congress at London, in 1891, met with general disapproval at the hands of the other bacteriologists present, and quite rightly, as no one has disputed since the time of Snow, that to introduce typhoid in a new district, a case of typhoid fever is first necessary; that the introduction of one case of fever could permanently modify the conditions outside the body in such a manner as to enable the bacillus coli to produce typhoid, is absurd.

At the same time, two circumstances bearing on this head have not received sufficient consideration:—1. A number of anomalous cases, which are diagnosed as typhoid fever from the fact that they present a fever of the continued type, with or without intestinal disturbances (the simple continued fever of the older writers, Flint, and others), may often not be typhoid fever at all, but are due to fermentative changes set up by the bacillus coli, and constitute a form of intestinal sepsis. 2. Where typhoid contamination of water exists, since it can only be naturally brought about by fecal pollution, the bacillus coli must be present. A water contaminated by typhoid is necessarily contaminated also by bacillus coli (Péré).

The frequency with which organisms of the colon group are met with in water is such as to cause these to be regarded as belonging to the class of water bacteria; at the same time it must be borne in mind that organisms of the colon type are not peculiar to man, but almost identical forms occur in animals and birds. It is possible that they also occur in the amphibia and fishes, as normal dwellers in the intestines possibly also in the crustacea, vermes, and other lower forms inhabiting the water; so that an abundant source of supply of these organisms in water and soil is assured, without assuming that they occur quite independently of animals.

Infection through drinking-water has probably been overrated as a factor in the production of typhoid, and too great a tendency exists to look upon this as constituting the only danger. Where infection can clearly be traced to a pollution of the water-supply having an obvious connection with a case of typhoid fever, there need be no hesitation in assuming that this has really taken place; but, at the same time, typhoid can be equally readily communicated by food-supply, milk, kitchen utensils, soiled linen, and furniture; and, probably, by the air.

An undue suspicion attached to drinking-water may lead to other sources being overlooked, more especially

the possibility of infection being communicated by the surroundings of the patient in the sick-room. The non-recognition of this tendency of infection in typhoid fever has led to too great latitude in the reporting and isolation of cases, and the carrying out of general hygienic precautions in stamping out an epidemic. Among troops in Landrecies, Mauberge, and Avesnes, in 1891, Arnould found that measures directed to the disinfection of the drinkiug-water had no effect; whereas, isolation of the patients, disinfection of the apartments and linen, etc., promptly resulted in its disappearance. If infection is due to drinking-water, attention directed to this point alone will promptly remove it. Probably the too general prevalence of typhoid fever is to be attributed, not to contamination of drinking-water, but to the tendency among practitioners and health officials not to regard typhoid as highly infectious, which it really is. The long incubation period, the uncertainty of diagnosis, and the fact that the susceptibility is almost confined to ages between fifteen and thirty, has led to the ignoring of the factor of contagion in typhoid. In all cases of typhoid, disinfection should be thorough and general, and not confined to the stools alone.

The influence of soil and drainage in determining the spread of this disease, in connection with drinking-water and otherwise, is difficult to estimate. Pettenkofer, of course, insists that his *Y* is the agency at work, and that the pollution of the ground-water is the real source of danger. He considers that a lowering of the ground-water level following an unusual elevation, leads to an increase of bacteria in the soil, and their penetration to a greater depth. However, during the epidemic at Berlin, referred to in another part of this article, observations made upon the level of the ground-water showed that it was stationary previous to and throughout the epidemic.

The infection of typhoid fever through air has been strenuously opposed by many authorities. That it does occur, however, the writer has no doubt whatever. In one epidemic, in which he was himself a sufferer, where 14 cases with two deaths occurred, among eighty individuals living on a large quadrangle in which a drain had recently been opened, all the cases, with one exception, occurred among those whose windows opened upon the courtyard where the opening was made. The exceptional case occurred in a person who had amused himself by sitting during his leisure hours on the edge of the drain, and chatting with the laborers, one of whom also became ill. As all the eighty persons were drinking the same water and eating together, there appears no reason for the peculiar distribution of this epidemic unless the air was the means of contagion. The epidemic occurred during the summer, at a time when the windows were left open at night, and the two fatal cases occurred in the two individuals whose rooms were nearest to the drain, and who, presumably, got the largest dose of contagion.

Special Methods.—The means of recognizing typhoid bacilli in drinking-water, are detailed in the sections, "Methods," and "Species." Extreme caution should be observed in pronouncing an organism, found in water, to be the genuine typhoid bacillus, and such an opinion should only be given after prolonged comparison between undoubtedly genuine typhoid organisms and those obtained from the water. The points of difference which exist between the typhoid cultures themselves are less than those between the suspected organism and the genuine cultures.

The detection of the typhoid bacillus in drinking-water was first accomplished in 1885, by Dr. Moers, in a sample of well-water obtained from Muelheim-on-the-Rhine, and yielding four thousand to five thousand bacteria colonies per c.c. The second occasion upon which typhoid was found was by Dr. Michael, in Dresden, in 1885. On a third occasion where typhoid bacilli were found in water, the investigators were Dreyfus, Brisac, and Weidal, in Menilmontant, France, on October 13, 1886. Shortly afterward, Brouardel and Chantemesse discovered the typhoid bacillus in the cistern of a house in Clermont-Ferrand, where typhoid appeared. In 1887 Boemer detected typhoid bacilli in the water of a spring near Greifswald; and since then numerous investigators have obtained similar results.

Special Methods Employed for Isolation of Typhoid Bacilli and Allied Forms.—The examination of water for typhoid bacilli frequently gives negative results, owing to the extremely small quantity examined. Where a few drops or a few cubic centimetres are used for each sample, it is evident that, even when two hundred or three hundred individual observations are made, the total amount of water inspected amounts to only a few litres—an infinitely small quantity to adopt as an indication of an entire water-supply.

Improvements in method have been made in three directions: 1, To enable a larger quantity to be examined; 2, to use media favorable to the growth of the typhoid bacillus and unfavorable to that of other organisms, especially the water bacteria; 3, to employ better means of identifying the organisms fouud.

The separation of the typhoid bacilli from larger samples of water is facilitated by combining the advantages of (1) and (2). One of the methods suggested is to remove the bacteria from the water by sedimentation (Finkelburg), so as to obtain that in a smaller compass, and then adopt the ordinary plate methods. The use of a centrifugal apparatus for concentrating sediments has been recommended, but does not accomplish what has been claimed for it.

Liquid Media.—Péré recommends the following method: Into a sterilized litre bottle or flask 100 c.c. of sterilized neutral beef stock are introduced, and 600 to 700 c.c. of the water to be analyzed; 50 c.c. of a ten per cent. solution of peptone, and 20 c.c. of a five per cent. solution of carbolic acid are added, and the flask is filled to the litre mark with the suspected water. This is divided among five or ten sterilized flasks (ordinary bottles will answer), and kept for twenty-four hours at a temperature of 35° C. Growth is indicated by the appearance of turbidity, usually commencing at the end of fifteen or twenty hours, but sometimes not for thirty hours, if the contamination is slight. When the turbidity is well marked the cultures are made in bouillon containing one per cent. of carbolic acid, one per cent. of beef broth, and five per cent. of peptone. On the appearance of turbidity cultures are again made, either at once in gelatine, in order to isolate the species, or after cultivating in one or two successive changes of phenol bouillon. The only forms surviving are the members of the colon group, namely, B. coli, typhoid bacillus, or some pseudo-typhoid forms.

This method is one of the most convenient of a series which have been devised, all depending in principle upon the alleged capacity of the typhoid and colon bacilli to grow in carbolized bouillon. The advantage it possesses is that larger quantities of water can be dealt with, five to ten litres being readily handled in the course of a single observation.

Several methods had been previously published, notably that of Rodet, who isolated the typhoid bacillus by keeping bouillon cultures at a temperature of from 42° C. to 45.5° C., at which temperature the ordinary water bacteria rapidly die out.

Chantemesse and Weidal, Vincent and Thoinot were the first to employ phenol bouillon; the first important publication being that of Brouardel and Chantemesse. The method employed here was that of adding five drops of a five per cent. carbolic acid solution to 10 c.c. of bouillon, and seeding five to fifteen drops of the water for examination in each of a series of tubes. The object of diluting the water to various degrees was that, when only a few of the typhoid or colon bacilli are present, the cultures sometimes remain sterile. The writer has employed graded dilution in connection with Péré's method, by introducing the carbolic acid by a burette, after the litre of water bouillon has been divided into five portions of 200 c.c. each, and distributing the 20 c.c. carbolic solution among the flasks in proportions of 2, 3, 4, 5, and 6 c.c. respectively.

Thoinot and Lois concentrated their material in examining for typhoid, by passing the water through the Chamberland filter and examining the sediment deposited in it.

Parietti employed an acid carbolized bouillon made by adding to 10 c.c. of neutral bouillon from three to nine drops of the following solution: Carbolic acid, 5; hydrochloric acid, 4; water, 100. The typhoid bacilli withstand the addition of the acid well, and if the beef tea becomes cloudy in twenty-four hours the probability is that they are present.

Solid Media.—Several methods have been suggested for obtaining solid media upon which typhoid bacilli would grow, and which would at the same time be unfavorable to other germs. Chantemesse announced that this could be effected by the simple addition of 0.2 per cent. carbolic acid to nutrient gelatine. This method was tested by Holz with somewhat unsatisfactory results, and the proportion of 0.2 per cent. was found to hinder the growth of the typhoid bacilli. Holz found that with pure cultures of typhoid bacilli, 0.1 per cent. phenol was the maximum amount tolerated, and 0.07 per cent. gave a better growth of typhoid bacilli. The discrepancy between the statements of different authors possibly depends upon the volatility of carbolic acid, the addition of which should be made after the sterilization is complete, and just before the cultures are to be used.

A method suggested by Riedel, in which 0.1 per cent. down to 0.02 per cent. of trichloride of iodine was added to gelatine, was also shown by Holz to have a tendency to check the growth of typhoid bacilli.

Dunbar, as a result of experimental studies, considers the methods of Chantemesse, Parietti, and others, for promoting the growth of typhoid bacilli at the expense of the other organisms of water, to be unreliable, since these methods at the same time hinder the growth in the typhoid germ itself, as compared with its growth in non-carbolized or alkaline media. Further, he states that its development in the special media is more retarded than that of the closely allied pseudo-typhoid forms.

A valuable nutritive medium suggested by Holz is potato gelatine. This is made by grating peeled potatoes upon an ordinary bread-scraper, squeezing the juice through a cloth, and allowing it to stand twenty-four hours in a refrigerator, by which time it assumes a dirty brown tint and becomes quite turbid. After filtration the filtrate is heated for half an hour in a steam sterilizer and again filtered. To the clear deep yellow filtrate ten per cent. of gelatine is added, the mixture steamed three-quarters of an hour, filtered, and poured into test tubes, which are to be sterilized on three successive days.

The potato gelatine so obtained is clear, transparent, and pale brown in color, with a strongly acid reaction (10 c.c. requiring 2.4 to 3.2 decinormal alkali). Upon this medium typhoid bacilli grow readily and somewhat more luxuriantly than on ordinary gelatine, while ordinary water-bacteria and most saprophytes do not grow upon it. Moulds grow slightly. The special advantage of this medium is that the plate cultures are not liquefied by the end of from three to five days, and the plates can therefore be kept longer under observation, for the purpose of watching the growth of slow-growing colonies, among which the typhoid bacilli are to be reckoned. Holz recommended the inoculation of the suspected water direct into this medium.

He was able to detect typhoid bacilli in an extremely foul sample of ditch water at the end of twenty-eight days, but only applied his method to water experimentally contaminated, and was unable himself actually to isolate typhoid bacilli by means of it from any water supply examined. He recommends the addition of 0.05 per cent. carbolic acid to the potato gelatine where extremely foul water is to be examined.

Uffelmann employed a gelatine acidified with citric acid until 10 c.c. require 1.4 c.c. of decinormal sodium carbonate for neutralization. After filtering, 2.5 mg. of methyl violet are added per c.c., coloring the medium a faint blue: the growth of typhoid bacilli intensified the blue color.

Grancher and Deschamps employed gelatine colored by the aniline mixture suggested by Noeggerath, made as follows:

Saturated aqueous solutions of			methylene blue..	2 c.c.
"	"	"	gentian violet....	4 c.c.
"	"	"	methyl green....	1 c.c.
"	"	"	crysoidin	3 c.c.
"	"	"	fuchsin	4 c.c.
Distilled water.....				200 c.c.

After standing two weeks the color produced upon absorbent paper should be deep gray or bluish black, which can be adjusted by adding, if necessary, the tints which are weak. Ten drops of this solution are added to 10 c.c. of gelatine, which is sown with the organism to be studied. The characteristic of the typhoid bacillus is stated to be the production of a brilliant purple-violet in the colonies, while the gelatine in the neighborhood is decolorized; but Vaughan has met with other forms giving the same results.

Gasser recommends the addition of twenty drops of saturated aqueous solution of fuchsin to a tube of agar, which becomes gradually decolorized by the growth of the typhoid bacillus. This reaction is not well shown when the medium is freshly prepared, but is more uniform if kept some weeks before inoculation.

All these methods have the common advantage of separating typhoid bacteria from other widely different forms, thus getting rid of the latter; but they have also, without exception, the drawback that they furnish an excellent medium for those bacteria which closely resemble typhoid, particularly the pseudo-typhoid organisms, in the strict sense of the term. These grow as well or better than the typhoid bacteria in Holz's potato gelatine, in the various phenol bouillons, and in Parietti's medium; they produce, moreover, as marked or more marked color changes in the various colored solutions or jellies. This decolorization depends simply upon the acid production of the bacteria, it being well known that basic anilines are decolorized by acids, and there is nothing distinctive in it, since the form which produces the most acid will produce the most powerful decolorization.

Hazen and White have recommended isolating typhoid bacilli from the common forms in water, by cultivating on agar-plates at a temperature of 40° C., at which very few other forms develop.

We therefore find that, while we have at our disposal a number of processes by any one of which, or by combination of several, we can easily obtain for further study what is either the typhoid germ itself or one of a number of allied species or races which closely resemble it, we have no universal medium or rule-of-thumb process by which it can be differentiated from these. To have attained certainty in the first step of the process is nevertheless a considerable advance.

A fact not usually known is that culture in the special phenol and other media mentioned above induces racial changes in the bacteria, and causes them to take the characteristics of the typhoid bacillus aud preserve them for a long time, and often through many generations.

I have employed as the most convenient means of isolating typhoid and pseudo-typhoid forms, the following combination of methods: 1, Péré's method, employing one or more litres of water as seeding material; 2, passage through phenolized bouillon in tubes; 3, plates from the latter upon Holz's gelatine; 4, plates on ordinary nutrient gelatine.

Diagnosis of Typhoid and Colon Bacilli from Closely Allied Forms.—The exact determination of these organisms is a matter requiring prolonged study. No universal rule can be laid down, but the organisms must be carried through a series of cultures, and compared with typhoid bacilli from an undoubtedly genuine source.

As the typhoid bacilli show certain tendencies to variation (Babes) and to the formation of races and natural varieties, several cultures from different sources should be selected for this comparison:

A. *Diagnosis of Typhoid from Colon Bacilli.*—The distinction between a typical typhoid culture and a typical

colon culture is so sharp and distinct that it is difficult to confuse them. The following points should be verified in any particular case: 1. Typhoid has active independent motion; colon only molecular or oscillating motion. 2. Typhoid in media containing sugar does not produce gas or destroy the sugar; colon does. 3. Typhoid produces no indol; colon does. 4. Upon potatoes typhoid grows invisibly; colon grows with a thick gray-yellow colony, staining the rest of the potato a grayish brown. 5. The typhoid bacillus has numerous flagella (from four to sixteen); the colon has no flagella at all, or only from one to three. 6. Milk is coagulated promptly by B. coli but not by B. typhi.

While these differential points hold good for typical cultures of both organisms, they are not true of the varieties, and aberrant types or races can be met with where it is impossible to make a diagnosis. As a general rule, it may be stated that the peculiarities of the typhoid bacilli are negative in character, while those of the colon are positive; so that any organism which produces gas, coagulates milk, and grows visibly upon acid potatoes, may be set down as almost certainly not typhoid.

B. *Diagnosis of Typhoid from Pseudo-Typhoid Bacteria.*—In this procedure all the resources and patience of the bacteriologist are called into play. Organisms which are identical with typhoid cultures through most of the comparative tests may often with patience be excluded by attention to some minor point. The degree of acidity produced; the intensity of the color reactions; the minor details of microscopic appearance; the power of withstanding temperature; the power of multiplying in simple water—are all points any one of which affords the requisite information.

Especially important are: 1. The chemical changes produced in bouillon, milk, aniline solutions, etc. These have been used by Cassadabat for the exclusion of three forms very closely allied to typhoid and simulating it perfectly in gelatine culture. 2. The date at which colonies appear is also stated by Cassadabat to be of prime importance. A large number of pseudo-typhoid forms, though having the same appearance in ordinary gelatine and potato gelatine as the genuine form, grow more rapidly and appear earlier on potato gelatine. 3. When the observations are extended over several weeks or months, changes appear which might be overlooked at an earlier period; one of these is a very late liquefaction of the gelatine, coming on from the 20th to the 120th day of the culture. The typhoid bacillus never under any circumstances liquefies gelatine, so that this is an unfailing cause for exclusion of a suspected form.

It has been noticed that a tendency to late liquefaction is especially observed in cultures which have been originally isolated by means of carbolized bouillon, and it seems that a lasting alteration in the life processes is developed by this medium, which alteration only disappears after successive cultivations in other substances. A culture in which liquefaction first appeared after three months was found upon successive passages through ordinary gelatine to liquefy at a much earlier date, having apparently regained its property of peptonizing.

The appearance of the growth in old cultures is always more delicate and less vigorous in genuine than in pseudo-typhoid forms. The spurious bacteria usually form a more abundant and coarse surface colony, and give a heavier growth along the needle track. In old Esmarch tubes or stab cultures a continued increase of the colony after from four to six weeks is indicative of a pseudo-form.

The brownish pigment which forms a smoky halo in the neighborhood of the colony near its surfaces, and the small clumps of whitish crystals which jet out from the needle track in old stab cultures, are usually more marked and abundant in pseudo- than in genuine cultures.

The growth of agar gives little information, though, as a rule, it is more delicate in the case of the genuine than in that of the pseudo-varieties. The growth on potato does not as a rule afford any assistance, though of course any organism which grows visibly on acid potato may be promptly excluded. The formation of a distinct scum upon bouillon is indicative either of an impure culture, or that the genuine typhoid organism is not present.

The reason for the scant success attending the examination for typhoid bacilli often may lie in the fact that the original water contamination was merely transient, and the bacilli had disappeared by the time when the outbreak of cases directed attention to the water.

C. *Colon Bacteria.*—The distinction between genuine colon bacteria and the spurious forms is even more difficult than between the former and typhoid, owing to the fact that the colon organism presents even more variation than the typhoid one, and that, as stated elsewhere, a number of slightly varying forms of the colon bacillus occur in the fæces of other animals besides man, which forms have not yet been systematically studied. It is almost impossible to say whether an organism resembling a colon bacillus is derived from the human fæces or not. As far as we know, the tendency to a grosser and more abundant growth is the only distinction between genuine and pseudo-colon bacteria. The inoculation into animals may possibly lead to more accurate information in future upon this head.

In conclusion, the best advice which can be given to those engaged in this work is that it is always safer to adopt a conservative point of view, and not to admit the genuine nature of organisms except on very strong grounds.

Bacillus Typhi.—Aërobic and semi-anaërobic, non-liquefying, motile bacilli. 1 to 3 μ long and 0.5 to 0.8 μ wide, with rounded ends. Sometimes they form long threads. They are decolorized by Gram's method. Unstained vacuoles are sometimes seen in rods. Spore formation is doubtful. Numerous thick flagella. Grows best at blood temperature.

On gelatine plate, small white colonies are found at the end of forty-eight hours. Under the microscope the colonies are oval or spherical, granular, and yellowish brown. At the end of three or four days the surface colonies form a grayish white, delicate, pearly layer, with wavy transparent margins and opaque central nucleus. Surface is marked with fine lines and furrows. In old colonies extension is never very great, and growth is never thick and coarse. In gelatine tube, white rounded colonies develop along the needle track, with delicate, pearly, translucent extension on surface. Growth is most abundant in the upper part. In older colonies a smoky brown discoloration appears just beneath the surface in the colony itself and in the surrounding gelatine. This color subsequently extends along the needle track; sometimes small white bunches of needle-shaped crystals project from the deeper part of the growth. The appearances vary considerably in different cultures, owing to the establishment of races. There is some discrepancy as to the exact appearance of the typical colonies as described by the best observers. On agar, there is an abundant white semi-translucent growth. On potato, the growth is invisible, producing a moist, shining appearance at the surface, of a stringy, viscous consistency; it is most characteristic upon strongly acid potatoes. On alkaline potatoes, a thin yellowish growth may be developed. In bouillon, there is simply a turbidity. There is no production of gas in media containing sugar. The bacilli do not produce indol. In milk they grow abundantly, with slight production of acid. They do not coagulate the medium or change its appearance. In serum, their growth is scanty, in the form of transparent, shining, isolated patches. They grow well in bouillon containing from 0.05 to one per cent. carbonic acid. They grow on potato gelatine, with or without carbonic acid; and also in acidulated bouillon (Parietti's solution).

Tetanus.—The occurrence of the tetanus organism in water has no special pathological significance; being present in the soil, it naturally finds its way into water. Infection of wounds through water is unknown. The peculiarity of the tetanus organism is that it only becomes able to infect under certain conditions, such as the presence of its toxic product, or the simultaneous introduction of certain saprophytes, or the presence of retained pus.

The bacillus of *malignant œdema* has also been isolated from water (Pasteur).

Vaughan has described, under the name of B. venenosus, a series of water organisms having what he calls *toxigenic* properties. Some of these resemble closely the typhoid bacillus.

The significance of the experiments of Vaughan and others upon the toxic and pathogenic bacteria in water, when tested on animals, cannot yet be estimated. Certainly, ninety-nine per cent of the organisms found in water have no toxic powers whatever, although the investigation of the pathogenic qualities of the ordinary water bacteria is a matter requiring further study.

Staphylococcus aureus has been frequently found in surface waters. The micrococcus associated with Biskra boil has also been found.

Ernst has described a bacillus producing septicæmia in frogs and other cold-blooded animals at low temperatures, 10° to 15° C., but losing its virulence if the animals are kept in water at 24° C. The name *B. hydrophilus fuscus* applied to this organism by Sauerelli, has been retained instead of the original one of *B. ranicida*, suggested by Ernst.

Globig reported the outbreak of a singular epidemic in a regiment of marine artillery, which was traced to swimming in unclean water. The disease somewhat resembled an abortive form of typhoid. In the description given by Jäger of this epidemic, out of 20 cases, with three deaths, a characteristic organism was obtained from the blood in the early stages; and from the organs—the liver, spleen, and kidneys—in one fatal case. According to Jäger, this organism is specific of the disease, and from its characters he has named it the B. proteus fluorescens. It was found abundantly in water of a small contaminated stream, near a point where the affected troops bathed in the Danube. The same organism had caused an infectious disease among fowls, and the contamination was apparently traced to contamination of the water by the dead bodies of the affected fowls. The evidence on this head is not particularly convincing.

Goître.—Goître has been known to prevail in districts where the water-supply contains large amounts of lime, but the relation which that bears to the etiology of the disease is extremely obscure. Lustig claims to have been able to produce goitre in horses, by making them drink water that came from Aosta, a region where goître is extremely prevalent; he also claims to have isolated a specific bacillus from this water, which, for some reason not very clear, he regards as the cause of the disease. Experimental proof of the production of goitre by inoculation or feeding with pure cultures, is not yet forthcoming.

Yellow fever has been thought to be due to contamination of drinking-water supplies, but there is no evidence to the effect, and Sternberg is opposed to this view.

Although experimental evidence is not yet forthcoming, it is highly probable, judging from the capacity shown by attenuated cultures of pathogenic organisms to become virulent after passage through a series of animals, that some of the ordinarily non-pathogenic water bacteria may acquire pathogenic powers when passed through many successive animals (Adami).

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WEIGHTS AND MEASURES. The Pharmacopœial Convention of the United States which met at Washington, May 5, 1890, ordered that the weights and measures employed in the Seventh Revision of the Pharmacopœia must be those of the Metric System exclusively. Hence the old English Apothecaries' Weights and Measures which were abolished in England in 1825, and which never had been adopted by law in the United States, have now lost their firm hold upon physicians and phar-

macists, and the use of the Metric System will necessarily be adopted and taught in medical and pharmaceutical schools to the exclusion of the obsolete units.

Another decided change which has taken place since the publication of the earlier volumes of the REFERENCE HANDBOOK OF THE MEDICAL SCIENCES is the adoption of metric prototype standards as the ultimate standards from which all weights and measures used in the United States for any and all purposes are now derived. The American National Prototype Standards of the metre and kilogram, made of irido-platinum, were received by the Government of the United States from the International Bureau of Weights and Measures at Paris in 1890, and placed in the custody of the Office of Standard Weights and Measures at Washington. In 1892 they were formally adopted by that office as the ultimate standards to which all comparisons of metrological values are referred, and the old Hassler standards are, therefore, no longer used.

The value of the American National Prototype Standard Metre is identical with that of the International Standard Metre derived from the *Mètre des Archives*, and the American National Prototype Standard Kilogram, like the International Standard Kilogram, is derived from the *Kilogramme des Archives*.

Theoretically, the litre is equal to one cubic decimetre, or 1,000 cubic centimetres; but the actual litre is the volume of one kilogram (actual International Kilogram) of pure water at the temperature of its maximum density, *in vacuo*. Thus, although the litre and the cubic decimetre are probably not identical values, the litre and the kilogram are commensurate with reference to water at 4° C. and *in vacuo*.

The American *yard* is now defined to be equal to $\frac{36,000}{39,370}$ metre; and the American commercial *pound* (avoirdupois) is defined as being equal to $\frac{700,000,000}{1,543,235,639}$ kilogram.

The American *liquid gallon*, which is designed to be 231 cubic inches, is now derived from the new American National Metric Prototypes on the assumption that the *theoretical* kilogram (the weight of one cubic decimetre of water at its maximum density, *in vacuo*) and the *actual* kilogram (the metal prototype) are identical values. As the metre contains, according to latest authority, 39.3700 inches, and the kilogram 15,432.35639 grains, one cubic inch of water at maximum density, *in vacuo*, weighs 252.-892 grains, and from this value is found the weight of 231 cubic inches. The present actual liquid gallon of the United States is, therefore, according to the Office of Standard Weights and Measures, the volume of 3,785.-434 grams (or 58,418.1444 grains) of water at the temperature of maximum density weighed *in vacuo*.

Oscar Oldberg.

WHOOPING-COUGH. The large number of articles on whooping-cough that appear yearly in the medical journals show very plainly that the subject is far from a cut-and-dried one, and that there is much still to be learned. Out of all this mass of literature, the references to which are given at the end of this article, we must try to pick out that which is new and valuable, and to discover, if possible, what advances have been made, if any, in our knowledge of this disease since the HANDBOOK was published in 1888.

With the exception of a few interesting records of complications, I shall confine myself almost entirely to the consideration of the etiology and treatment, the two subjects about which, particularly the latter, much has been written.

ETIOLOGY.—When the original article on whooping-cough was written, the discoveries of Affanassieff of what he claimed to be the specific bacillus of the disease had just been announced. In the same year Sseintschenko [90] confirmed these observations, and, although he finds the bacilli in the sputa, they are, as might be expected, mixed with numerous others from the mouth. In a later article [89] he concludes: "1. The bacillus of Professor Affanassieff is specific. 2. Bacilli may be found in the sputum about the fourth day of the disease; in some cases earlier. 3. They multiply in the tissues of the body, and as they increase the severity of the disease increases. 4. The bacilli disappear before the entire cessation of the attacks of coughing, or when the paroxysms are reduced to from two to four daily. 5. With complications such as, for example, a catarrhal pneumonia, there is a great increase in the number of whooping-cough bacilli found in the sputum. 6. A pneumonia developing under these circumstances differs from ordinary attacks of catarrhal pneumonia. 7. The bacillus of whooping-cough is of value not only in etiology and diagnosis, but in the prognosis of the disease."

Burman thinks that, whatever the etiology may be, the severity of the nocturnal paroxysms points to the preponderance of the nervous over the catarrhal element. The nervous mechanism inducing an attack would be more active during the night, owing to the insufficient oxygenation of the blood caused by the shallow respirations during deep sleep.

COMPLICATIONS AND SEQUELÆ.—Like other acute infectious diseases, whooping-cough has been followed by nephritis. Scheltma [79] reports a case in a child of two years. Mettenheimer [58] also has reported a case. Mircoli [59] had a singular experience in this respect, finding in one epidemic of whooping-cough albuminuria in from ten to twelve per cent. of the cases, and a mortality of five to six per cent. He believes that this state of things is not rare, and is generally overlooked, and that the urine should be examined from time to time during the course of the disease. He thinks, however, that the nephritis is of a mechanical rather than infectious nature, and is caused by venous stasis, due to the obstruction of the vena cava from the violent paroxysms of coughing.

Of complications due to cerebral disturbance, Alexander [1] reports a case of blindness, with symptoms of cerebral compression and death, due, it was believed, to cerebral anæmia. In a second case, not fatal, blindness occurred, due to optic neuritis from meningitis. Fritsche [30] reports paralysis of the right facial nerve, unilateral spasms, hæmianæsthesia, and aphasia, with recovery. Möbius [60] relates a case of paralysis coming on six weeks after the onset of the disease.

Troïtzky [94] reports three cases, all ending favorably, where whooping-cough was accompanied by considerable mental disturbance, difficulty in talking, and more or less paralysis due to disturbances in circulation and to subsequent morbid changes in the brain. Jacoby [42] reports two cases of temporary blindness of brief duration, due, it was thought, to œdema of the brain.

Emphysema was spoken of in the main article as a complication due to the forced expiration with closed glottis. A case of this sort is reported by Pernet. [71] An extraordinary case of complete subcutaneous emphysema beginning after a paroxysm of whooping-cough is related by Croker. [15] The child, five years old, developed a swelling of the neck below the jaws after a hard fit of coughing. This swelling gradually increased and spread over the entire body, so that the neck, cheeks, chest, arms, legs, and trunk resembled a series of huge bladders. The scalp was blown out in front and at the sides, the scrotum was inflated to the size of a large ostrich egg. The case prove fatal in five days.

INCUBATION.—As bearing on the incubation stage, Perskind reports a case where a child began to have whooping-cough five days after birth, there being several other cases in the family. As the mother was not suffering from whooping-cough herself, it is not likely that the disease was acquired *in utero*.

TREATMENT.—It is interesting to study the various waves of enthusiasm or fashion in the use of different drugs or modes of treatment for whooping-cough. A specific has not been found, although this has been proclaimed, and is still being proclaimed from time to time. Of the etiology that whooping-cough is a germ disease, we are reasonably sure, although the specificity of the bacillus of Affanassieff may be doubted. This knowledge of the etiology is the first step to the rational treatment

of any disease. We should naturally expect to find, therefore, antiseptics to be the drugs most in vogue. It has been said that "no particular antiseptic should be inferior to all others. Either they are all useful in destroying the presumed microbe, or else none of them have any great value." This certainly is not true, for it is apparent that different vegetable germs, as well as different members of the animal kingdom, are affected differently by different poisons or antiseptics. While the organism of malaria may be destroyed by quinine, it is not much influenced by mercury, the reverse being true in the case of syphilis. Belladonna is comparatively harmless to rabbits, but extremely poisonous to men. If one antiseptic has no effect on the course of whooping-cough, it does not follow that another will be equally ineffectual. For this reason an incentive is given for the trial of various antiseptics, and also of various methods of administration described in the original article—by the mouth, by nasal insufflations of sprays or powders, or by insufflations into the throat, or by topical, nasal, pharyngeal or laryngeal applications. Let us now take up *seriatim* the various drugs recommended since the HANDBOOK was first published.

Antipyrin.—As I have already remarked, treatment directed to the general condition of the patient to enable him to resist the disease while it ran its course, is far better than any treatment which at the same time lowers the vitality of the patient. One of the most striking examples of this is antipyrin, first used and greatly extolled in 1887 and 1888, by Sonnenberger, Genser, and Laborderie, as almost a specific for whooping-cough, and one free from danger. Geffrier, Griffith, and Jacques Bey also speak favorably of it. Guaita employed nasal insufflation of the drug in addition to its internal administration.

The great dangers of depression with collapse and cyanosis from antipyrin began later to be recognized—although Sonnenberger stated he never had this result—and has debarred, and with reason, many from using antipyrin for a disease which is in itself depressing. Its advocates have diminished in number, and some have even stated that the disease was not shortened, or the paroxysms reduced in number. Thus Baginsky and Monti had entirely negative results from the use of antipyrin. Tuczek treated his own child of four with six grains of antipyrin three times daily. At the end of the third week he became soporose, with violent convulsive attacks, the heart's action became weak and frequent, the temperature subnormal and the pupils dilated, all of which was attributed by Tuczek to the antipyrin. Notwithstanding this, Ree[75] reported that in the convulsive stage antipyrin would abate the disease on the third or fourth day, and Hare,[36] and also Muttler,[64] even in this last year maintain that there is no remedy for whooping-cough so satisfactory as antipyrin. The former gives two grains to a child of ten years every three hours, until an effect is obtained, and then every four or five hours. Cyanosis of the face and finger-nails is to be carefully watched for, and the drug to be stopped. He says that cyanosis first appears under the thumb-nail. Dubusquet-Labordie[20] used antipyrin in three hundred cases with good results, one hundred and ninety-seven cases recovering very rapidly.

Bromoform is a drug that has come into use for whooping-cough only since the HANDBOOK was published. It is a heavy, colorless liquid of the composition $CHBr_3$, thus resembling chloroform and iodoform. It is an anæsthetic. As it is decomposed by light it must be kept in dark-colored bottles. Stepp[91] believed it superior to any other remedy for whooping-cough, using it with satisfaction in seventy cases, diminishing the number of paroxysms, and curing the disease in three weeks. He used the following formula:

℞. Bromoform..... gr. x
Alcohol..... ʒ j
Syrupi..... ʒ ss
Aquæ..... ʒ iij
Sig. One teaspoonful every hour.

Senator[84] is particularly enthusiastic about this remedy, using it in one hundred cases, and getting good effects as early as the second or third day.

Neumann[66] found in twenty-five cases that bromoform cut short the disease and reduced the number of paroxysms.

Krieger[43] used it in nine cases with great success, and Fischer[28] in sixteen cases, also with success, seventy-five per cent. being discharged well in from two to three weeks.

Earle,[22] of Chicago, reports eight or ten cases treated with bromoform, with good results.

Nauwelaers,[66] although he considers bromoform almost a specific, sounds a note of warning, as it acts powerfully on the nerve-centres, and advises small doses at first, to be gradually increased. He considers its action in whooping-cough that of an antispasmodic, not a germicide.

Schippers[81] considers bromoform of great value and gives the following doses: six months to one year, ♏ ij., three times daily; from one to two years, ♏ iij.; two to three years, ♏ iv.; three to four years, ♏ v.; four to seven, ♏ vj. to vij., in a spoonful of syrup, three times daily.

An unfavorable view is given by Üllmann,[95] who compared the result of treatment with bromoform with that of an indifferent drug and found no difference, with the exception that bromoform, as a narcotic, sometimes influenced the child unfavorably.

The writer's experience with this drug has been very satisfactory up to the present time.

Ouabaïne, an alkaloid from the roots of the Ouabaïo, of the formula $C_{30}H_{46}O_{12}$, is another new remedy for whooping-cough, first used practically in this disease by Dr. Gemmell,[33] of Glasgow. He treated forty-nine cases with no ill effects, and with the result of markedly diminishing the paroxysms, and shortening the course of the disease. Dr. I. L. Porteus[72] has used it in this country with similar good results.

The dose is very small, $\frac{1}{100}$-grain every three hours, in a child of five years, $\frac{1}{400}$-grain being given to a child of fifteen months by Dr. Porteus. The flow of urine is increased and the appetite improved. Its action is said not to be cumulative. The toxic effects to be looked for and avoided are slowing of the pulse and respiration, particularly the latter. Further trial of this drug is certainly indicated.

A curious and odoriferous treatment is recommended by Chibret,[13] who sprinkled the room and the poor patient with *iodoform*—and with good results.

Wild Thyme in infusion, Thymus vulgaris, has been used with wonderfully good results by Neovius.[67] A cure is generally obtained within fifteen days.

As was to be expected, *Peroxide of hydrogen*, which seems to arouse so much enthusiasm and is reported to cure anything in which there is a suspicion of a germ, has been found an infallible remedy for whooping-cough. Dr. B. W. Richardson, also Dr. J. Mount Bleyer, recommend it.

I have made a list of the special papers on the treatment of whooping-cough published in the last four years, and classified them according to the drug used. Those on the use of antipyrin head the list, which is as follows, and is of interest in showing the tendencies in treatment:

Antipyrin, 15.	Nitrate of silver, 2.
Bromoform, 11.	Ouabaïne, 2.
Resorcin, 8.	Antifebrin, 2.
Carbolic acid, 4.	Sulphur, 2.
Vaccination, 4.	Peroxide of hydrogen, 2.
Belladonna, 3.	Quinine, 2.
Phenacetine, 3.	Ergot, 2.
Benzoin, 2.	

Cocaine, oxymel scillitique, oil of cypress, naphthalin, iodoform, eucalyptus, ozone, hydrate of turpentine, thyme, and chloride of gold and silver, each have one article.

Surely one might say, after reading the favorable results recorded by different writers on the treatment of

this disease, whooping-cough is plainly one of the most amenable of all diseases to treatment, and moreover, there is a great number of drugs that will produce the desired result. The opposite of this, however, is much nearer the truth. The stage in the disease when treatment was begun, the mildness or severity of the epidemic, and the fact that whooping-cough often runs an atypical course, should always be borne in miud.

Although there may be some slight advance in our treatment of whooping-cough since the HANDBOOK was first published, there still remains much room for improvement in the management of this troublesome disease. *Charles W. Townsend.*

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WINES, SPIRITS, AND BEER. The following additions to the article published in Vol. VIII., giving some information not easily available to the general reader, and bringing the statistics of the subject as nearly as possible up to the date of publication, will be found very useful.

THE PASSE-TOUT-GRAINS AND THE ORDINARY WINES OF BURGUNDY.—The glorious names of the grand growths of Beaune, Pommard, Volnay, Nuits, Chambertin, etc., are universally known and appreciated to the utmost, as they deserve, but there is a class of Burgundy wines, not so well known and less admitted into foreign consumption, but which is worthy in every respect of being brought forward and becoming an article of constant and daily use wherever wine is drunk. We mean the Burgundian *vins ordinaires*, the cheap dinner wines, usually drunk in France with an admixture of water.

These wines have, in the first place, the merit of being more within the reach of modest purses than the first growths, which are costly luxuries, and their quality entitles them to a special place in the list of the cheap wines that are now grown nearly everywhere in the world where the climate and the soil permit the cultivation of the vine. Ordinary Burgundy, in common with French wines in general, possesses a perfect cleanliness of taste, and it has besides, without being heavy or heating, a sapidity and a freshness which make it an agreeable, healthful, and refreshing beverage. These qualities, added to the body peculiar to its robust constitution remind one, to a certain extent, of the grand growths.

In making a careful study of the wines of the district, we find a complete series ranging without a break from the cheapest up to the first growths.

Before describing the ordinary wines, properly so called, we should give a word to the *Passe-tout-grains*, which should be classed as "grand ordinary" or "little fine" wines, as they occupy a place between the grand wines and the ordinary.

The *Passe-tout-grains* are produced from vineyards planted with both the superior Pineaus and the ordinary Gamays—the more Pineaus there are in the vineyard, the more the wine will approach the class of "fine" wines. It is the mixture of the two sorts of grapes that gives this wine its name of *Passe-tout-grains* (including both sorts).

Nothing is better than a good *Passe-tout-grains* as an intermediate wine between the grand growths and the ordinary wines. It is the *grand ordinaire* of the tables of the rich, and the good *Extra* of the modest Burgundian home, being both a fine wine and an ordinary one, as it combines the virtues of both the Pineaus, which give bouquet and elegance to the fine wines, and the Gamays which produce the others. The former give it its delicacy and perfume, the latter its freshness and solidity. It is like a marriage between a nobleman and a peasant's daughter; the children of the union possess the fresh and sturdy health of the mother and the aristocratic grace and elegance of the father.

This wine is not scarce; it is grown all over the *côtes*

(hills) of Beaune and Nuits. On the hills of Beaune, the Parish of Meursault deserves special mention for the extent of the vineyards devoted to the production of *Passe-tout-grains*. On the hills of Nuits, all the district between Alexe, Corton, and Prémeaux, near Nuits, as well as the vineyards that stretch from Gèvrey-Chambertin to the gates of Dijon, are given up to the growth of this wine. It is highly esteemed in Burgundy, and the Burgundians eagerly seek to produce it in all localities where the soil and exposure would not suffice for the production of the grand wines.

The ordinary wines are divided into three classes, the *ordinaires* of the *côtes, arrières-côtes* (upper hills), and the *plaine* (flat country). These wines do not possess the delicacy of the *Passe-tout-grains*, but they have in their stead body and strength, together with a fresh and agreeable fruity taste.

The *ordinaires* of the côtes are the best and the highest priced, and come in the scale of Burgundy wines immediately after the *Passe-tout-grains*. They are the product of the Gamay grapes gathered among the lower hills, and the best of them are made in the region of the *Passe-tout-grains*.

In the district called the *Côte de Beaune*, Corpeau, Puligny, and Meursault produce many Gamay wines; in the *Côte de Nuits*, Serrigny, Corgoloin, Comblanchier, and further north, in Perrey, Brochon, Fixin-Couchey, Marsannay, and Chenove excellent Gamays abound. As these wines are produced in the *Côte de Beaune* or the *Côte de Nuits*, they are generally sold respectively as "Beaune" and "Nuits," which must be considered as abbreviations for *ordinaires* of the *Côte de Beaune* and *ordinaires* of the *Côte de Nuits*.

The *ordinaires* of the *Arrières-Côtes* possess the same characteristics as the *ordinaires* of the Côtes, but with less richness and less body. They are proportionally cheaper. They are excellent wines for habitual drinking, particularly in the good years, and an amateur who has grown accustomed to them will not use any other wine for his "*ordinaire*." These wines are grown throughout the extent of the Arrières-Côtes. The most important localities are Villars-les-Fontaines, Magny-les-Villers, Echevronne, in the *Côte de Nuits*, and Nantoux, Mandelot, Meloisey, St. Romain, Larochepot, and Nolay, in the *Côte de Beaune*.

The wines of the plains are weaker than those we have mentioned, and have no interest for the export trade.

This short sketch of the cheaper wines of Burgundy may serve to show that in addition to the antique renown of her grand vintages, she may claim the modest merit of growing excellent ordinary wines, admirably fitted for transportation, and richly deserving the attention of foreign markets.

The wine production of the principal countries of the world since 1874 has been as follows:

WINE PRODUCTION OF THE WORLD.*

YEAR.	France.†	Spain.	Jerez.‡	Italy.	German Empire.	Austria.	Hungary.	Croatia-Slavonia.	Portugal.	Douro.	Madeira.	United States.
1875..	2,213,159,520	522,000,000	5,998,080	725,440,000	156,959,430	169,654,716	165,270,811	41,317,703	130,750,000	7,700,000	921,464	12,954,961
1876..	1,105,019,520	537,504,000	4,184,664	760,320,000	153,120,000	63,076,777	49,052,097	12,273,020	63,000,000	7,000,000	864,562	14,968,085
1877..	1,489,099,920	528,000,000	4,040,520	831,600,000	171,626,400	84,541,300	94,298,682	23,574,670	132,000,000	10,360,000	852,761	16,942,592
1878..	1,286,234,400	518,648,800	3,364,680	670,612,800	80,877,173	177,695,311	213,201,991	53,300,500	79,380,000	8,820,000	841,632	17,953,386
1879..	680,328,000	646,800,000	5,363,820	799,444,929	26,054,716	73,300,104	166,698,655	41,674,660	68,640,000	7,560,000	833,412	19,845,113
1880..	895,382,400	618,288,000	6,689,440	914,385,095	13,832,497	45,434,400	64,068,546	16,017,136	61,740,000	6,860,000	741,258	23,298,940
1881..	1,018,459,200	569,712,000	4,118,400	747,012,651	70,634,478	80,152,353	111,691,272	27,922,318	70,560,000	7,840,000	694,371	18,931,819
1882..	1,026,590,460	540,672,000	3,091,968	1,110,109,704	42,189,009	88,898,360	108,584,721	27,146,180	79,380,000	8,820,000	701,382	19,934,856
1883..	1,218,756,000	623,092,800	4,324,320	1,170,358,047	74,226,711	91,546,752	122,393,964	30,698,490	60,480,000	6,720,000	685,721	17,406,028
1884..	918,211,166	580,800,000	4,501,200	521,238,514	78,671,096	88,901,100	115,460,822	23,865,205	45,000,600	5,040,000	594,302	17,402,938
1885..	831,098,400	660,000,000	6,633,000	628,556,006	98,477,305	104,881,336	143,158,620	31,598,424	66,780,000	7,420,000	587,624	17,404,698
1886..	661,663,200	567,600,000	6,676,900	971,562,622	39,711,281	97,115,040	103,824,632	42,061,656	54,180,000	6,020,000	621,432	17,366,393
1887..	668,210,400	739,569,600	4,626,072	871,609,648	63,197,939	124,131,031	130,973,119	33,527,348	63,000,000	7,000,000	654,721	27,706,771
1888..	794,696,787	608,591,000	6,909,408	797,744,640	75,561,374	109,685,664	103,312,220	25,828,055	133,085,000	9,240,000	712,491	31,680,523
1889	612,102,300	699,716,368	4,328,016	574,388,485	53,410,013	108,398,400	119,387,400	29,846,850	65,320,000	7,280,000	764,772	26,617,034
1890..	783,790,033	888,949,670	4,290,000	777,650,757	78,688,683	95,383,200	90,914,812	22,753,703	112,200,000	7,840,000	863,002	24,306,905
1891..	875,684,252	899,654,422	7,639,236	923,210,640	13,427,484	47,691,600	50,624,000	15,645,201	115,300,000	7,560,000	887,634	23,724,890

* Quantity in American gallons. † Including Algeria. ‡ Not including Sanlucar, Port St. Mary's, Moguer, etc.

PRESENT AVERAGE ANNUAL PRODUCTION.

Russia	75,000,000	Turkey, including Cyprus	65,000,000	Argentine Republic	30,000,000
Greece	39,600,000	Servia	72,800,090	Chile	39,520,000
Roumania	53,000,000	Bulgaria	70,000,000	Cape of Good Hope	2,642,000
Switzerland	28,420,000			Australia	3,000,000
				Tunis	2,500,000
				Persia	739,000
				Canaries	3,950,000

The following table shows the quality of Bordeaux, Champagne, and German wines in each year since 1867:

	Bordeaux.	Champagne.	German.
1868....	Generally good.	Fine.	Good.
1869....	Very fine.	Superior.	Ordinary.
1870....	Varying.	Very good.	Fair, light.
1871 ..	Elegant, thin.	Ordinary.	Inferior.
1872....	Ordinary, fair.	Good ordinary.	Middling.
1873....	Bad.	Middling.	Fair.
1874 ...	Fine.	Very fine.	Fine generally.
1875....	Very good.	Generally good.	Inferior, light.
1876....	Bad.	Fair.	Good.
1877....	Well made, elegant.	Fair.	Inferior.
1878 ...	Very fine generally.	Good.	Fair, light.
1879....	Inferior.	Below medium.	Hard, bitter.
1880....	Thin and poor.	Good ordinary.	Part good.
1881....	Good, ripens slowly.	Medium.	Irregular.
1882....	Bad, mildew.	Ordinary.	Thin, sour.
1883....	Medium.	Fair, some good.	Good.
1884....	Much good.	Very great.	Better than 1883.
1885....	Inferior.	Good ordinary.	Middling.
1886....	Very bad.	Ordinary.	Fine, best since 1868.
1887....	Good.	Bad, mildew.	Medium, small,
1888....	Generally good.	Poor.	Poor to fair.
1889....	Very good.	Fair.	Fair.
1890....	Very fair.	Good.	Middling.
1891....	Good.	Good.	Miserable.
1892....	Very fine.	Grand.	Very good.

PRODUCTION OF LAGER BEER.—The production of the ten largest lager-beer breweries in the world in 1888 was:

Brewery.	Where Located.	Barrels.
Anheuser-Busch	St. Louis	465,943
Spaten	Munich	413,550
Dreher	Vienna	390,029
Empire	Milwaukee	347,410
Schlitz	"	319,837
Ehret	New York	311,337
St. Marc	Vienna	290,480
Löwenbrau	Munich	337,739
Bergner & Engel	Philadelphia	241,143
Pachorr	Munich	228,366
Liesing	Vienna	251,739

The Anheuser-Busch Brewing Company of St. Louis, Missouri, is the largest brewery in the world. Its production in 1888 was 510,313 barrels, in 1889, 600,000, and in 1890, 700,000. It enlarged its capacity in 1891 and is now (1892) producing 6,000 barrels a day. The business employs some 2,500 men, consumes about 3,000,000 bushels of barley, nearly 2,250,000 pounds of hops, and 600,000,000 gallons of water. The Association bottled in

1888, 27,000,000 bottles of beer. A large bottle factory at Belleville, Illinois, is kept at work all the time making bottles for this concern. Its establishment at St. Louis covers over 400 acres. The piping of the brewery is more than 100 miles in length. The present annual capacity of the house is more than 800,000 barrels.

The method of Pasteur for sterilizing germs is adopted by the association for their export beer, and the product of the brewery has now gained a certain footing, not only on German ships sailing from New York, but in Germany itself. The total annual exports exceed 5,000,000 bottles.

As our country is entitled to the credit of having the largest brewery in the world, it is only fair to add that she owes it almost entirely to the energy and ability of the President of the Anheuser-Busch Association, Adolphus Busch.

The French are working hard at brewing and have made beer a fashionable drink, but up to the present time their production leaves much to be desired in the way of quality. It is probable, however, that it is only a question of a few years when they will make as good beer as anybody in the world. *Charles McK. Leoser.*

WORMS. The frequency of infection by worms in villages is strikingly shown in the following report of Grusdieff, though the relative frequency of the fish and pork tape-worms would be reversed with us. The fact is, the fish tape-worm is not encountered at all in this country.

Grusdieff examined the stools of two hundred and sixty children at a school in Kostroma, a village in Russia. The children varied in age from nine to eighteen years. The examination was microscopic. Of the two hundred and sixty cases examined, one hundred and forty-one, that is fifty-four per cent., were free of worms. The other cases showed one variety of worms, sometimes two, once three, as follows: Round-worm, eighty-six times; fish tape-worm, forty-four times; whip-worm, six times; thread-worm, six times; pork tape-worm, once.

Protozoa.—Cohen found in the stools of a previously healthy four-year-old child, treated at the Polyclinic in Gratz for fever and diarrhœa, besides the eggs of intestinal worms, white blood-corpuscles, and epithelium, cellular elements of active amœboid movement, mostly embodied in particles of mucus. They coincided morphologically with the amœbæ of dysentery described by Kartulis and Locsh, save that they were smaller, being but two or three times the diameter of the red blood-corpuscles. The author had previously reported the case of a six-months-old child likewise affected, in whose stools were found protozoa, of pear-shape, with pointed ends and a long swinging lash, and with a distinctly circumscribed nucleus at the end. These monadines disappeared from the stools after the use of a sublimate injection, and the colic and diarrhœa ceased.

Filaria.—Matas has reported a case of filaria sanguinis hominis in New Orleans. A cigar-maker, aged nineteen, suffered with dropsy in the right tunica vaginalis testis, which was ascertained to be chylous. A microscopic examination showed the presence of embryos of the filaria, a parasite hitherto unknown in that region. The filaria itself was not found, on making the radical operation. The tunica was of natural thickness, the testicle perfectly healthy. The blood of the patient contained, as usual, only at night, numerous embryos.

Whip-worm.—Mossbrugger has described a case of infection by the whip-worm in myriads, producing an intense anæmia, uninfluenced by any kind of therapy. The author believed that the whip-worm was not, therefore, always such an innocent parasite.

Trichinosis.—Fränkel ascribes the frequency of trichinosis in Germany, not to the importation of infected American meat, but to the ingestion of domestic meat, raw, or uncooked. The inspection of meat for trichina is expensive and unsatisfactory because of its imperfectness.

Lewin finds the changes in the muscles in trichinosis to be exclusively a parenchymatous myositis with tendency to degeneration. In the myositis of anthrax the process begins and remains confined mostly to the connective tissue, the perimysium internum, while in the myositis of trichinosis the perimysium is unaffected and the true muscular element is the seat of the pathological process. A more decided example of the dependence of the form of inflammation upon the cause of the inflammation could scarcely be imagined.

Distoma.—Raillet finds that the distoma hepaticum is not nourished by bile, as Küchenmeister supposed, but by blood. The arterial system of a sheep, which suffered distomatosis, was injected with a solution of gyps, 500.0; ultramarine blue, 45.0; water, 1,000.0. The specimens of distoma in the bowel discharges of the sheep were, in the majority of cases, colored blue in consequence of the absorption from the blood.

Tape-worm.—Courmount and Bataillon, zoölogical prosectors at Lyons, showed to the Lyons Medical Society a tape-worm which they had found living in the peritoneal sac of a chimpanzee which had died of peritonitis and diarrhœa. The worm was found in the vicinity of a perforation of the stomach, and was supposed to have wandered from the intestine.

Pernicious Anæmia from Tape-worm.—Szimanski reported a case of anæmia which he considered pernicious, and for which he had made a fatal prognosis. The accidental discharge of segments led to the treatment of tape-worm, and secured the evacuation, under severe pain, of four worms with heads. All the bad symptoms disappeared in a short time. The patient shortly afterward became pregnant, and was delivered of a healthy child.

Pálmai reported a case of a woman, aged twenty, affected for ten years with tape-worm diarrhœa, neurasthenia, *anæmia* of high degree, terrible dysmenorrhœa; sterile, though married for three years. A dose of fresh male fern brought away a tape-worm in toto, 3½ m. in length. The patient's condition improved in the course of the next few days; all the subjective signs yielded, the menses returned, the woman became pregnant, and the dysmenorrhœa subsequently disappeared.

Cysticerci.—Laboulbene describes a method of making muscle cysticerci visible in slaughtered animals. They shrink usually on contact with air and become almost invisible. The cysts appear in the form of white spots, and show their original characteristic form under the application of either water or glycerine. The recognition of the cysticercus is, therefore, easier than that of the trichina. The echinococcus multilocularis is, according to Ostertag, frequently observed in cattle, especially in the liver, but differs from the same disease in man in the fact that it shows no icterus, no cirrhosis. The author found but one case in two hundred thousand pigs. With Vierordt he considers it a special variety, and the coincidence of the multilocular with the unilocular echinococcus is, he says, an accident.

Echinococcus.—König reports a case of rupture of a liver echinococcus into the peritoneal sac. Certain cysts passed to the hypogastric region, where they commenced growth, and were removed by operation.

Chaintere demonstrated, by means of laminaria tents and rubber tubes, the presence of cysts in the spleen.

Halidford cured a case by incision and drainage. Subsequent cysts were cured by puncture and aspiration.

Archangelskaja reported a fluctuating tumor at the lower border of the left scapula, which consisted of hydatids, and was cured by incision.

Vierordt reports the occurrence of two cases of multilocular echinococcus in a boy and girl, at the ages of eight and eleven.

Herrmann reports four cases of echinococcus of the spleen, in which the diagnosis of the abdominal tumor was established by puncture.

Langenbuch, in his work on "Echinococcus of the Liver and its Surgery," with special reference to various operations, declares that puncture has the danger of peritonitis and of dispersing echinococcus germs. It is unreliable and not to be recommended as an accurate method, and is justifiable only for diagnostic purposes

before radical operation. Electro-puncture is likewise imperfect. The various medicated injections have only historic interest, except that of sublimate, which may have a future.

Naphthol, recommended by Chauffard, merits consideration. The multiple punctures of Jobert de Lamballes, with the capillary trocar, and the aspiration method of Dieulafoy, have been set aside for the method of puncture, subsequent drainage, and irrigation, which may be practised by the ordinary physician. This method forms a transition to the radical operation for the removal of the parasite after adhesion has been secured between the liver and the abdominal wall. This adhesion is accomplished by various caustics or by the insertion of two cannulæ, that an agglutination may take place between them. This is the principle of the double section, which has found wide advocacy. The chief merit of it lies in the prevention of scattering of echinococcus germs in the peritoneal sac. This dissemination may be prevented also by ligation, with sutures hermetically shutting off the peritoneal sac. This method, according to the author, gives the safest results. It may be done some time before the radical operation. More heroic procedures, resections, or extirpations, are attended with too great dangers for general adoption.

Total discharge of all the worms may be secured by the use of the knife, or the Paquelin cautery, with subsequent drainage. Subphrenic echinococcus may require displacement of the liver (Landau) to secure room for operation, or peripleural incision (Israel, Genzner), or extra-peritoneal lumbar section, according to the situation of the worm. Echinococci in the peritoneal sac are removed by irrigation, the patient lying upon the side, with elevated chest. Multiple worms may require numerous laparotomies and sublimate injections. This last procedure may be adopted in cases of multilocular echinococcus.

Maydl has reported a case of pleuritic exudation, due to echinococcus and metastases from the liver. Frequent recurrence necessitated repeated incisions and resections. During this time the patient expectorated echinococcus cysts mixed with blood. Final recovery.

ANTHELMINTICS.—Murovicz finds the following objections to the various anthelmintics: First, unreliability owing to the essential ethereal oil; second, secondary irritant effects on the intestinal canal; third, some agents, like santonin, may in strong doses induce general intoxication. *Naphthalin*, which the author recommends, is a safe means with prompt effect. Thread-worm and tape-worm, the last with heads, are voided after a single dose of fifteen grains of naphthalin. The dose is to be graduated, according to age, from five to fifteen grains. Castor-oil may follow the remedy in adults, and should preferably be administered with it in children.

Bronowski increased the value of the ethereal extract of *male fern* by the addition of a purgative and of *chloroform*. Chloroform benumbs the parasite and relaxes the hold of the hooks.

According to Poulson, the ethereal extract of male fern in the treatment of tape-worm has several times led to fatal poisoning. In other cases reported, death sometimes occurred in consequence of irritation of the stomach and intestines; at other times, in consequence of paralysis and affection of the central nervous system. Death occurs in consequence of general central paralysis. The inequality of the active principle in the extract is evidenced by the fact that, on one occasion, as small a quantity as four grammes produced very dangerous symptoms in an adult, while as much as twenty or thirty grammes has often been taken without danger. Of all the chemical constituents of the ethereal extract of male fern one only merits consideration: Filix acid. Its chemical composition, according to elementary analysis and molecular weight, is fixed at $C^{35}H^{42}O^{13}$. In this composition it is separated from a solution in alkalies by the addition of HCL, as an amorphous substance which is pharmacologically very active. The crystalline substance which is sometimes separated from the older ethereal extracts, and which has been called Filicin, is, from a pharmacological stand-point, perfectly ineffective, and is really an anhydride of Filix acid. Filix acid in the frog affects the central nervous system, which after a short period of excitement is entirely paralyzed; further, the heart, whose energy is markedly reduced. The pulse is diminished in both force and frequency. Innervation is disturbed in the automatic heart ganglia. The skeleton muscles of the frog lose the power of recovery after effort. In warm-blooded animals the paralysis of the heart occurs simultaneously with the general paralysis, which begins as an ascending spinal paralysis. Attacks of diarrhœa supervene, as in cases of poisoning by the extract in man. It is advisable, therefore, instead of using the extract, whose constituents vary, to employ the filix acid itself, as this acid is easily soluble in the intestinal canal, and is but little absorbable. Filix acid is soluble in oils, and is thus dissolved in the ethereal extract. It is advisable, also, instead of giving castor-oil at the same time for the purpose of removing the parasite, to use some other laxative, because the oil favors absorption. *James T. Whittaker.*

WOUND TREATMENT. The improvements which have been made in surgical technique during the last few years have transformed the province of surgery. Operations are daily performed with success which were not attempted two or three decades ago, or which were attended with so much danger as to make them unjustifiable.

Injuries which formerly were followed by death or amputation are now treated with little discomfort and without loss of life or limb. These truths come out with startling force if one compares the cases recorded in the "Surgical History of the War of the Rebellion" with the cases of to-day, and they are equally forceful when one reads our old hospital histories or the cases recorded by the older writers. Formerly the patients whose breasts were removed were under treatment for a period of from three to six months. Now, after the removal of the breast and axillary contents, patients are usually discharged from hospital care in about two weeks.

One of the older Bellevue Hospital surgeons once told me that at one time almost every case of compound fracture which was admitted to that hospital resulted fatally. At the present time, in this same hospital, compound fractures are regularly expected to do well, and many of them heal as well as simple ones.

Lindpainter reported at one time that eighty per cent. of all wounds in Nussbaum's clinic in Munich became infected with hospital gangrene; and also that erysipelas was so common that its appearance came to be considered as almost a normal occurrence. The suturing of wounds about the head was given up because the retained secretions favored erysipelas.

Healing by first intention was almost unknown. In one year, out of 17 amputations, 11 died of pyæmia alone.

A compound fracture was seldom to be observed in the division, since the limb was either amputated or soon became infected, and death followed from hospital gangrene or septicæmia.

The mortality after compound fractures, in Volkmann's clinic in Halle, during a long period of years, which embraced the administration of his predecessor and a part of his own, was forty per cent.

Compare these statements with Halsted's reports of the first 122 surgical cases treated in Johns Hopkins Hospital. Of 111 cases which were not suppurating when operated upon, 108 healed by primary union, 2 had suppuration, 1 had hemorrhage; of 11 cases which were actively suppurating at the time of operation, 8 healed primarily, 2 had some suppuration, 1 had active suppuration—122 cases, good and bad, and of these only 6 which did not heal by primary union.

At the present day hospital gangrene is almost unknown. Pyæmia is so uncommon that a man may well gain a large surgical experience without meeting more than a dozen cases. A suppurating wound is a reproach

to the surgeon or his assistants and leads to inquiry as to its cause.

It is evident that the modern changes in surgical technique are of vital importance, and that the surgeon is well repaid for a study of the principles which underlie them and the details which are necessary in carrying them out.

They have come because we have learned the causes of suppuration, and improvements in technique are all the time occurring as we learn more and more about these causes.

The introduction of antisepsis was a great stride in the advancement of surgery, but so many changes have been made since the carbolic spray and the Lister dressing were introduced that we may fairly say that we have advanced to yet another epoch in surgical progress.

We must recognize that there are two opposing forces in most cases where there are open wounds: 1. The developing form of the infectious agent. 2. The resisting form of the patient.

Bacteria which have the power of causing pus are present in the majority of surgical wounds. They exist in the patient's skin so deeply that they are not to be washed away, they are frequently present in the diseased tissue, they are far too often on the surgeon's hands and those of his assistants in spite of careful washing, and if they are not on the instruments or sponges at the beginning of an operation they are very likely to be there before its end owing to contact with some unsterilized object.

Bossowski studied the bacteria in fifty fresh wounds which were treated antiseptically. In forty of them he found bacteria: the staphyloccus aureus, nine times; the streptococcus pyogenes, two times; the staphylococcus albus, twenty-six times; and non-pyogenic bacteria, many times.

Kümmel found that pieces of muscle, adipose, or connective tissue taken from fresh wounds immediately after irrigation with a 1 to 10,000 sublimate solution, which had been continued throughout the entire operation, contained bacteria. The same result was obtained after a frequent washing with 1 to 1,000 sublimate solution.

There are many kinds of bacteria which are capable of causing pus production. The peculiarities of the suppuration differ with the different varieties of infection, and treatment must be modified accordingly. The tubercle bacilli, for instance, cause a slowly progressing suppuration which often results in the production of cold abscesses. A pint of this tubercular pus may exist in the system for weeks and cause very moderate constitutional symptoms.

The streptococcus pyogenes, on the other hand, is an infective agent of a very different nature. If a colony of these cocci get under the skin of the finger-tip, as, for instance, in a scratch which comes in contact with the fluid from a case of puerperal peritonitis, they may cause a septicæmia so virulent as to be fatal in a few days.

Or if somewhat less virulent they may start an inflammation which runs up the tendon sheaths and produces pus in many of the tissues of the hand and forearm, which involves the lymphatics and causes abscesses in the axilla or elsewhere. They are especially apt to cause spreading phlegmon, and are found either alone or in combination with other bacteria in numerous varieties of inflammation.

Moreover, they are so abundant and so generally disseminated that they must continually be guarded against.

In sixty-five cases of suppuration at the Vanderbilt Clinic, which were examined by Dr. Park and myself, streptococci were present in forty-eight. They were present in practically all of the severe inflammations.

The staphylococcus pyogenes aureus organisms are still more common; they are found in the majority of suppurating wounds, abscesses, boils, etc. They tend to form circumscribed abscesses rather than the spreading inflammation which is caused by the streptococci.

They are so generally disseminated that unprotected wounds may regularly be expected to become infected by them, and they may be so virulent as to cause fatal pyæmia or septicæmia.

Welch found them very frequently on the hands of surgeons and their assistants who had to do with suppurating cases of any kind; sometimes they were present several days after contact with surgical cases.

Prudden and Ullman found them frequently present in the air, and among the dust particles, especially in much-used rooms.

They do not die easily nor are they easily killed by freezing, and they grow readily under varied conditions.

Surgically speaking we have no right to expect any unsterilized object to be free from them.

The staphylococcus pyogenes albus is similar to the staphylococcus aureus in many respects, but seems to be far less virulent.

In the fresh wounds in which Bossowski found the streptococcus pyogenes and the staphylococcus aureus, there was regularly suppuration; but in those in which the staphylococcus albus was present alone there was either primary union or a very slight and almost harmless infection along the drainage-tube or the sutures. It is quite possible that the staphylococcus epidermis albus which Welch has described is identical with the staphylococcus pyogenes albus, which has frequently been found by other observers. This coccus is remarkably interesting in that it exists in the epidermis so deeply that it cannot be removed by ordinary disinfection. The skin seems to be its normal habitat. After thoroughly cleansing and disinfecting it, this white coccus may be obtained on a piece of sterilized thread by passing it through the deeper layers of the skin. Its infective power seems to be very weak. It is capable of producing small stitch-hole abscesses, or suppuration along the sides of a drainage-tube or superficial abscesses. But unless the tissues have very slight vitality it does not seem to be capable of producing serious inflammation. The bacillus coli communis is also capable of producing serious infection and suppuration. This bacillus lives normally in the large intestine. In cases of injury to the intestine it may get into the peritoneal cavity and cause fatal peritonitis. Welch reports several cases of peritonitis in which only this bacillus was found. It was found several times in pure culture in aseptically treated laparotomy wounds. It was generally accompanied with moderate fever and a thin, brownish, slightly purulent discharge, and the smooth and rapid healing of the wound was interfered with.

Numerous other bacteria may be concerned in pus production: The diplococcus pneumoniæ of Fränkel and Weichselbaum, the typhoid bacillus, the staphylococcus pyocyaneus, gonococcus, bacillus pyogenes fetidus, proteus zenzeri, and micrococcus tetragenus may be mentioned among these.

The same species of bacteria differ greatly under different surroundings. In certain abscesses they seem to exhaust themselves, and the pus becomes strictly sterile. Numerous cases of this kind have been reported. On the other hand, under certain conditions they seem capable of showing increased resistance to germicides.

Trambusti made cultures of various micro-organisms, and then transferred them into bouillon, in which he put increasing quantities of sublimate. He found that the bacteria in this way gained a tolerance of antiseptics. For example, Friedländer's pneumococci could be put into a 1 to 2,000 solution of sublimate in bouillon without the prevention of their growth, while the growth of the same bacteria without such treatment was checked in a 1 to 15,000 solution of sublimate in bouillon. The pathogenic action of the bacteria also differed. Some retained their pathogenic qualities as long as they retained the power of growth; others lost it much earlier. It should be remembered that in this experiment a certain part of the sublimate probably was exhausted by chemical combination with the elements of the beef-tea.

In order to test this matter of varying virulence Welch injected into the ear veins of rabbits bouillon cultures, forty-eight hours old, of the staphylococcus aureus obtained from many different sources. "Considerable

variatious in virulence were found to exist both in the original cultures and in the successive generations of the same culture. The most virulent culture was one from a beginning furuncle. The injection of 0.1 c.c. of this culture caused the death of the rabbit in twenty-four hours, with a large number of staphylococci in the blood and many necrotic foci in the kidneys. After the second generation the virulence was lessened. On the other hand, he injected into the ear veins of rabbits 1.5 c.c. of a similar bouillon culture of staphylococcus pyogenes aureus, which came from a cirrhotic liver, without any apparent effect, the animals being still alive eight months after the injection.

"These extremes are met only occasionally. In a great majority of cases we have found the injection of 0.2 to 0.3 c.c. of bouillon cultures sufficient to kill the animal in four to seven days, with abscesses in the kidneys and heart, and occasionally elsewhere. As a rule, there was no material change in the degree of virulence for many successive generations; but sometimes, without any apparent cause, there would occur a marked weakening of the virulence, either after a few generations or after many."

It is possible that accompanying toxic substances may have an influence on these variations. This question of the varying virulence of different bacteria, and of the same species of bacteria under varying circumstances, is of very great importance to the surgeon. How frequently do we hear men say that it is unnecessary to treat a wound or abscess antiseptically, because it is already infected! Such men forget that there are different grades of infection, and that we may do a patient a very great injury by permitting a mild infection to become changed into a virulent one. A surgeon who introduces streptococci or the yellow staphylococci into a tubercular abscess has done his patient an injury which may have the most disastrous results. If an abscess from hip-joint disease has burrowed into the thigh it may be far better to leave it unopened, in the hope that the joint may become shut off from the abscess, than to open it and make an avenue for general infection, which will not be easily managed in this locality.

If an abscess is caused by the staphylococcus epidermis albus, it is plainly wise to keep out the yellow staphylococcus and the streptococcus pyogenes, because they are much more virulent than the white coccus.

In the opening of an abscess which contains sterile pus one should use as much care as in the making of a fresh wound.

Inasmuch as we cannot clinically determine all of these conditions, it is plainly a surgical duty to regard all unsterilized objects as septic and all infected wounds as capable of receiving worse infection.

The inflammation which takes place about a suppurating wound is a barrier against further infection, but in spite of this an abscess or infected wound may frequently be made far worse by the introduction of new sepsis.

We have personally traced this process by making cultures from the pus in wounds during various stages of suppuration, and have found that the symptoms vary when new infection has occurred. Moreover, we must endeavor to keep out all infection, and not to be misled by moderately good results. If a laparotomist saves the peritoneal cavity and yet has abscesses in the abdominal wall, it shows that there has been an error in technique, and that the peritoneum has escaped either through chance or because it has been able to overcome the bacteria. If a surgeon has frequently a slight form of suppuration in his wounds, it shows that there is an avenue of infection somewhere, and that if a virulent infection happens to find the avenue, he may lose his patient.

On the other hand, the system of the patient is able to successfully cope with a limited number of pyogenic bacteria and to prevent their growth. Cheyne estimates that several thousand may be present in a wound without causing suppuration.

Nearly all surgeons have met with cases in which infected material has come in contact with a fresh wound, and still the wound has healed kindly.

Grawitz found that he could inject 5 to 10 c.c. of the suspension of the yellow staphylococcus in salt solution into the abdominal cavity of rabbits and dogs without producing any perceptible effect. These cocci, however, are capable of producing suppuration in these animals, as a fraction of a drop of a similar suspension, when injected into the rabbit's eye, will set up a suppurative inflammation. A larger amount will produce an abscess in the loose subcutaneous tissue of the back. These experiments have been verified by numerous observers. Waterhouse injected under the skin of the human abdomen and of the scrotum 0.25 c.c. of a suspension of staphylococcus aureus made from mixing one loopful from an agar culture with 5 c.c. of water, and the result was completely negative.

This same power of the system to overcome infection is shown in medical diseases. Tubercle bacilli are found encapsulated and shut away in the bronchial lymph-nodes. The Klebs-Loeffler bacillus causes a false membrane and very slight constitutional symptoms in one person, while in a patient infected from this person it may cause profound constitutional symptoms and death.

In considering, then, the problems of wound treatment, we must ever bear these two forces in mind: the growing power of the bacteria, the resisting power of the patient. We should keep out infective agents. We should avoid injuring tissues and so impairing their vitality and power to overcome any bacteria which may gain entrance. The first is more difficult, and the second more important, than was formerly supposed. A few years ago men satisfied their surgical consciences by washing their hands in soap and water with more or less care, and then dipping them in a 1 to 1,000 bichloride solution, immersing their instruments in a five per cent. solution of carbolic acid, and sponging and irrigating the cut tissues with 1 to 1,000 bichloride solution.

This method, however, did not keep out the bacteria, and it did unnecessarily injure the tissues; hence it was defective in both respects. The present methods aim at a technique which will exclude bacteria more effectively and injure the tissues less.

GERMICIDES.—Before studying the details of this technique we should arrive at an understanding of the values of various germicidal agents. The blind faith which has been put in the germicidal power of solutions of corrosive sublimate and carbolic acid is startling. We were told years ago that a short immersion in these fluids killed bacteria, and so generally has this belief been accepted that towels, cotton pledgets, instruments, dressings, and even the hands of the operator, have been supposed to be aseptic after an immersion of a few seconds or a few minutes. Recent studies have shown many fallacies in this belief.

The original experiments, which were made with solutions of bichloride of mercury, were so conducted that a small residue of the bichloride was transferred to the nutrient media in which the bacteria were planted. This small quantity has been found sufficient to inhibit bacterial growth.

Geppert, after saturating threads with anthrax spores, and immersing them in a 1 to 1,000 corrosive sublimate solution for varying lengths of time, precipitated the adherent sublimate with ammonium sulphide, and then placed the threads in culture media. He found that after one, two, and three hours in sublimate solution a few spores retained their power of growth, and in one exceptional case he obtained a growth beside a knot in the thread after twenty-four hours' immersion. Behring obtained growths from anthrax spores which had been immersed in 1 to 1,000 sublimate solution for ten hours. Nissen found that anthrax spores could live after a four hours' immersion in one per cent. corrosive sublimate solution. Abbot repeated Geppert's experiments and obtained similar results. He also found that staphylococcus pyogenes aureus would grow after a one hour's stay in 1 to 1,000 solution of sublimate in nutrient bouillon, or after twenty minutes' exposure in a 1 to 1,000 watery solution of sublimate.

The writer has collected pus in small amount on cotton pledgets which were saturated with 1 to 1,500 corro-

sive sublimate solution, and two and a half hours later he has touched nutrient agar with them and obtained abundant growth of streptococcus pyogenes. He has also repeatedly touched swabs to wounds which had just been thoroughly irrigated with 1 to 1,000 sublimate solution, and has obtained abundant growth of streptococci and staphylococci pyogenes aurei from the swabs.

There are numerous considerations which should influence the use of germicides. It is believed that sublimate solutions kill bacteria by a chemical action which takes place between the sublimate and the bacteria. If the number of bacteria is very great, and the amount of sublimate is small, it is evident that the chemical power of the sublimate may be exhausted before the bacteria are all killed. Abbot found that large quantities of bacteria were not killed in a solution which was strong enough to destroy small quantities. Similarly, any albuminous substance which forms a chemical compound with the sublimate leaves far less sublimate to act on the bacteria. Abbot found that a 1 to 1,000 watery solution of sublimate had a far greater germicidal power than a 1 to 1,000 nutrient bouillon solution.

In a similar way, solutions of sublimate which have stood for a considerable time may have lost their power. Abbot found a marked difference between the germicidal power of a fresh sublimate solution and one that had stood for four days.

Temperature, again, exerts a great influence. Heider found that a five per cent. solution of carbolic acid, at a temperature of 75° C., killed anthrax spores in fifteen minutes, whereas a similar solution did not kill them in thirty-six days at the ordinary room temperature. Behring found that staphylococci pyogenes aurei, when exposed to a 1 to 1,000 corrosive sublimate solution at a temperature of 3° C., were not killed in one hour. At a temperature of 22° C. they were not killed in twenty-five minutes, whereas at a temperature of 36° C. they were killed in five minutes. He also found that anthrax spores were killed in thirty to sixty minutes at 70° C., and in eight to ten minutes at 85° C., when immersed in a one and four-tenths per cent. aqueous solution of sodium carbonate.

It is of vast importance in the consideration of germicides to remember that certain substances may protect the bacteria from chemical action. Oil and grease are the most marked instances of this, but pus, blood, and dirt may have a decided protective influence. Koch reported, more than ten years ago, that oil prevented the action of germicides. Silk threads which are impregnated with pus bacteria and then dipped in oil may lie for days, and even for weeks, in an aqueous 1 to 2,000 corrosive sublimate solution without the killing of the bacteria. Blood, pus, sputum, etc., may in a similar way protect bacteria from chemical action.

Furthermore, different bacteria of the same species seem to have a very different tolerance of germicides. This has already been referred to in the paragraphs on bacteria. Esmarch, in studying the subject, found that some anthrax spores were killed by steam in one minute, whereas an exposure of twelve minutes was necessary to kill others.

In consideration of all these possible sources of error it is evident that we cannot blindly trust to the quick action of chemical sterilization. A one per cent. solution of bichloride of mercury may sterilize an object in a few minutes, but if there is grease, oil, mucus, blood, or pus upon it the object may still be septic after an immersion of an hour, or even of many hours. Furthermore, what we suppose to be an efficient solution of sublimate may be almost useless, owing to the combination of the sublimate with albuminous material, soap, minerals in the water, etc. The weakening of the sublimate solution by the presence of other minerals in the water may be avoided by adding table salt to the solution.

The considerations which apply to sublimate solutions apply also to other chemical solutions. It is always to be remembered that the germicidal power of a five per cent. carbolic acid solution is far less than that of a one per cent. solution of corrosive sublimate. Heider, Geppert, Reidel, Fränkel, and many other observers record the survival of anthrax spores after an immersion in five per cent. solution of carbolic acid for days.

The appended table shows the germicidal power of a few heated liquids, with the authorities for the same:

Germicidal agent.	Temperature at which it was used.	Kind of micro-organism.	Length of exposure necessary for killing the micro-organisms.*	Observer.
Boiling water.	100° C.	Anthrax spores.	2 minutes.	Geppert, Berl. klin. Woch., 1890, p. 246.
				Schimmelbusch, Arch. f. klin. Chir., xlii.
Boiling water.	100° C.	Bacilli and cocci.	2 to 5 seconds.	Ibid.
Boiling water.	100° C.	Staphylococcus pyogenes aureus; bacillus pyocyaneus.	2 to 3 seconds.	Ibid.
Boiling one per cent. aqueous solution of sodium carbonate.	100° C.	Anthrax spores.	2 minutes.	Ibid.
Boiling one per cent. aqueous solution of sodium carbonate.	100° C.	Pus; staphylococcus pyogenes aureus; bacillus pyocyaneus.	2 to 3 seconds.	Ibid.
One and four-tenths per cent. aqueous solution of sodium carbonate.	85° C.	Anthrax spores.	8 to 10 minutes.	Behring, Zeitsch. f. Hygiene, 1890, p. 451.
One and four-tenths per cent. aqueous solution of sodium carbonate.	80° to 83° C.	Anthrax spores.	10 minutes.	Ibid.
One and four-tenths per cent. aqueous solution of sodium carbonate.	77° C.	Anthrax spores.	15 minutes.	Ibid.
One and four-tenths per cent. aqueous solution of sodium carbonate.	75° C.	Anthrax spores.	20 minutes.	Ibid.
One and four-tenths per cent. aqueous solution of sodium carbonate.	70° C.	Anthrax spores.	30 to 60 minutes.	Ibid.
Five per cent. solution of carbolic acid.	Ordinary room-temperature.	Anthrax spores.	Not killed in 36 days.	Heider, Centralblatt f. Bakt. und Parasitk., Bd. ix., p. 221.
Five per cent. solution of carbolic acid.	55° C.	Anthrax spores.	30 minutes.	Ibid.
Five per cent. solution of carbolic acid.	75° C.	Anthrax spores.	15 minutes.	Ibid.
Blood.	55° C.	Anthrax bacilli.	10 minutes.	Toussaint, quoted by Fränkel, Grundriss Bact'kunde, p. 257
Weak alkaline bouillon.	54° C.	Koch's comma bacillus (cholera).	3 minutes.	Van Geun's Arch. f. Hygiene, 1889, p. 402.
Weak alkaline bouillon.	56° C.	Bacillus of typhoid fever.	3 minutes.	Ibid.
Weak alkaline bouillon.	60° C.	Bacillus of septicæmia of mice.	Few seconds.	Ibid.
Weak alkaline bouillon.	78° C.	Bacillus of malignant œdema.	Few seconds.	Ibid.
Weak alkaline bouillon.	80° C.	Pneumococcus of Friedländer.	1 minute.	Ibid.
Weak alkaline bouillon.	70° C.	Tubercle bacilli.	10 minutes.	Yersin, Annales de l'Inst. Pasteur, t. i., No. 2.
Milk.	68° to 69° C.	Tubercle bacilli.	30 minutes.	Bitter, Zeitsch. f. Hygiene, 1890, p. 255.

* The times given are not absolute, because in some cases the organisms were exposed to a certain varying heat while the medium was being heated and was cooling.

Heat is to be used wherever it can be in sterilization. Boiling fluids have very great germicidal power. According to Geppert and Schimmelbusch, boiling water kills anthrax spores in two minutes. The latter observer states that the vegetative forms of the bacilli and the cocci are killed by it in from one to five seconds. Steam is less powerful; it kills anthrax spores in from five to twelve minutes (Esmarch). Under pressure its temperature may be raised and its efficacy somewhat increased.

Dry heat is considerably less powerful. Sporeless bacteria are killed in air at a temperature of 212° F. in an hour and a half (Koch and Wolfhügel); while spores must be exposed to a temperature of 140° F. for three hours to insure their destruction.

Heated liquids furnish us another method of using heat in disinfecting. It sometimes happens that boiling liquids will injure materials which may be thoroughly sterilized by liquids which are heated to 160° and 175° F. Freeman has thoroughly studied this subject, and applied it to the preparation of milk by a method called Pasteurization. His method consists in putting the bottles of milk into a measured quantity of boiling water and allowing them to remain there as the water cools. This raises the milk to a temperature of about 167° F., and holds it there for about twenty minutes. This temperature he found sufficient to sterilize milk which held 8,000 to 230,000 bacteria to each c.c. Van Gueno found a similar or even a lower temperature sufficient to kill, in times varying from ten minutes to a few seconds, Koch's comma bacillus, the bacillus of septicæmia of mice, and the tubercle bacillus, when in suspension in weak alkaline bouillon. The bacillus of malignant œdema was killed in a few seconds at 173° F., and the pneumococcus of Friedländer was killed in one minute at 176° F. Behring found that anthrax spores were killed in $1\frac{1}{10}$ per cent. aqueous solution of sodium carbonate, at temperatures from 167° to 185° F., in from eight to twenty minutes.

Bearing these points in mind, it is evident that heat should be used for surgical disinfection whenever it is possible. Boiling alkaline solutions overcome almost entirely the objections which are raised to cold chemical solutions. And where boiling solutions or steam cannot be used, we can still, in most instances, heat the solutions, and thus increase their germicidal action.

In coming to the consideration of surgical technique proper, our subject may fairly include all those details which are essential to the exclusion of bacteria, and the keeping of the tissues in the best condition possible, for upon these details depends surgical success. The limitations of this article, however, forbid the exhaustive study of all details.

Our subject naturally divides itself into three parts: 1. Preparation for the operation. 2. The operation itself. 3. After-treatment.

Under the first, we may consider preparations of the surgeon, his assistants, the patient, the room, the table, towels, instruments, dressings, ligatures, sutures, sponges or absorbent pads, solutions, and dishes.

Under the second we may consider the methods of avoiding contact between sterilized and unsterilized objects, the management of dead spaces, healing under blood-clot, draining, irrigation, and the injury to tissues.

Under the third we may consider after-dressing and certain principles of medication.

I. Preparation for the Operation.

Preparation of Surgeon and Assistants.—It is believed to be wise for the surgeon and his assistants to avoid contact with septic cases and with contagious diseases so far as is possible, and to preserve the strictest personal cleanliness. This is of especial importance on the day of the operation; if septic cases must be cared for during the day they should not be visited until after the operation. If septic and clean cases are both to be operated upon, the clean cases should be attended to first.

Before operation a freshly washed, short-sleeved gown or duck suit which fits closely about the neck and extends to the ankles, should be put on. A damp sterilized towel may be pinned across the chest like an apron. The sterilizing of the hands is one of the most difficult of procedures. All surgeons' hands become infected again and again, each contact with pus or any unclean matter leaving its residue of infection. We may state positively that simple washing in soap and water will not sterilize infected hands. At the Johns Hopkins Hospital bacterial cultures were made from the subungual spaces of physicians who believed they could thus clean their hands, and cocci were regularly found to be present after the washing. Welch found the staphylococcus pyogenes aureus very frequently on the hands of surgeons and their assistants who had to do with suppurating cases of any kind. It was found several days after any contact with surgical cases. It was only exceptionally found on the hands of other persons.

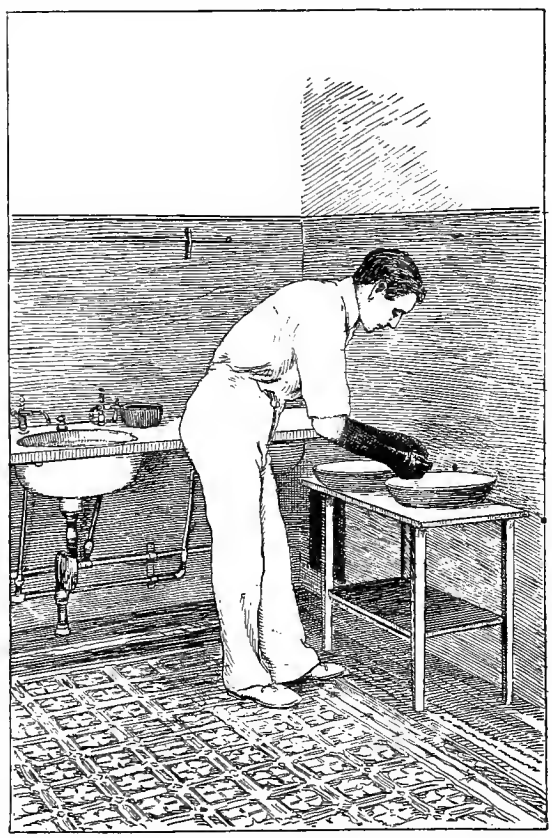


Fig. 681.—The Assistant in the concluding Steps of Sterilizing his Hands and Forearms, preparatory to Operation. The hands and arms are seen stained a deep mahogany color by saturated solution of permanganate of potash. (Kelly.)

Fürbringer's method of cleaning the hands is as follows: The nails should be kept trimmed short; the hands are to be scrubbed with brush and soap in hot water for one minute, especial attention being paid to the subungual spaces, which then are to be scraped carefully with a nail cleaner; then the hands are to be immersed for another minute in strong alcohol, and afterward in a 1 to 1,000 solution of corrosive sublimate for a minute.

This method is fairly efficient, but Geppert found that, after all, the bacteria on the hands were not entirely destroyed in that way, but that if the adherent sublimate was precipitated by the ammonium sulphide they would still grow. His observations have been verified at the Johns Hopkins Hospital, where the following method has been developed:

1. The nails are kept short and clean.

2. The hands are washed thoroughly for ten minutes with soap and water, the water being as hot as can be comfortably borne, and being frequently changed. A brush, sterilized by steam, is used, and any excess of soap is washed off with water.

3. The hands are immersed for from one to two minutes in a warm saturated solution of permanganate of potash.

4. They are then placed in a warm saturated solution of oxalic acid, where they remain until complete decolorization of the permanganate occurs.

5. They are next washed off with sterilized salt solution or water.

6. They are then immersed for ten minutes in sublimate solution, 1 to 1,500.

The bacteriological examination of the skin thus treated, even after the mercury has been precipitated, yields al-

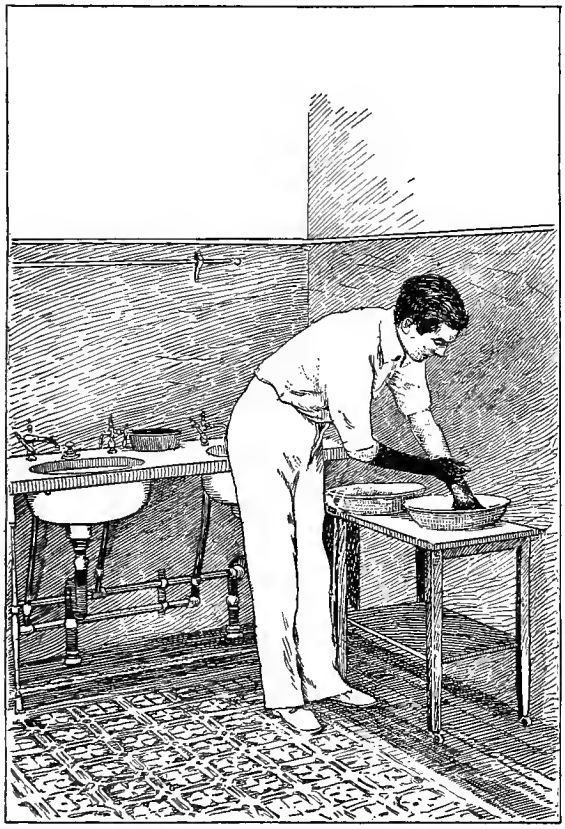


FIG. 682.—The Final Step in this Method of Disinfection, the Removal of the Permanganate Stain by Oxalic Acid. The decolorization of the left arm is seen. (Kelly.)

most uniformly negative results, the material for the cultures being taken from underneath and around the nails.

Threads which are impregnated with bacteria are not sterilized by this procedure. A great objection to the method is that it irritates the skin so much as to frequently cause a dermatitis. Some men cannot use it at all, and hardly anyone can use it frequently. We advise its use by those who do not get a dermatitis thereby, and Fürbringer's method by those who do.

One point has been much overlooked in the case of the hands, viz., the keeping of the skin itself in a healthy condition. Healthy skin may harbor thousands of bacteria, but inflamed skin harbors them by the million. Again, skin which is cracked and furrowed by the use of strong antiseptics offers innumerable crevices for the lodgement and protection of bacteria.

Hang-nails and little cuts or scratches should be immediately protected. They may be well cared for by covering them with a bit of gauze, wet in sublimate solution, and then slipping on a rubber finger-cover. If one must operate with a defect of this kind on the hand, he should either wear a rubber glove or a rubber finger-cover which has been efficiently sterilized in sublimate solution. A finger-ring should never be worn during an operation. The nails should always be kept short.

The hair or beard may carry infection. I have frequently seen men with loose dry hair touch heads directly over an open wound, and nurses with wavy unprotected hair working about in such a way as to give much danger of infection from falling dandruff or dust. The hair should be so dressed that dandruff cannot fall, or else the head should be covered.

The nurses and assistants should be as careful as the operator in all dress details.

The preparation of the patient involves two lines of procedure: 1. The cleansing of the skin or mucous membrane at the site of the operation. 2. The constitutional treatment.

The first of these is of very great importance. Nearly twenty years ago Eberth described numerous bacteria in the normal perspiration, and since that time numerous observers have described bacteria on the skin and hair. The uniform temperature, the moisture, and the desquamating epithelium give the conditions favorable for bacterial growth. They are particularly abundant in the axilla, the anal furrow, and the interdigital space. The staphylococcus epidermis albus of Welch has been already referred to. We may expect it to be regularly present in the skin, and must remember that it is capable of setting up a suppuration which is more or less virulent according to circumstances. Lockwood stained sections of skin of two breasts which had been carefully cleaned, and found bacilli and cocci in the epidermis and hair-follicles. They were probably living when the skin was removed, for another bit of similarly-prepared skin, dropped into bouillon, yielded a free growth of streptococci, diplococci, and bacilli. After surface disinfection the contents of the sebaceous glands yielded cocci and bacilli, as did also the sweat-glands.

More than one large book has been written about the micro-organisms found in the mouth. Winter states that in one-half of all cases the female genital canal contains pathogenic organisms in a condition for virulent growth. Gönure and many other writers describe them in much detail. The male urethra also contains them, as do the secretions from the nose and conjunctiva.

The proper preparation of the site of operation is therefore a difficult problem, and of very great importance. The most satisfactory proceeding which I know of is the following: When the incision is to be made through the skin, frequent warm baths should be taken before the operation, and the night before it any hair which grows about the site of operation should be shaved. A poultice made of mild soft soap should then be applied and left on overnight. After this a large amount of dead epithelium comes off by gentle rubbing. A piece of gauze may then be put on moistened in a solution, alum sulphate, 1 part; acetate of lead, 5 parts; water, 200 parts. After the patient is on the operating-table the part should be again scrubbed with soap and water by a person whose hands are aseptic, the soap, water, and hand-brush having all been previously sterilized, The skin may then be washed off with a solution of corrosive sublimate, 1 to 2,000. These procedures do not cause a dermatitis. Any procedure which does should be avoided.

If the operation is within the vagina, a warm douche of three per cent. boric acid solution, or one per cent. solution of carbolic acid, should be given twice daily for several days before the operation, and after the patient is on the table the vagina should be thoroughly scrubbed out with warm soap-suds, and douched with one per cent. carbolic solution, or bichloride solution 1 to 3,000.

In preparing for operations within the mouth, a peroxide of hydrogen mouth-wash (seven volumes) should be used for several days. In patients who have thus been treated I have found that, after removal of parts of the

upper and lower jaws, a packing of iodoform gauze would remain in the mouth for six days without becoming fetid; a mouth-wash being also used after the operation.

The *constitutional treatment* of the patient is to be conducted on the general principles of medicine. The bowels should be evacuated before operation. The stomach should be empty before the ether is administered. A syphilitic condition should be treated vigorously. Diabetes contraindicates any serious operation, unless without it the disease or injury is likely to terminate fatally.

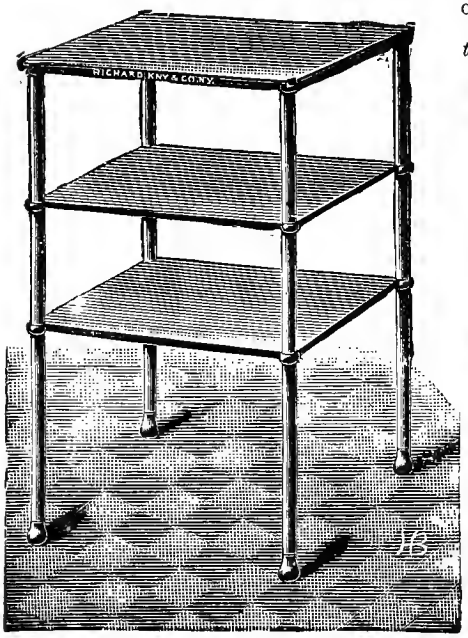


FIG. 683.—Stand Made of Iron and Glass for Holding Surgical Dressings.

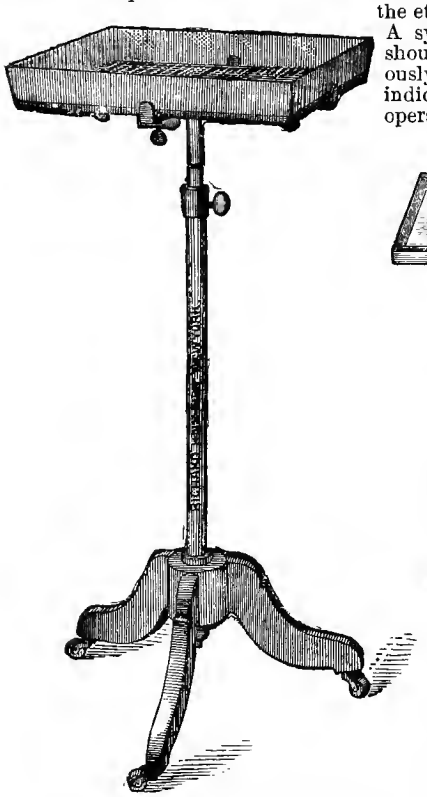


FIG. 684.—Stand for Holding Glass Instrument Tray.

The room should be large enough for the patient, the surgeon, and the assistants. It should have good light; it should be reasonably clean, and should be free from dust. There is no danger from air-infection unless particles of dust fall on the wound, or on something which will come in contact with it. It is not wise to sweep or dust a room just before an operation. This fills the air with dust particles which are capable of carrying infection. It is far better to close it for a few hours before the operation, and then, if the floor is carpeted, to cover it with something which will prevent the undue raising of dust. Stern found that after stirring up the dust in a room and then closing it, nearly all the dust settled to the floor in one and a half hour, although the more attenuated particles, such as those which came from woollen and rags, and the mould spores, were somewhat slower in settling. The pieces of furniture or tables with which the operator or assistants come in contact should be covered with sterile sheets or towels. In regular operating-rooms, stands for dressings and instruments may well be made of metal or glass (Figs. 683 and 684). If, however, such stands have deep cracks between the glass and the metal they are really harder to clean than wooden ones are.

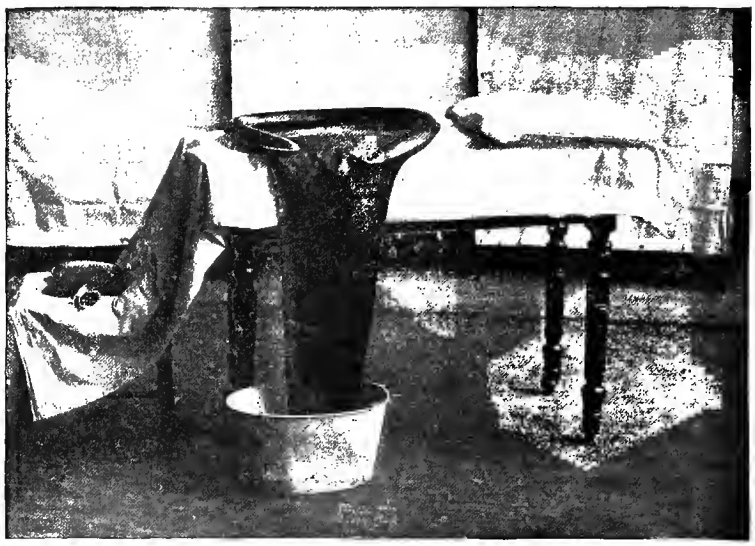


FIG. 685.—An Efficient Operating-table such as may be easily Prepared in any House. The patient's feet may rest on the warm-water bag which is on the chair. The Kelly pad is unnecessary if irrigation is not to be used.

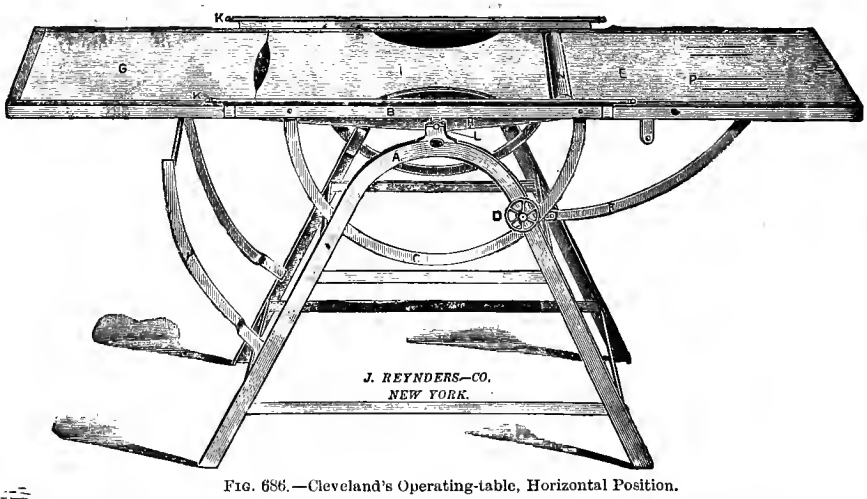


FIG. 686.—Cleveland's Operating-table, Horizontal Position.

The operating-table may be a plain kitchen-table, and still be efficient.

It should be 2 to 2½ feet wide. A length of four feet is sufficient if the patient's feet are placed on a rest at the foot of the table, or if the patient has to be placed in the lithotomy posture. It should be longer if the feet are to be extended on the table. If the operation is on the hand or arm, a small side-table should be used, or a leaf may be provided for the regular table.

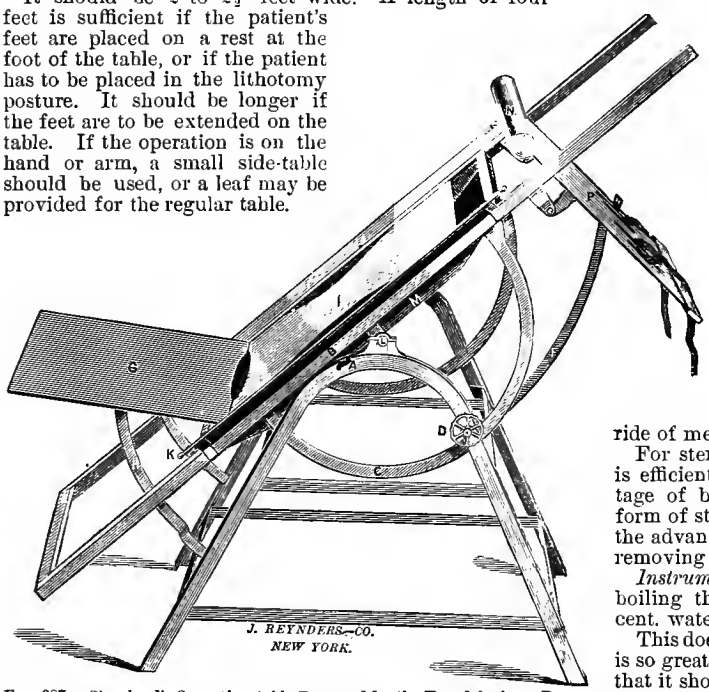


FIG. 687.—Cleveland's Operating-table Prepared for the Trendelenburg Posture.

If Trendelenburg's posture is to be used, an especial table or appliance is necessary. Cleveland's table is the most complete.

A table of glass and iron is the best for a regular operating-room, as it can be easily washed. In any case, contact between the table and operator should be prevented by sterile sheets or towels. Kelly's pads provide drainage for fluids.

Towels.—Sterilized towels are very extensively used in surgical operations. Two or three dozen good-sized ones are not too many for such an operation as the removal of the breast and axillary contents. They should cover the patient's blankets from the feet up. They should be placed about the field of operation so as to protect implements and hands from contact with any unsterilized substance, and these should be removed from time to time. The ether cone should be covered with one. They should be pinned in front of the surgeon's gowns. They should cover the tables, and they should be used to cover the hands when it is necessary to lift or move any unsterilized object, such as a dressing-case or the cautery. The irrigators, the bowls for solutions, etc., should be enveloped in them. Their use in all these instances is a very great safeguard against infection.

The questions arise, When is a towel aseptic? What are the best methods for making it so? Behring made a study of the sterilizing effect of the methods which are used in the laundry. A common method of washing linen articles is to put them into hot water which contains about $1\frac{4}{10}$ per cent. of washing soda. If this is raised to a temperature of 175° to 185° F. its germicidal power is very great. He found that at 185° F. anthrax spores were killed with certainty in from eight to ten minutes, and that they were frequently killed in four minutes. Since anthrax spores are far more resistant to germicides than the ordinary pyogenic bacteria, we may feel that all towels or pieces of linen which are subjected to immersion in this hot soda solution for ten or fifteen minutes are sterilized by it. They may, however, become infected later; and again, we can never feel certain that all the towels go through this process. Some may not get into the hot solution at all, and in some laundries the washing of towels consists in dipping them in hot water and hastily scrubbing them on a washboard for a few seconds or minutes. Hence, in addition to the laundering, towels should be boiled in the operating-room five to ten minutes, or steamed in a steam sterilizer fifteen to twenty minutes, or submerged in a warm 1 to 1,000 solution of bichloride of mercury for half an hour or more.

For sterilizing by steam, Arnold's steam sterilizer is efficient in nearly every instance; it has the advantage of being cheap. A more expensive but better form of sterilizer is that shown in the cut, which has the advantage of drying the sterilized objects without removing them.

Instruments. — Instruments are best sterilized by boiling them for five to fifteen minutes in one per cent. watery solution of washing soda.

This does not admit of much discussion; the method is so great an improvement on the ones formerly used that it should be universally adopted. It is somewhat amusing that, after all the years of study that have been given to the preparation of surgical instruments, and the thousands of instruments which have been

FIG. 688.—Cleveland's Operating-table, with Patient in the Trendelenburg Posture.

ruined by steam and strong chemical solutions, we should at last find that our best instruments are best treated just as our washerwoman treats our clothes. Davidsohn im-

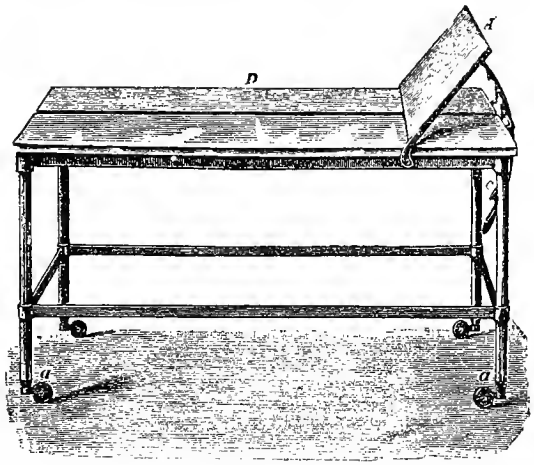


FIG. 689.—Plain Glass and Iron Operating-table. The head-rest is unnecessary.

pregnated threads with anthrax spores and put them into a little hole in a piece of lead, and boiled it all for five minutes in water; it was sterile. He then repeated the

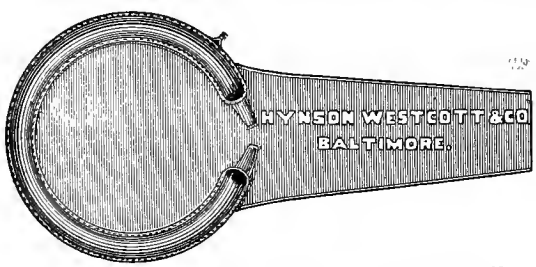


FIG. 690.—Kelly's Pad or Surgical Cushion. See also cut No. 685.

experiment and used pus and pyogenic bacteria, and put them into instruments, catheters, syringes, etc., as well. He found that after five minutes' boiling sterilization was regularly complete. Schimmelbusch continued the

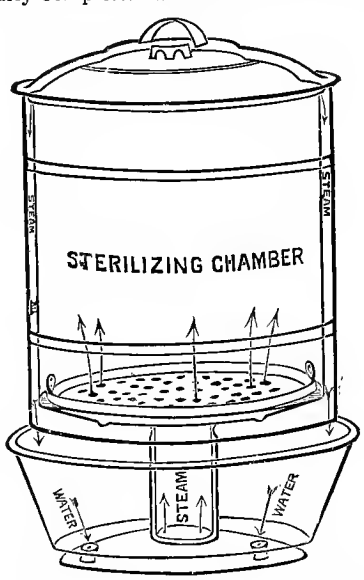


FIG. 691.—Arnold's Steam Sterilizer, Showing the Course of the Steam.

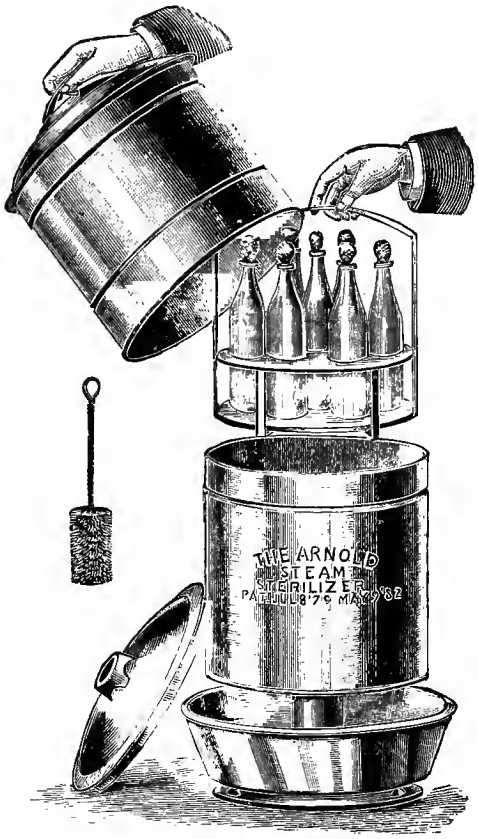


FIG. 692.—Arnold's Steam Sterilizer.

studies, adding one per cent. of washing soda to the water. He impregnated silk threads and thick woollen

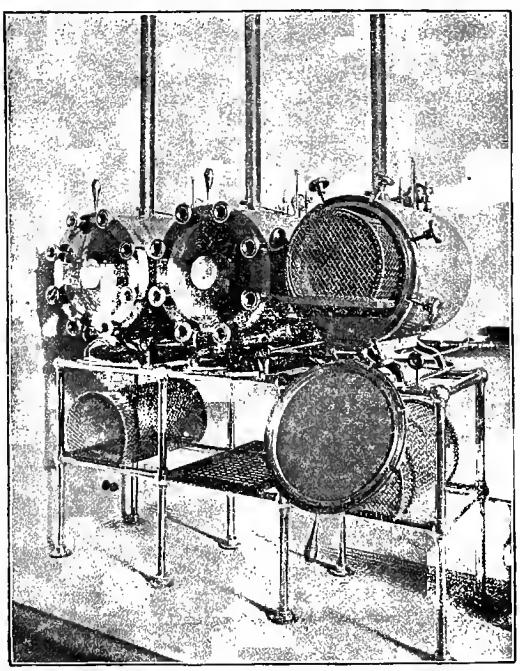


FIG. 693.—Sterilizers for Sterilizing Dressings by Steam under Pressure and Drying them without Removing them from the Sterilizer. Syms's Operating Theatre of Roosevelt Hospital, New York City.

threads with pus and pure cultures of staphylococcus pyogenes aureus, bacillus pyocyaneus, and anthrax spores, and then dipped them for varying lengths of time in the boiling one per cent. soda solution. He found that the pus, the staphylococci, and the bacillus pyocyaneus were killed in from two to three seconds, and the anthrax spores in two minutes.

Thus we see that in the boiling soda solution we have one of our strongest germicides. The method has been very extensively and satisfactorily used since the publication of Schimmelbusch's article in 1891. It has the very great advantage that it prevents rust. Instruments which are regularly cleaned in this way, and kept in a dry place when not in use, are almost as bright as new. This is important, as surfaces which are made uneven by rust are apt to harbor bacteria. Repeated boiling in soda solution injures wooden-handled instruments.

The method is remarkably convenient, as in every household there is water, a stove, and washing soda, or some alkaline washing compound which is equivalent to it. If need be, the instruments may be immersed in this soda solution in an ordinary covered pan, and then boiled on the stove for five or ten minutes. All may then be removed from the stove and allowed to cool while the other preparations for the operation are going on. The instruments may be used directly from this solution without being transferred to any other pan.

For regular use, however, a sterilizer should be constructed in which the solution may be kept boiling during the operation, so that it will be possible to sterilize any instrument which has not been prepared, or which has come in contact with an unsterilized object. Agate-ware asparagus boilers or fish-kettles make very good sterilizers (see Figs. 694 and 695). The asparagus boilers are $10\frac{3}{4} \times 7\frac{1}{4} \times 6\frac{1}{2}$ inches in size, and hold any of the ordinary instruments and enough of them for an ordinary operation. Each contains a movable tray upon which the instruments may be transferred to an instrument-pan, which should contain sterilized water. These boilers are so small that they may easily be carried in a hand-satchel. They may be packed full of implements, and hence do not use up a great deal of space. They, or something which takes their place, may be used to advantage in all operations and in every surgeon's office. The instruments may be held in a bag or towel if there are too many of them to be lifted on the tray without falling off.

FIG. 694.—Agate ware Asparagus Boiler for Sterilizing Instruments.

FIG. 695.—Agate-ware Fish-kettle for Sterilizing Instruments.

Knives are somewhat dulled by this boiling in soda solution. Schimmelbusch recommends the following method of sterilizing them: They should be smooth and have metal handles. They should be thoroughly rubbed with sterilized gauze soaked in alcohol or ether; after they seem to be thoroughly cleaned they may be dipped in the boiling soda solution for a few seconds. This is sufficient to kill the ordinary pyogenic bacteria. It seems to me to be an advantage to precede this dipping in soda solution by a preliminary boiling of the handles for five minutes in the same solution. This may be accomplished by standing the knives in a wire rack, so that the blades may project from the solution. The blades are not materially dulled by this preliminary boiling. By this method the pyogenic bacteria are killed. It will not kill the more resistant germs, such as anthrax spores, but it is not at all likely that such spores will exist on instruments so prepared.

All instruments should be of as simple construction as possible, and should have metal handles. Locks which allow the two parts of forceps-like instruments to be separated are desirable.

Syringes.—Syringes should be sterilized by boiling them in water or soda solution when possible. Schimmelbusch infected hypodermic syringes by drawing into them pus and cultures of staphylococcus pyogenes aureus and bacillus pyocyaneus, and then experimented with different ways of sterilizing them. He found that after boiling water had been drawn in and expelled five times they were germ-free. After drawing in and expelling three per cent. carbolic solution ten times, he obtained more than five thousand bacteria from them.

Sutures and Ligatures.—For sutures and ligatures five substances are in common use: Silk, silk-worm-gut, silver wire, horse-hair, and catgut.

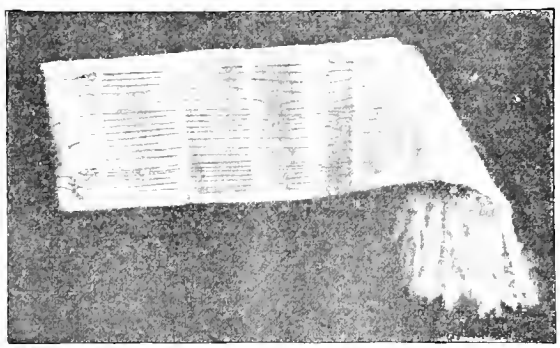


FIG. 696.—Needles and Thread for Intestinal Sutures, Fastened in a Towel, Ready for Sterilization.

Silk is used for skin and intestinal sutures, and for ligatures where there are distinct pedicles, as in ovariotomies, and by some surgeons it is also used for the ligation of blood-vessels, large and small. Its advantages are that it is easily sterilized, is very pliable, and it will not slip after it has been properly applied and knotted. Its great disadvantage is that it easily becomes infected in the wound, and then is a source of great irritation. Stitch-hole abscesses are more common with silk sutures than with sutures of a hard substance like silk-worm-gut, and on examination it has been found that they more frequently contain bacteria.

As long ago as when Marion Sims was working over vesico-vaginal fistulæ, he found that he could close fistulæ with silver-wire sutures which he could not close with silk ones. The abdominal sinuses which sometimes remain after laparotomies are usually due to infected silk ligatures, and after the ligature comes away the sinus closes. Silk may be sterilized by boiling in one per cent. soda solution five to ten minutes, or by being steamed in a sterilizer fifteen to thirty minutes. This may be well done on bobbins in tubes; the silk will remain sterile so long as it is left in the tubes, if the cotton plugs are left in. In preparing fine silk for intestine work, it should be threaded before it is sterilized, and then arranged on towels and boiled with the instruments, or steamed with the dressings. It is always better to prepare the silk, so far as possible, for each operation, and not to subject it to the dangers of infection which come from keeping a large reel of it and using pieces of it from time to time. It may, however, be kept permanently sterile on small bobbins in cotton-plugged test-tubes which have been sterilized by steam.

Silk-worm-gut is an excellent material for skin sutures and is coming more and more into favor. It is hard and smooth, and hence is free from little crevices and meshes

which harbor discharges and favor bacterial growth. It is easily tied and easily prepared. Wounds sewed with it heal more kindly than those sewed with silk. It may be sterilized by steam in cotton-plugged test-tubes and kept ready for use, or it may still better be boiled with the instruments in the soda solution.

Silver wire is unirritating, just as the silk-worm-gut is. It is used of a larger size than the silk-worm-gut, and can be tightened by twisting and shaped by binding. This is an advantage in such operations as trachelorrhaphy, and its strength is an advantage in closing abdominal wounds. It should be sterilized in boiling soda solution with the instruments.

Horse-hair is also unirritating, as are silver wire and silk-worm-gut, and is so small that it is well adapted to the sewing up of small skin incisions, especially about the face where a scar is to be avoided. It should be selected from the back of a horse's tail, where it has come in contact with neither fæces nor urine. It should be washed in soap and water and then boiled in strong alcohol for an hour.

Catgut is not well fitted for skin sutures; as it becomes disintegrated it favors bacterial growth. It is, however, the ligature material which is most generally used both for the small vessels which are clamped and tied in ordinary operations, and for large vessels. Some operators use it for the tying of the large pedicles of tumors as well. Catgut is absorbed in the tissues. The length of time which this takes varies widely. When catgut stitches are taken in the skin they usually come away in about a week, but bits of hardened catgut have sometimes been found in the tissues months after operation. The proper preparation of catgut is a problem which has long puzzled surgeons. Few are willing to use the gut which is sold already prepared in the shops. The general feeling is that its preparation should only be intrusted to those who have had a regular training in aseptic and antiseptic methods, and who have a personal responsibility for the welfare of the patients. Furthermore, sterilization by immersion in chemical solutions is coming into much disfavor. Heat, or heat and chemical action combined, are found to be more convenient and more efficacious in almost all instances. Catgut, however, can neither be boiled in water nor exposed to steam without being rendered useless, and the suitable application of dry heat is difficult.

Dr. George R. Fowler, of Brooklyn, has found that if catgut is boiled in strong alcohol it is sterilized, and is stronger than that prepared by chemicals. The boiling-point of the alcohol used was 175° F. This heat, together with the action of the alcohol, sterilizes the gut in an hour or less.

Dr. Hodenpyl made a series of experiments to test the efficacy of this method, and obtained the following results: Unsterilized catgut regularly contained bacteria. Commercial catgut is generally sterilized by five minutes' boiling in strong alcohol; it was always sterile after an hour's boiling. Catgut impregnated with streptococcus pyogenes, staphylococcus pyogenes aureus, and the anthrax bacillus, was sterilized in fifteen to thirty minutes, and that impregnated with anthrax spores in forty-five minutes, by boiling in strong alcohol. These experiments gave scientific proof of the germicidal power of boiling alcohol.

For the purpose of adding further evidence on the subject, I repeated Hodenpyl's experiments with gut which was impregnated with pus which was a pure culture of streptococcus pyogenes, and pus which also contained staphylococcus pyogenes aureus, and I obtained similar results.

Catgut which has been boiled for an hour in alcohol is considered aseptic, and has been much used since the publishing of Dr. Fowler's article. His method, or some slight modification of it, has been satisfactorily employed, for times varying from two years to a few months, in St. Luke's Hospital, Roosevelt Hospital (Out-patient Department), and the Cancer Hospital in this city, in some of the Brooklyn hospitals, and by many surgeons in their private work. The only valid objection made to it, so far as I know, is the difficulty in preventing the undue evaporation of alcohol. If it is boiled in an open jar, or one with the cover a little raised, the evaporation is so rapid that the alcohol is wasted and the gut becomes uncovered unless carefully watched. If the cover of the jar is tightly screwed down we may hope that the alcohol will boil at 175° F. to 177° F., and that not more than one-fifth of its volume will evaporate in an hour's boiling. Such a result will usually follow, and the catgut may be efficiently prepared in this way. A cold object, such as an ice-bag on the top of the jar, aids in the recondensing of the alcohol. This method, however, has serious objections: On the one hand, the leakage may be more than one-fifth of the alcohol; on the other, the jar may be so tightly sealed as to allow the alcohol to rise to 195° F. or 200° F., and the gut is rendered useless by an hour's exposure to this temperature. It is far better to boil the alcohol under ordinary atmospheric pressure, and then recondense it. This gives a constant temperature and very little liability to mishap. Hence, very small-sized gut may be used with the knowledge that it will be strong after the preparation.

The accompanying apparatus is the simplest I have yet seen: A condenser (Fig. 697) is made by encasing a coil of block-tin tubing in a cylinder of sheet copper. The height of the cylinder is seven inches; its diameter three and one-half inches. The length of the tubing over all is four feet; its internal diameter, one-eighth inch. A piece of the tubing, five inches in length, projects from the top of the cylinder, and is shaped into a hook. A straight piece, two inches in length, projects from the bottom. The condenser may be suspended by this upper hook, or may rest on a retort-stand or tripod. Two taps are inserted into the cylinder for the transmission of water in and out. The lower one is attached by rubber tubing to a faucet for running water, the upper one is fitted with a rubber tube to provide for the escape of the water. Where running water is not convenient the cylinder may simply be filled with cold water, and that will suffice for recondensing the alcohol evaporated in an hour's boiling. The catgut is put into alcohol in such a jar or bottle as is convenient. The piece of block-tin tubing at the bottom of the condenser is fitted into a perforation in the cork of this bottle or jar. A water-bath is made by placing a small basin of water on a gas-stove or over a Bunsen burner. The apparatus should be so placed that the jar which contains the alcohol is partly immersed in the water (Fig. 698). Heat is then applied to the water-bath until the alcohol boils. It may be kept boiling as long as is desired, without especial attention and with no loss of alcohol, since it is recondensed as fast as it is vaporized and drops back into the bottle. The capacity of the condenser is such that the vapor from a quart of alcohol is condensed as rapidly as it is produced by ordinary boiling. It is not necessary to boil the water or the alcohol so vigorously as to force it through the condenser. The alcohol after an hour's boil-

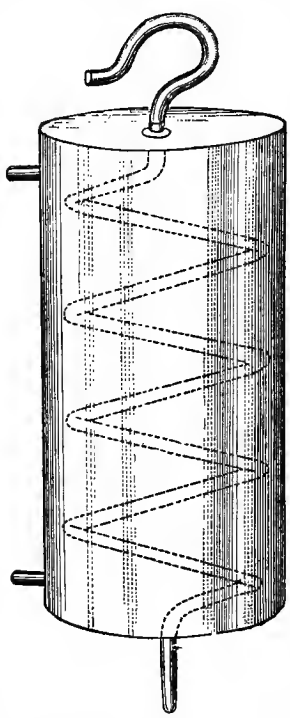


FIG. 697.—Condenser for Recondensing the Alcohol Evaporated in the Sterilizing of Catgut.

ing and recondensing shows no trace of either tin or lead from the tubing. A bit of absorbent cotton should be inserted in the upper end of the tubing.

The apparatus may be obtained from the W. F. Ford Surgical Instrument Co., Thirty-second Street and Fifth Avenue, New York City.

This method puts within the reach of every surgeon an easy and efficient way of obtaiuing catgut which is aseptic, and which is pliable and strong. For the ligation of the smaller vessels, such as are tied in an ordinary operation, gut No. 00, about the size of spool cotton No. 10, is strong enough. For such vessels as the anterior tibial the diameter of the gut should be about twice as great. It is believed that boiling alcohol is much more efficient than any chemical antiseptic solution which weakens the catgut so little.

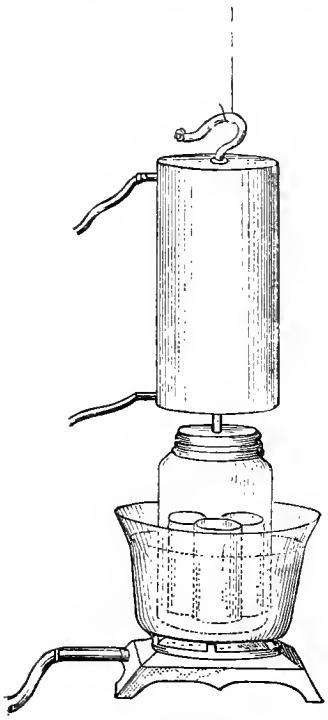


FIG. 698.—Apparatus for Sterilizing Catgut.

Oil or fat is a great protection against the action of chemical solutions. Catgut is regularly greasy before it has been bleached, and in the process of twisting it much of the greasy surface is turned into the interior of the strand. It is thus particularly difficult to destroy the life of the bacteria or spores which are carried within the strand in the twisting, and are there more or less protected by fatty matter. Boiling alcohol is a strong solvent of fatty matter, and is thus especially well fitted to penetrate the small crevices in the catgut, and so to bring the germicidal action of the heat and the alcohol to bear on all contained bacteria and spores. Heated liquids seem to have remarkable germicidal power, as has been already indicated. If we turn to the table on page 1041 we shall see how great a sterilizing power liquids have when heated to 175° F.

Judging from the results expressed in the table, we would expect that the ordinary pyogenic bacteria would be killed in boiling alcohol in five or ten minutes, anthrax spores in about half an hour. This corresponds well with Hodenpyl's results. Hodenpyl used ninety-seven per cent. alcohol with a boiling-point of 175° F. I have found that the boiling-point of the ninety-five per cent. alcohol obtained from a reliable druggist is about a degree higher. The more water there is in the alcohol the higher is the boiling-point, the greater the germicidal power when boiling, and the greater the injury done to the catgut by the process.

Although, according to Fränkel, anthrax spores are considered the most resistant of infective agents, it is important that the medium which is used for sterilizing the catgut should be capable of killing them, since there is always a possibility that they may exist in the sheep's intestine, from which the so-called catgut is prepared. Volkmann has reported two cases where anthrax pustules appeared in wounds at the points where catgut sutures were taken. He thought the infection due to the catgut.

Another advantage in this method of boiling in alcohol comes from the ease with which infection of the catgut may be prevented after it is once sterilized. Professor Halsted has devised an excellent method of sterilizing his silk ligatures and sutures, on bobbins in test-tubes, and using them one by one as needed. A somewhat similar device may be used for catgut. Glass reels are made, each half an inch long, with flanges one inch in diameter, which are so shaped that the ends of the reels are concave. Two or three yards of gut can be wound on each without overlapping enough to prevent the free access of the alcohol. Three of them fit, one above the other, in a small cylindrical screw-topped jar. Rubber washers are fitted into the covers of these jars, and they, containing reels of catgut, filled with alcohol, and having the caps screwed on, are put, four at a time, in a quart Mason preserve-jar. The jar is then three-fourths filled with alcohol, attached to the condenser, and put in the water-bath. After an hour's boiling the small jars are taken out and their caps tightened. Each reel may be taken from the jar as it is needed. The surgeon holds it in his left hand and unrolls the gut as he ties the ligatures. It unrolls easily if the reel is held loosely between the thumb and third finger so that the nails are in contact with its concave ends. The flange protects the gut from contact with any foreign substance until it is unwound. Thus, from the time the gut is sterilized until it is applied in the wound the only foreign substance which it touches is the hand of the surgeon. It is not exposed to infection from contact with perforated stoppers, necks of bottles, scissors, forceps, towels, gowns, hands of assistants, etc. That which remains in the jar has not been disturbed. It is not difficult to tie the ligatures with the reel in the hand, if the hands are crossed in tightening either the first or the second half of the knot.

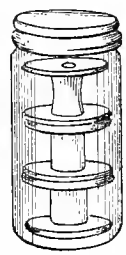


FIG. 699.—Small Jar Containing Reels for Sterilized Catgut.

Catgut may be efficiently prepared in other ways. In von Bergmann's clinic, in Berlin, the following method is used:

1. Sterilization of the glass dish which is to hold the gut, for three-quarters of an hour in steam.
2. Winding of the gut on glass spools or plates.
3. Cover the gut with ether and let it stand for twenty-four hours.
4. Pour off ether and pour on the following solution:

Bichloride of mercury	10 parts.
Absolute alcohol	800 parts.
Distilled water	200 parts.

5. Renewal of the sublimate alcohol daily; after the second renewal sterilization is complete.
6. Exchange the sublimate alcohol for ordinary alcohol. If twenty per cent. of glycerine is put in this last alcohol the gut is hardened.

For such operations as Hegar's perineorrhaphy and Bassini's operation for the cure of hernia, a very hard gut which cannot be easily absorbed, is needed. Macewen's chromicized gut is the kind used. It is prepared as follows: Put the gut overnight in the following solution:

℞. Acid chromic	ʒ iij.	ʒ vss.
Aquæ	Oj.	
Then add with care,		
Glycerine	Ov.	
M.		

Store the gut in a five per cent. solution of carbolic acid in glycerine.

Some surgeons do not believe that this sterilizes the gut. It is wise to extract the fatty matter by alcohol and ether before immersing it. The solutions may be used warm.

Drainage-tubes, whether of rubber or glass, should be prepared as the instruments are, by boiling in soda solution. Sponges or wipers of some kind for absorbing the blood or fluid discharges must be used in nearly all operations, and since these come in such close contact with the wound, the greatest care is necessary in their preparation. Sponges absorb the blood more quickly and thoroughly than any other material now in use. The great disadvantage is that they are expensive, and are usually washed by an assistant time and again during the opera-

tion, as they become bloody. This manipulation very materially increases the chances of infection. It furthermore makes additional nurses and assistants necessary. Pads of sterilized absorbent gauze, or little balls of sterilized cotton encased in absorbent gauze, make very

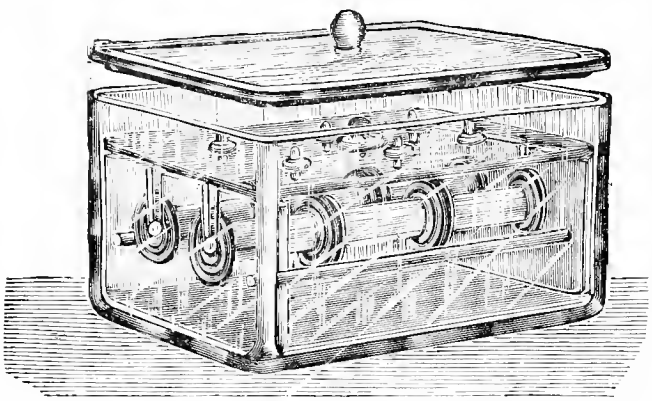


FIG. 700.—Glass Dish for Keeping Catgut in Operating-room in Alcohol.

good wipers. The pads should be made each of a piece of gauze about twelve by twelve inches in size, so folded that the cut edges are all turned into the interior of the pad, so that threads need not be left in the wound. When folded they should be about three inches square. They are encased in a towel or put in cases (see Fig. 701), and sterilized in steam by an exposure of from thirty to sixty minutes. They should be placed within the reach of the surgeon and his assistants, and should come in contact with absolutely nothing between sterilization and use. Each pad is thrown to the floor after it is used. About two or three dozen are used in such an operation as the removal of a breast and axillary contents. For an amputation of a leg eight or ten may suffice. Richardson and Mumford, of Boston, use these pieces of gauze without folding in the edges, and consider that the threads which come away from the edges are not important. The danger of sepsis is less from these pads than from sponges, but they are not good for the abdominal cavity, because they become so easily doubled up into wads, nor for such operations as the removal of the jaws, where we need something which can be easily managed on holders, and which will absorb blood very rapidly. Sponges should be used for such purposes. There are several methods of preparing them.

The so-called permanganate-of-potash method is one which is much used. The sponges are first thoroughly washed and beaten, and then put into a 1 to 500 solution of potassium permanganate for twenty-four hours. They are then put into a one per cent. solution of hyposulphite of soda, to which eight per cent. of hydrochloric acid is added. They remain here until bleached, and are then washed and transferred to a five per cent. solution of carbolic acid, in which they are kept. Fritsch found that twenty per cent. of the sponges so prepared in Billroth's clinic contained germs.

Kelly prepares his sponges in the following way: Some of the handier ones are carefully washed in many waters, until the water is no longer discolored. Then, after immersing them for twenty-four hours in a weak solution of hydrochloric acid, two drachms to the pint, to dissolve out the chalky particles, they are put in the sterilizer for twenty minutes. But few sponges will stand this, however. The usual method is to transfer them from the hydrochloric solution to distilled water, in which they are washed until the water remains clean. They are next immersed in a 1 to 1,000 bichloride solution for twelve hours. They are taken from this and rinsed in warm distilled water, and then put in large lots in big jars in a three per cent. solution of carbolic acid. It is particularly unfortunate that sponges cannot be boiled in water or steamed long without becoming hard and shrunken.

Schimmelbusch recommends the following method: The sponges should be beaten and washed and kneaded several times, in both cold and warm water, to clear away the sand, shells, and dirt. They should then be pressed together in a linen cloth, or in a bag made for the purpose, and put into a large pot of boiling one per cent. soda solution which has just previously been taken from the stove. They should remain immersed in this solution half an hour. The heat of this gradually cooling solution is not sufficient to injure the sponges materially. It is, however, enough to sterilize them, according to the investigations of Behring, Freeman, and Van Geuns. Schimmelbusch found that sponges that were saturated with anthrax spores and with pus were sterile after ten minutes' immersion in this hot soda solution. They may be transferred to boiled cooled water in the sack which contains them, to be freed from the soda, and then be kept in an antiseptic solution—preferably corrosive sublimate, 1 to 2,000. They turn dark in carbolic solution, also in the sublimate solution, if they have been previously treated with sulphuric acid. The method is simple and has the great advantage that there is little handling of the sponges after the process of sterilization is really begun.

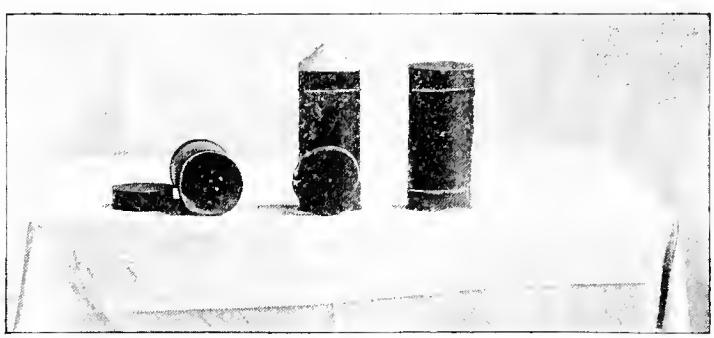


FIG. 702.—Metal Cylinders for Holding Sterilized Gauze and Cotton.

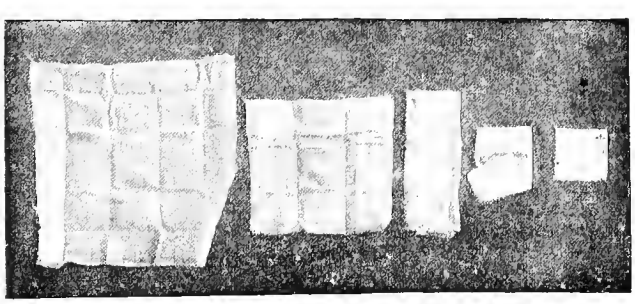


FIG. 701.—Absorbent Pad (a substitute for sponges). The figure at the right shows a gauze pad folded in readiness for absorbing the blood in a wound. The other figures show the stages of folding.

Dressings. — Surgical dressings are becoming more and more simple all the time. Absorbent gauze is the material most used. The requirements of a good dressing are that it shall protect the wound without irritating it; that it shall absorb discharges, and that it shall prevent bacterial growth. Sterilized gauze combines these qualities to a remarkable degree. The commercial name of the gauze is butter-cloth. It is a bleached

cheese-cloth. It should be so absorbent that a bit of it thrown on water will sink immediately; and if one end of a little twist of it is dipped in a glass of water and the other end allowed to hang over the edge of the glass, the water should drip from the hanging end. A strip of gauze 1½ by 8 inches should in this way lower the level of the water in a tumbler 1½ inch in half an hour. This gauze is best prepared by steaming for forty-five minutes or more in a sterilizer. After sterilization it should come in contact with no object until it is used. A convenient method is to have some cylindrical boxes made (see Fig. 702), 4 inches in diameter and about 10 inches long; the bottom is raised and is perforated to facilitate the access of the steam to the gauze. A layer of absorbent cotton is put on the bottom of the box, a roll of gauze above this, and again a layer of cotton above the gauze. The box is uncovered in the sterilizer, but the cover should be sterilized with the rest and applied after the box is taken from the sterilizer. The gauze dries if the box is put near a Bunsen flame or a gas-stove. It is, however, not very moist at any time. Enough gauze can be put in one of these to cover any ordinary wound. They can be carried easily to the hospital wards or to the house of a patient without contaminating the gauze. An ordinary glass fruit-jar makes also a very good receptacle for sterilizing the gauze and carrying it about. This gauze may be used for our inside dressing. It meets our first requirement, it protects the wound without irritating it. Its absorbing power is great, and hence it meets our second requisite of a good dressing.

Does it fulfil the third? Does it prevent bacterial growth? Yes, to a very marked degree so long as it is dry. If the discharge from the wound is so great as to saturate the dressing and keep it wet, the absorbent gauze is not germicidal; if, however, it absorbs the discharge and quickly dries it, bacterial growth is prevented, since dryness is one of the greatest inhibitors of bacterial development. Schimmelbusch states that "there is no agent which hinders decomposition of the wound secretion in a dressing more simply, harmlessly, and promptly than does dryness, the evaporation of the products of secretion." "Moisture is the peculiar life-principle of the lower organisms, dryness their greatest foe." Schlange demonstrated by experiments how rapidly the drying of gauze stopped bacterial growth in it. He saturated pieces of sterile gauze with nutrient bouillon and infected them on the surface with the green pus fungus. The impregnated pieces of gauze were laid in glass dishes. When the dishes were uncovered so that evaporation was free, there was little growth of the mould. When these dishes were covered so that evaporation was hindered, the bacillus grew rapidly, and soon the green color extended all over the piece of gauze. If the green growth was allowed to extend about half an inch and the dish was then left uncovered, in a short time the dryness of the gauze prevented further growth.

In von Bergmann's clinic, in Berlin, these sterilized dressings have been used for years with great satisfaction. They have also been used in numerous hospitals and by many surgeons in this country and abroad. I have found that wounds in which there was a slight discharge healed more quickly under them than under dressings which are saturated with chemical germicides. If these germicides are strong enough to stop bacterial growth, they are injurious to the tissues about the wound. Certain classes of wounds, such as incisions for spreading cellulitis, need wet dressings, and for these simple sterilized gauze is not suitable. But for fresh wounds, which have no inflammation of the cellular tissue about them, it seems to be the dressing *par excellence*.

Those wounds in which there is a thick purulent discharge which cannot be absorbed by the gauze do not do well under simple sterilized dressings. The thick pus stays about the opening of the wound, and retards its rapid healing. For such wounds as this, iodoform gauze is the most suitable dressing. Iodoform has held its place in surgery in spite of all the attacks which have been made upon it. Its best use seems to be in those cases where there is a purulent discharge. The iodoform in combination with such a discharge gives up its iodine and so prevents excessive putrefaction. There are many fallacies about iodoform gauze as it is frequently used. It is exposed to all sorts of infection in the progress of preparation, and frequently becomes contaminated in the holders in which it is kept. It seems hardly rational to put in close contact with fresh wounds gauze which has been handled in a careless way by druggists' clerks, and which has perhaps been hung on clothes-lines to allow the evaporation of the benzine. The gauze, after it is prepared, cannot be sterilized by steam or heat without largely decomposing the iodoform.

The iodoform gauze should be prepared by the surgeon or his assistant by moistening sterilized gauze with boiled water, and then rubbing dry powdered iodoform into it, on a sterilized cloth, with a sterilized piece of gauze or roller bandage. It should not be prepared from a solution of iodoform in ether, for the iodoform is then easily decomposed; nor should an emulsion of glycerine be used, since the glycerine diminishes the absorbing power of the gauze. Sterilized absorbent cotton prepared like the gauze is usually put outside of it to protect it from contamination, and to absorb any fluid which may come through the gauze. Bandages of gauze or mull should be sterilized in steam. Those of muslin, crinoline, or plaster, need not be sterilized, as they are applied at a distance from the wound.

A protective dressing of rubber tissue is frequently applied immediately over wounds to protect healing tissues from mechanical violence. This is best sterilized by immersion in a 1 to 1,000 sublimate solution for several hours. It should be dried before application.

There are numerous other substances which have been used in surgical dressings, but the surgeon need seldom use any which are not mentioned above.

In applying the dressing enough should be put on to cover the wound thoroughly and protect it from any possible external infection. Usually pressure over the wound and restriction of motion about it should be obtained. The putting on of an insufficient dressing is a very common mistake.

The accompanying cuts show neck and breast bandages in position.

FIG. 703.—Dressing Applied after the Removal of a Tumor of the Neck. New York Cancer Hospital.

Solutions should be prepared from water which has been boiled. It is an advantage to have it filtered before the boiling. It should not be exposed to any sources of infection after the boiling. The simplest method is to boil the water in flasks which are plugged with cotton, and which are not opened until the time of operation. Where large quantities of water are needed, an apparatus is made by which the water may be boiled and then cooled by running cold water through a coil of pipe which is in the boiler. Since solutions of weak antiseptic power are so much in vogue, it is eminently unsuita-

ble to expose them to dangers of infection by transferring them into various receptacles, or by cooling them, or diluting them with unsterilized water.

Dishes.—Dishes which are used in the operating-room should all be sterilized. This is best done by boiling them in soda solution. If this is inexpedient, they should be put in a pot or pail of hot soda solution, as the sponges are. If this cannot be done, they may be thoroughly washed and then filled with hot 1 to 100 sublimate solution which should be left in half an hour or more. Any adherent sublimate may be washed away in hot water.

FIG. 704.—Dressing Applied after Removal of Breast and Axillary Contents. (Schimmelbusch.)

In the final preparation for an operation one may frequently wish to be delivered from one's friends. It is astonishing how often medical men come to the operation and wish to grasp the hands which have just been sterilized with so great care, or to touch the patient or implements about the room. The density of ignorance which these men show is well illustrated by the rejoinder of an attending physician in a neighboring town, who, when warned away from the patient by the consulting surgeon, exclaimed that he was not afraid, as he had never received any injury from touching either the patient or instruments ! ! !

It is clearly one's duty, unpleasant though it be, to prevent this form of contamination. Throughout these preparations cleanliness is the one underlying principle. If we can keep everything surgically clean, our wounds will heal quickly and kindly. It is far better to do this than to allow infection and then attempt to remove it by strong chemical solutions which injure the tissues and diminish their power of repair.

When operations are to be done in private houses, it often becomes a question as to how these somewhat bulky appliances are to be made portable. The accompanying cut shows an arrangement of instruments and implements which would avail for such an operation as the amputation of a leg.

1 2 3 4 5
6 7 8
9, 10, 11, 12, 13, 14, 15, 16, 17, 18,
19.

FIG. 706.—Appliances to be Packed in Satchel for an Operation such as the Amputation of the Leg.

1. Cylinder containing sterilized gauze for dressing.
2. Cylinder containing sterilized cotton for dressing.
3. Cylinder containing sterilized pads for absorbing blood from wound.
4. Jar of sponges (probably not to be used).
5. Gown for operator.
6. Roller bandages.
7. Rubber adhesive plaster.
8. Esmarch bandage.
9. Tablets of corrosive sublimate.
10. Catgut ligatures.
11. Catgut ligatures.
12. Sterilized silk.
13. Safety-pins.
14. Silk-worm-gut (sterilized).
15. Carbonate of soda for boiling instruments.
16. Sterilized drainage-tubes.
17. Iodoform gauze (probably not to be used).
18. Instruments contained in roll.
19. Needles.

Dishes and a boiler for the instruments may be supplied at the house or may be sent by the surgeon.

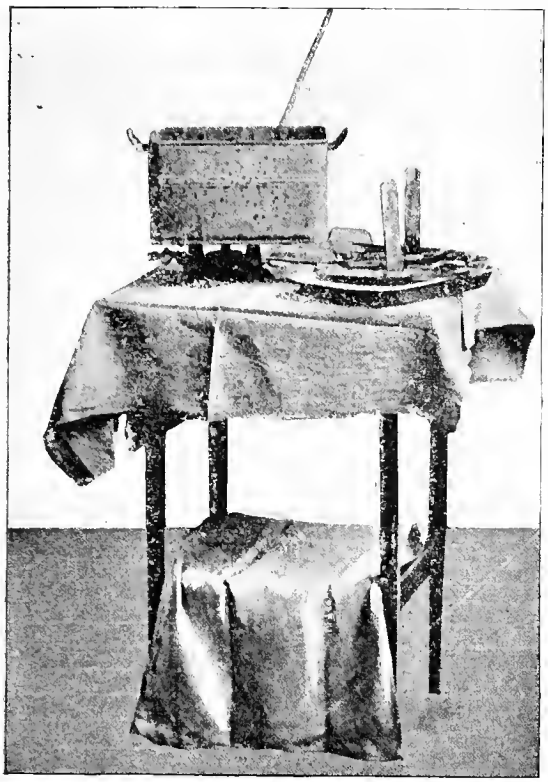
Fig. 706 shows a convenient arrangement.

FIG. 705.—Cotton-plugged Flasks of Sterilized Water.

II. THE OPERATION ITSELF.

The operation itself calls for as great care as do the preparations. By following out the rules which have been given, the operation may be begun in aseptic *régime*. One great difference between the preparation for the operation and the conducting of the operation is, that the former may usually be done leisurely, while the latter must frequently be done hurriedly, and by some unguarded action sepsis creeps in. Hence, in planning our operative technique we should endeavor to have our sterilized implements untouched between the time of sterilization and the time of their use in the wound. Our catgut, our gauze pads, some of our instruments, and some of our sutures need touch no object between the time of sterilization and their use in the surgeon's hands. The principles which make this possible should be applied wherever they can be. The fewer hands which go into the wound, the better. The fewer hands which touch the instruments or implements, the better. The greater the extent to which assistants can learn to retract tissues

and make it easy for one man to do the actual cutting, clamping, and tying, the fewer are the chances of infection. Infection often creeps in during the operation,



1 2
3

FIG. 707.—1. Instrument boiler with its tray removed, containing the instruments which are to be transferred to 2, Instrument pan. 3. Portable gas-stove.

owing to unguarded contact with objects which have not been sterilized.

No new principles are to be considered in this regard. Those already laid down, however, are to be followed with the strictest care. If, for instance, an instrument is to be taken from the case and used, a sterilized towel should be put over the hand and the instrument transferred to the boiling soda solution, where it is sterilized before using. I once took from an instrument-case a pair of artery clamps which had been carefully washed and put away. I have reason to believe that they were as clean as instruments usually are in an instrument-case; yet when they were covered with nutrient gelatine about fifteen hundred bacterial colonies grew from them. If such forceps were handled by assistants or by the operator, a large avenue of infection would evidently be opened. In the same way a cautery, unsterilized dressing-boxes, ether bottles, etc., must on no account be touched by the operator or an assistant who handles instruments or sponges. If such implements are to be used, a sterilized towel or pad must be put over the hand. Towels so used should be thrown to the floor and not handled again. Instruments which fall to the floor are manifestly unfit for use until further sterilization. Warm sublimate solutions should be so placed that the hands may be conveniently washed in them from time to time. Towels should be renewed as they become soiled. Ligatures or sutures should be so short that they need not drag on towels, or unnecessarily come in contact with any foreign body.

It frequently happens in an operation that pus is evacuated, and still it is important to have aseptic conditions following, so far as is possible. For instance, a pustule, an ovarian or perityphlitic abscess is opened in the abdominal cavity; this pus is often virulently infective, and if instruments and sponges are contaminated with it and are then used on the peritoneum and about the abdominal wound, we must fear sloughing of the wound and peritonitis. When pus appears in this way it should be quickly collected on sponges, towels, or gauze, and if the tissues are touched by the pus they should be carefully wiped off, and all instruments, sponges, etc., which have touched the pus should be immediately removed. The instruments should be washed and resterilized if they must be used again; the other things should be thrown aside. All hands should be thoroughly washed again, fresh towels should be put about the patient, and the operation may then be continued as before. The advisability of washing out the abdominal cavity after such an occurrence is a disputed question. The weight of evidence is in favor of washing it out with warm six per cent. sodium chloride solution.

During the operation the surgeon has continually to consider questions apart from the aseptic technique which we have been dwelling upon. We have already stated that there are two opposing forces to be dealt with, viz., 1. The growing power of the bacteria; 2. The repairing power of the system. In the operation it is necessary to consider the second as well as the first.

One must continually give heed to: 1. The proper limitation of the constriction, laceration, and chemical and mechanical injury of the tissues. 2. The management of dead spaces. 3. The use of drainage. 4. Irrigation.

Tissue which is constricted is prone to suppuration far more than that which has a good circulation. Welch reports a case in which there was fatal peritonitis, which started from a volvulus which had become infected with

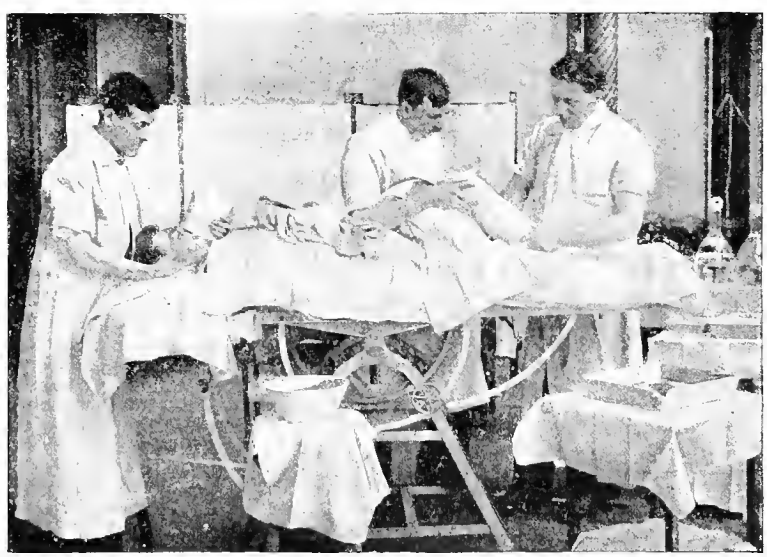


FIG. 708.—Arrangements for Amputation of Leg. (New York Cancer Hospital.) The instruments are in the pan at the right. The ligatures and sutures are on small reels in jars in this pan. Sterilized towels prevent contact with patient's clothing or body. Absorbent pads are in a towel near assistant's right elbow. Basin of sublimate solution for operator's hands is on a stool beside the table. Assistants are in position to hold leg and to sponge and catch bleeding vessels, if necessary. Operator stands at patient's right, beside instrument pan. The jars and flasks in the background are not used in this operation.

staphylococcus epidermis albus. The infective power of this coccus is very slight under ordinary conditions, but the constriction diminished the vitality of the intestine so much that it was unable to withstand the infection of this ordinarily mild bacterium. In a similar way, he found that pieces of potato containing pure cultures of staphylococcus pyogenes aureus produced fatal peritonitis when inserted into the abdominal cavities of rabbits, although they regularly survived the injection of a similar number of these cocci without the potato. The inference is that the mechanical bruising caused by the pieces of potato injured the peritoneum so that it could not withstand the attack of the cocci.

All surgeons have noticed that the portions of a wound which are sewed very tightly, or which are brought together under a strong tension, are more likely to suppurate than those parts which are under less pressure. The undue laceration of a wound, as for instance, scoring of a flap in a Syme's amputation, diminishes the chance of primary healing in the lacerated tissue.

Each particular wound gives its own problems of this nature. Laceration of the tissue in a vascular part, such as the face or scalp, is far less likely to occasion sloughing than it is in a less vascular place, such as the leg or abdominal wall. Patients with a syphilitic taint, or with atheromatous arteries, stand far less laceration than those in a healthy condition.

The Management of Dead Spaces.—There are two methods of dealing with spaces which are made in the tissues. One is, to take buried sutures and in this way draw the tissues together; the other, to allow blood to fill these spaces in the expectation that organization will take place in the clot. The objections to the former method are that the tissues are strangulated, and hence their vitality is greatly impaired, and the large strands of catgut which are used for the buried sutures increase the amount of foreign material in the wound. The other method, the healing under a blood-clot, gives considerable trouble if the clot breaks down and suppuration follows. If, however, the wound is aseptic, some of the most brilliant results in surgery follow.

Schede developed the system and used it extensively for the filling of bony cavities. It has been considerably used since then for the filling of cavities in soft parts. In Phelps's operation for club-foot the gaps between the cut tissues are filled with the blood-clot, and organization should occur there. Halsted has used it with great success. He avoids all laceration or irritation of the tissues, and then allows the cavities to fill with blood. The dressings are left undisturbed for a week or two, sometimes longer. By that time the organization is well advanced in the clot. Acting on this principle he was able to do the remarkable operation of resection of a large aneurism of the first part of the left subclavian artery. He allowed the cavity to fill with blood, in which organization took place, and there was no trouble from sepsis or secondary hemorrhage. So long as it is aseptic, this clot forms a favorable medium in which tissue-formation may take place. It is believed that the tissue-formation takes place in the clot, and not that the clot itself really changes to organized tissue.

The blood-clot method is certainly a good one for those surgeons who are sure of aseptic conditions. But where these conditions do not exist, blood-clots in the wound tend to cause suppuration. Therefore the older surgeons have insisted strenuously on their removal.

This method must be considered one of the refinements of surgery; a very useful one, but one which should be used with caution by those who are not aseptic experts.

Irrigation.—The irrigation of wounds, once so much in use, has now fallen into much disfavor.

It has been practised in the belief that the antiseptic solution used would kill any bacteria which might get into the wound. It has been found that it does not do this, but, on the other hand, it does irritate the tissues and impairs their power of union. In almost all instances it is better to do away with irrigation. The ingress of infection should be prevented, and thus make irrigation unnecessary. Where pus is present irrigation may be used for the mechanical cleansing of the tissues, but not with the idea that it will render the wounds aseptic. I have found that the cultures of the pyogenic bacteria can be made about as easily from wounds which have been irrigated with 1 to 1,000 sublimate solution as from those which have not been irrigated. In the abdominal cavity it sometimes seems wise to irrigate where pus has escaped into the cavity. In such cases a warm six-tenths per cent. sodium chloride solution should be used.

The Drainage of the Wound.—The present tendency is to do away with wound drainage, and we may state that an aseptic wound in a healthy patient need never be drained. The principle of relieving the discharges from a wound and thus diminishing the tension, and carrying away substances which invite suppuration, is certainly a conservative one. Surgeons who are forced to operate under conditions where asepsis is not assured will be wise in using it. It is far better to delay the complete healing for a little time than to risk including septic material in the wound and causing general suppuration. I have known of the fatal termination of a comparatively simple operation, performed by a skilful surgeon, which would have been avoided had drainage been used. I have seen other surgeons of great skill resort to drainage where some occurrences in the operation gave the feeling that asepsis was not complete.

On the other hand, there are many dangers from the use of drainage. One of the greatest of these is that wounds which contain drainage-tubes must be dressed in order to remove the tube, or the discharges which are in or about it. It is far better to leave the dressing undisturbed until healing is complete and the stitches can be removed, than to change it from time to time, and so open new avenues for infection.

Welch has formulated the following objections to the use of the drainage-tubes:

1. They tend to remove bacteria which may get into a wound from the bactericidal influence of the tissues and animal juices.

2. Bacteria may travel by continuous growth or in other ways down the sides of a drainage-tube, and so penetrate into a wound which they otherwise would not enter. We have repeatedly been able to demonstrate this mode of entrance into a wound of the white staphylococcus found so commonly in the epidermis. The danger of leaving any part of a drainage-tube exposed to the air is too evident to require mention.

3. The changing of dressings necessitated by the presence of drainage-tubes increases in proportion to its frequency the chances of accidental infection.

4. The drainage-tube keeps asunder tissues which might otherwise immediately unite.

5. Its presence as a foreign body is an irritant and increases exudation.

6. The withdrawal of tubes left for any considerable time in wounds breaks up forming granulations—a circumstance which both prolongs the process of repair and opens the way for infection. Granulation-tissue is an obstacle to the invasion of pathogenic bacteria from the surface, as has been proven by experiment.

7. After removal of the tube there is left a track prone to suppurate and often slow in healing.

To these Professor Halsted added an eighth:

"That tissues which have been exposed to the drainage-tube are suffering from an insult which more or less impairs their vitality, and hence their ability to destroy or inhibit micro-organisms."

In regard to the question of blood-clot and drainage, we must pay careful attention to two diverse conditions: sepsis and asepsis. Where asepsis exists we can use the blood-clot and can dispense with drainage. Where the condition of the wound or the surroundings of the operation lead us to fear that sepsis is present, it is wise to remove all possible blood from the wound and resort to drainage. As to the material which may be used, perforated rubber or glass tubes are the best. A small opening may sometimes be kept in a wound by inserting a little twist of sterilized or iodoform gauze or rubber tissue.

In doubtful cases a drainage-tube may be put in and removed at the end of forty-eight hours. When this is done primary union need not be prevented. Abscess cavities should be packed with iodoform gauze, allowing the end of the gauze to protrude through the incision. This drains better and irritates the tissues far less than does a piece of hard tubing. Gauze drainage is especially indicated in such abscesses as those incident to appendicitis. These pieces of gauze should not be removed until they are loose in the tissues. The laceration of raw or granulating surfaces is to be avoided.

III. After-Treatment.

The after-treatment should be so conducted as to aid the patient in combating the injuries and to prevent infection. One of the most important features in after-treatment has come with the employment of laxatives. To Mr. Lawson Tait belongs the credit of developing this principle. It is particularly applicable after laparotomies. The former practice was to administer opium and so paralyze the intestines. Mr. Tait pursued the opposite method, and by the use of saline purges endeavored to drain away the serous contents of the abdominal cavity, and so prevent bacterial growth. This treatment is one of the most essential elements in the success of modern abdominal surgery. If the bowels move within two or three days of the operation the laparotomist feels comparatively secure as to the ultimate result. The same principle applies to other surgical operations and to puerperal fever. A purgative diminishes the virulence of infection in almost all cases.

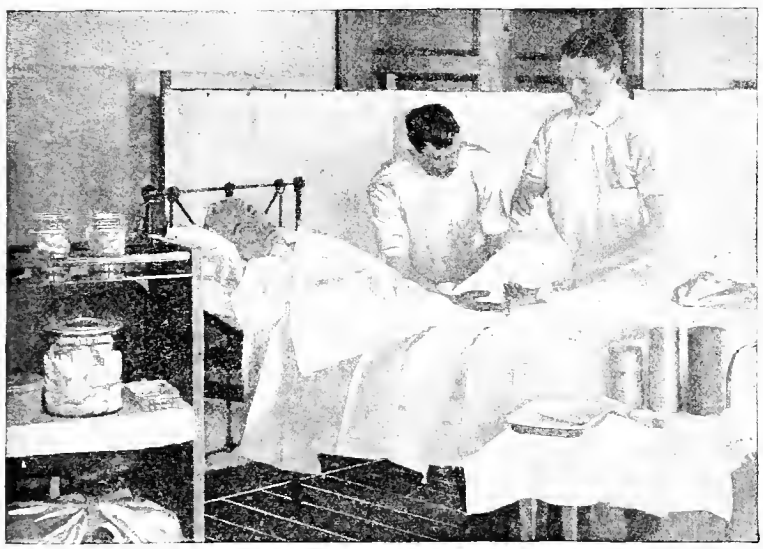


Fig. 709.—First Dressing after Amputation of Leg. (New York Cancer Hospital.) Bed covered with sterilized towels, upon which is a folded towel containing absorbent pads. On stand are placed sterilized dressings in cylinders; scissors and forceps in instrument jam; roll of rubber adhesive plaster. The dressing-case at the head of the bed is not used in this dressing. The surgeon who does the dressing stands at the right of the bed and removes the inner dressing after the outer one has been removed by the assistant.

After-dressing of wounds within a week of the operation should be avoided if practicable. If it is necessary, as for instance, for the removal of a drainage-tube, it should be conducted with all the aseptic precautions which are used in the operation itself. Sterilized towels should be so placed as to prevent any septic contact. Such instruments as are used should be boiled and brought to the surgeon in the dish and solution in which boiling takes place. The surgeon and assistants should cleanse their hands as at the beginning of the operation. The dressing which is to be applied should be sterilized and brought to the bedside either in the sterilizer or in the dressing-cases which have been described above. The outside dressing should be cut away by an assistant. This assistant, and the shears he has used, must then be considered septic until further cleansing has been effected. The outer dressing must then be covered with sterilized damp towels or entirely removed. The inner dressing may be removed by the surgeon. It should on no account be moistened. The moistening of tissues while dressing them renders them far more liable to infection than dry tissues are. Not long ago, in one of the hospitals in this city, a surgeon was greatly perplexed to find that the wounds which regularly looked well at the time of the first dressing afterward broke down and suppurated. He found that the house-surgeon wet the wounds with bichloride solution in order to remove the dressings, and afterward washed them off with the same solution, in the endeavor to make them clean. After stopping this procedure, and having the gauze removed dry, layer by layer, he found that his wounds healed kindly. After the removal of the dressing the surgeon should take out the drainage-tube with a pair of sterilized forceps, and, if all looks well, should immediately apply a new dressing of sterilized gauze. If he considers it necessary to prevent the closing of the drainage opening, he may insert a little piece of sterilized gauze. In this entire procedure nothing but a pair of sterilized forceps should come in contact with the wound. Great care should be taken throughout the entire dressing to avoid injuring the tissues. The patient should be kept from moving as much as is practicable. And in the taking off of the dressing great care should be used to avoid pulling or stretching the parts. If slight suppuration occurs it is usually best treated by absorbent sterilized dressings frequently applied. If these absorb and dry the discharge, healing will quickly follow. If suppuration is too extensive for this, thorough drainage should be obtained by reopening as much of the incision as is necessary, and packing the wound with iodoform gauze.

Peroxide of hydrogen is useful in cleansing such wounds. Their undue irrigation and irritation in the dressing is to be avoided. Where suppuration involves such structures as the knee-joint, the continuous irrigation of water or mild antiseptic solution may be used.

The after-treatment in such operations as excision of the tongue or superior maxilla, resection of intestine, opening of the bladder, etc., varies with each operation. They involve no new principles, and there is not space here to consider them in detail.

Where large granulating surfaces or cavities exist, balsam of Peru is a useful stimulant. It may be injected, or strips of gauze may be saturated with it, and then inserted into the wound. In the management of such wounds care must be used lest there be burrowing and pocketing about its margin. Where there is such burrowing free incision should be made at once.

Throughout all of these details the technique is made with the effort to irritate the tissues as little as is possible, and to keep out infection. The operator may expect success according as he is able to fulfil these two requirements. As a practical illustration of the working of these methods I will give the history of a case of amputation of a leg, as done at the New York Cancer Hospital:

The patient was a man of twenty-three, who had suffered in boyhood from tubercular ulcers in various parts of his body. For four years a sarcoma had been grow-

ing in the calf of the leg; at the time of operation it was as large as a cocoa-nut. He was emaciated and in poor condition. Before the operation his oral temperature was frequently 100° or 101° F., and while he was taking the ether his pulse went up to 150. It was manifestly important to get the leg off with the least possible shock and without sepsis. Much shock or much sepsis would, either one, have been fatal to the patient. The arrangement of the patient, assistants, and instruments, is shown in Fig. 708. The operator stood beside the instrument-case at the patient's right. The instruments were transferred from the boiler directly to the instrument-tray, without touching anything. Some retractors, etc., were in another tray within reach of the assistants. Gauze pads were used instead of sponges; they were sterilized in steam, and are seen pictured in the towel which held them. The catgut is in the little holders in the instrument-tray. The silk-worm-gut was boiled with the instruments, several strands were threaded before the boiling. As the operation was short, and not many instruments were needed, the operator took his instruments and the catgut directly from the tray. The dressings were sterilized in cylinders, and were not removed from them until they were applied.

In glancing at these arrangements it will be seen that there was hardly any opportunity for septic contact. Drainage was not necessary in this case, but as the patient's condition was so bad, two small tubes were put in as a safeguard. Carden's amputation was done, making the flaps rather longer than those he describes.

On the afternoon following the operation his temperature went to 101° F., but as it had frequently done this before the operation, little importance was attached to it. The next morning it was normal, and it remained so steadily. On the second day the dressing was taken down and the tubes removed; the arrangements for this are indicated in Fig. 709. The wound was aseptic. On the ninth day the dressing was again taken off and the stitches removed. Healing was then complete by first intention, without a drop of pus at any part of the wound.

This case is cited to show what results may confidently be expected, even in debilitated patients, when stringent aseptic precautions are employed.

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Charles N. Dowd.

ZINC, POISONING BY. The most important salts of zinc, from a medico-legal point of view, are the sulphate and chloride.

Zinc sulphate, or *white vitriol* ($ZnSO_4$, $7H_2O$), is a colorless salt, crystallizing in small four-sided prisms, which slowly effloresce in dry air. It is soluble in about two times its weight of water at the ordinary temperature, and in less than its own weight of boiling water; insoluble in alcohol, ether, and chloroform. Its taste is astringent and metallic; its reaction, acid.

Zinc chloride ($ZnCl_2$), commonly called *butter of zinc*, is a soft, white, very deliquescent, readily fusible solid, freely soluble in water and in alcohol. Its taste, in the solid state or in concentrated solution, is acrid and corrosive; in dilute solution, astringent and metallic. Its reaction is acid. When brought into contact with raw surfaces or mucous membranes it acts as a corrosive. It has considerable antiseptic power also, and, in aqueous solution, is frequently used as an antiseptic, deodorizer, and disinfectant. The liquid known under the name of "Sir William Burnett's disinfecting fluid" is such a solution, containing over 200 grains of the salt in each fluid-ounce.

Cases of poisoning by these salts have been of rare occurrence, and usually the result of accident. Zinc sulphate resembles magnesic sulphate (Epsom salts) very closely in its appearance, and has frequently been taken by mistake for the latter, while Burnett's fluid, which has been the cause of most of the reported cases of poisoning by zinc chloride, has frequently been mistaken for water or other harmless liquid.

Symptoms.—Zinc sulphate acts as an irritant poison, but only when a large quantity has been taken. The symptoms are almost entirely local. The most prominent are: an astringent and metallic taste, burning pain in the œsophagus, stomach, and bowels, nausea, vomiting, purging, dyspnœa, small and frequent pulse, and cold extremities. The intellect usually remains clear.

The symptoms usually make their appearance almost immediately after swallowing the poison; but, in rare cases, have been more or less delayed.

Wormley quotes a case in which vomiting was delayed for fifteen minutes, and there was no purging for ten hours. In this case a solution containing 46.5 grammes (℥ jss.) of the salt was swallowed. In a case communicated by Lutier active symptoms appeared first after the lapse of fifteen hours.

The symptoms produced by zinc chloride are similar in character to those just described. This salt has, however, a violent corrosive action, which is wanting in the sulphate. The local symptoms are therefore usually more severe than they are in cases of poisoning by the sulphate, and are more frequently followed by symptoms of profound collapse and death. In non-fatal cases recovery may not be complete until after the lapse of several days, or even weeks.

The investigations of C. Ph. Falck, Blake, Letheby, and Harnack show that the salts of zinc paralyze the striated muscles and cause death by their action on the heart and muscles of respiration, without influencing, to any great extent, the central nervous system. F. A. Falck, who experimented with rabbits, found that the

temperature of the body is reduced 7° to 13° C. in cases of acute zinc poisoning.

Fatal Quantity.—Fatal Period.—The quantity of any of the preparations of zinc required to endanger life is not exactly known. The sulphate is not a powerful irritant. In large doses it acts as a prompt emetic, and is frequently rejected by the stomach without producing any other serious symptoms. Quantities varying from 4.3 to 124 grammes (67 grains to ʒ iv.) have been taken without fatal result. Death has occurred in five hours (a child), thirteen and a half hours (adult, 5.8 grammes), thirty-six hours (7.6 grammes), three days (adult, quantity unknown), and five days (adult, 15.5 grammes). The chloride is much more dangerous than the sulphate. Most of the reported cases of poisoning by this salt have been caused by Burnett's solution, and the quantity taken has usually been known only approximately. Recovery has followed the administration of quantities of this solution varying from half a wineglassful to three fluid-ounces, the quantity of salt varying, so far as known, from 0.8 to 26 grammes (12 to 400 grains). Six and one-half grammes (100 grains) has caused death. Death usually takes place within twenty-four hours. The shortest fatal periods are two hours (Taylor), four hours (Allanson), seven and a half hours (Cousins), ten hours (Letheby). Occasionally the patient has recovered from the primary effects, only to succumb to the secondary effects after the lapse of several weeks. In such cases death usually results from starvation, following upon stricture of the œsophagus, pylorus, or intestines.

Post-mortem Appearances.—When the sulphate has been taken, the lesions are substantially similar in character to those observed in cases of poisoning by other pure irritants. A slight ulceration, near the pyloric end of the stomach, has been noted in a single case. Rarely, there may be contraction of the stomach or intestines.

The chloride of zinc resembles in its action the mineral acids and caustic alkalies. In cases of poisoning by this salt the mucous membranes of the mouth, throat, œsophagus, stomach, and intestines are usually more or less disorganized. In a few cases, however, there has been an absence of corrosion even in the mouth. Perforation of the stomach, and stricture of the œsophagus, pylorus, and intestines may be met with, especially in cases which are not rapidly fatal. Congestion of the brain and its membranes, and of the lungs and kidneys, are usual sequels of acute poisoning.

Treatment.—Vomiting should be encouraged if necessary. Sodic carbonate precipitates and zinc carbonate from solutions of soluble zinc salts may therefore be employed as a temporary chemical antidote. In other respects treatment must be symptomatic.

Other Compounds of Zinc.—The remaining soluble salts of zinc are, substantially, duplicates, in their effects, of the sulphate or chloride.

Zinc oxide and *zinc carbonate* are white amorphous solids, insoluble in water, but soluble in dilute acids, the carbonate dissolving with effervescence. Either of these compounds, if taken internally in considerable quantity, may dissolve in the fluids of the stomach and intestines and give rise to acute or subacute poisoning, with the usual symptoms of irritant poisoning.

Chronic zinc poisoning has been ascribed to the long-continued inhalation of the vapors of zinc oxide. This form of poisoning has been observed in workers in zinc, brass, and galvanized iron, and is characterized by headache, chilliness, pains in the extremities, a strong metallic taste, nausea, vomiting, diarrhœa, and colic. It is to be borne in mind in this connection that commercial zinc usually contains lead, and frequently arsenic, and that the above symptoms may be those of poisoning by one or the other of these metals, and not by zinc oxide.

The use of galvanized iron pipes for conveying water, and of galvanized iron utensils for the preparation and storage of food, appears to be attended with some danger. Water that has passed through galvanized iron pipes almost always contains zinc compounds, either in solution or in suspension. There is some difference of opinion as to the effect of such water on health, but it is generally believed that the danger of poisoning from the zinc in solution in the water is very slight. When the water has stood in contact with the pipe for several hours it frequently holds in suspension a considerable quantity of insoluble zinc compounds. It seems probable that the use of such water would be attended with danger. As a precautionary measure, therefore, the water that has stood in contact with a galvanized iron pipe for several hours should be allowed to run to waste, or should be filtered before use.

Certain liquids used in cooking, especially such as contain vegetable acids, may dissolve a sufficient quantity of zinc from galvanized iron utensils to produce symptoms of poisoning. Wormley reports a case of zinc-poisoning caused by the use of apple butter prepared with cider which had been concentrated in a galvanized iron pan. The concentrated cider was found to contain 1.14 grain zinc oxide to each fluid-ounce.

Absorption and Elimination.—When compounds of zinc are taken internally the metal is absorbed, presumably in the form of albuminate, and may be detected after death in the blood and in all the tissues of the body. Matzkewitsch administered the acetate of zinc to dogs by subcutaneous injection, and found, as the result of five experiments, that the greater proportion of the zinc thus introduced was localized in the muscles and bones. The skin, brain, liver, heart, lungs, kidneys, bladder, stomach, and intestines contained zinc, but in relatively small quantities. Zinc is eliminated with the urine, bile, and milk (Falck, Harnack). According to Michaelis the metal is first detected in the excretions on the fourth or fifth day after the administration of its compounds. The time required for complete elimination is unknown. According to Popoff it can be detected in the urine for months after removal from its influence.

The study of the localization and elimination of zinc is attended with peculiar difficulties, inasmuch as the human system frequently contains small quantities of the metal even when its compounds have not been purposely administered. Raoult and Breton isolated 7 milligr. of zinc from 700 grammes of human liver in one case; 12 milligr. from 400 grammes of liver in a second case. In four other cases they extracted 10, 30, 34, and 76 milligr., respectively, from 1,000 grammes of liver. Lechartier and Bellamy obtained similar results. In one case 1,780 grammes of liver contained 20 milligr. of zinc oxide. The same authors extracted 30 milligr. of zinc oxide from 913 grammes of muscle from the ox, and 20 milligr. from 1,152 grammes hard-boiled egg. They also detected traces of zinc in corn, maize, barley, and white beans.

The frequent presence of small quantities of zinc in the organs of the body may be explained in some cases by the use of water which has been conveyed through galvanized iron pipes, or by the use of food which has absorbed zinc from galvanized iron utensils; in other cases, by the medicinal administration of preparations of zinc before death, or the introduction of embalming fluids containing salts of zinc, after death.

In consideration of the foregoing facts it is obvious that the detection of zinc in the tissues after death cannot, when unsupported by other evidence, be accepted as proof that death was caused by zinc-poisoning.

William B. Hills.

ADDENDUM.

PLASMODIA MALARIÆ. Although one of the criteria which are generally demanded to establish the parasitic nature of a disease is yet wanting in malaria, still the evidence is quite convincing that the disease is caused by a specific micro-organism; or, more probably, by several different organisms which are nearly alike, but differ from each other in each type of the disease; one kind of parasite causing tertian fever, another but similar organism causing quartan fever, etc. The break in the chain of evidence is the fact that the parasites have not yet been cultivated upon artificial media. Still the observations of a great many trustworthy observers, agreeing as they do in everything except a few matters of minor detail, leave little room for doubt. The parasites are classed as protozoa, and are called the plasmodia malariæ. They are always found, according to all observers, in the blood of persons suffering from malaria, and are not found in the blood of any other persons. The only matter about which there is still a difference of opinion is whether there is only one micro-organism which causes all the different forms of malaria, or whether there is a different micro-organism for each of the forms of malaria which present diverse clinical peculiarities. Barbacci,[1] from whose admirable review I have taken most of the data for the present brief article, has carefully sifted the literature upon the subject of the malarial parasites. He finds that the authorities may be divided into two schools: Laveran and his followers on the one hand, and the Italian school on the other. American observers seem to favor the views of the Italian school. Laveran holds that a single kind of parasite is the constant cause of malaria, and that the polymorphic varieties of this parasite have no close connection with the different clinical phenomena of the various forms of malaria. The Italian school, on the contrary, contends that there are different kinds of malaria-organisms, which bear a close relation to one another, but which are not identical; and that each different clinical form of the infection is dependent upon the cycle of development of its peculiar parasite. According to Laveran the fully developed organism is represented by moving filaments which are developed within small cystic bodies, the so-called pigmented bodies, and finally become detached from these, and move about in the blood plasma; whereas the Italian school regards the amœba, or plasmodium of Machiafava and Celli, as the fundamental form of the organism. This is a more or less round mass of protoplasm containing no pigment granules, and endowed with amœboid movement. Finally, Laveran maintains that those organisms which are not found floating around free in the blood are merely in contact with the red blood-corpuscles, or are at most simply attached to these, but not in them. The Italian school, on the contrary, maintains that the parasite in these cases is in the red blood-corpuscles; that it derives its nutrition from the hæmoglobin of the latter, and goes through many or all of its phases of development, even to reproduction, inside the red blood-corpuscles.

Laveran clearly deserves the credit of having first established the parasitic nature of the cause of malaria, and the fundamental facts which he has established no longer meet with serious opposition. The matters in dispute, as stated above, are mainly questions of interpretation.

Before going on to describe the micro-organisms, a few words as to the methods of preparing the blood for examination may not be amiss.

The blood may be examined fresh without any special preparation, or it may be examined by staining it with different dyes, either with or without previous fixation on the glass by means of various fixing agents. If no special or prolonged study is needed, it is only necessary to take a very small drop, half the size of a pin-head, from the spleen, or end of the finger, or from the lobe of the ear. For puncturing the finger or lobe of the ear it is better to use a very fine lancet rather than a needle. After the puncture is made a cover-glass, which must be thoroughly clean, is applied to the drop of blood which appears, and is then simply placed on the slide and examined. Preparations of this kind can be used for examination for a longer time if the edges of the cover-glass are sealed around to the slide with paraffin to prevent evaporation.

It is usual to make colored preparations, and for this purpose the aniline dyes are best, especially a concentrated alcoholic or aqueous solution of methylene blue. The cover-glasses with the blood spread over them are allowed to dry, passed over a flame in order to fix the blood, and then placed in the alcoholic solution for half a minute, or in the aqueous solution for one or two hours. After staining, the dye is washed off with water and the specimen may be examined at once; or it may be allowed to dry and then mounted in balsam; or better still, in a concentrated solution of gum arabic. There are a great many modifications and improvements on this method, such as the use of special fixing and hardening reagents, and the use of contrast stains, many of which will suggest themselves. An account of all the various methods will be found in Barbacci's article above referred to.

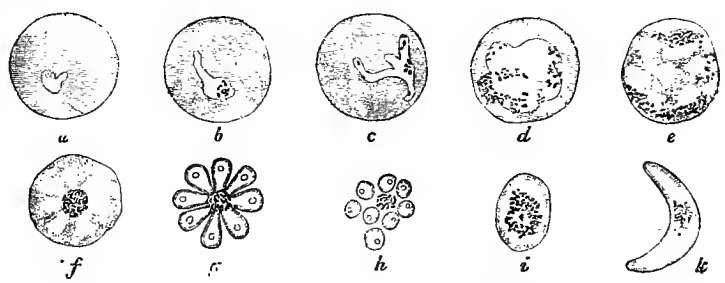

FIG. 710.—Plasmodium Malariæ of a Quartan Fever in Different Stages of Development (according to Golgi). *a*, Red blood-corpuscles containing a small non-pigmented plasmodium; *b*, *c*, *d*, *e*, plasmodia varying in size, inside red blood-corpuscles and containing pigment granules; *f*, plasmodium at the beginning of pigmentation with pigment in the centre; *g*, a segmented plasmodium, *h*, *a*, plasmodium segmented into little spheres, *i*, *k*, two free plasmodia of different shapes. (Ziegler: Lehrbuch d. All. Path. Anat., 7te Auflage, p. 622, Fig. 384, Jena, 1892.)

Laveran[2] in his recent book clearly defines his interpretation of the different pictures met with in preparations of malarial blood. According to Laveran the malarial parasite exhibits a variety of different forms, all of which can be brought together under one of four fundamental types:

1. *Spherical Bodies.*—These are spheroidal bodies with amœboid movement, varying in size from 1 μ to twice the size of a red blood-corpuscle (Fig. 710 *h*, *i*). The smaller forms are devoid of pigment, but as they increase in size they take up pigment granules, and these granules are then seen to have a lively oscillatory movement. The movement, according to Laveran, is probably imparted to the granules by the amœboid changes of the plasmodium. The spherical bodies are either free in the plasma, or are in contact with the red blood-corpuscles from which they derive their nutrition. It is still a disputed point whether they possess nuclei and reproduce by segmentation. They are the commonest forms met with in malaria.

2. *Bodies with Flagella.*—These are spherical bodies free in the blood plasma, with long moving filaments (Figs. 711, *f*, and 712, *g*) attached. At a certain stage these flagella separate from the spherical bodies and swim around free in among the blood-corpuscles. Laveran says that at this stage it is perfectly evident these flagella have an independent existence, and that they constitute the most characteristic form which the malarial parasite assumes.

3. *Crescents.*—These are semilunar bodies or crescents with more or less pointed ends (Figs. 710, *k*, and 712, *e*, *f*), consisting of a colorless substance and having pigment granules about the centre. They are double-contoured, and have usually a long diameter greater than that of a red blood-corpuscle. They are found lying free in the blood plasma, or when they are attached to the red blood-corpuscles the attachment is so slight that it is easily broken by a slight jarring of the preparation. They are without motion and devoid of flagella. The pigment contained in them is also motionless. By observing them for some time under the microscope they are seen gradually to assume first an oval, and then a spheroidal, shape. They are oftenest seen in patients with malarial relapse, or with malarial cachexia.

4. *Rosettes.*—These are elements floating around free in the blood (Fig. 710, *g*), pigmented in the central part, and regularly divided into a varying number of round or oval bodies.

All of these four forms are to be regarded, according to Laveran, as merely successive phases in the development of one and the same organism, and not as separate and distinct organisms, in spite of the great differences in shape. The small, hyaline, unpigmented bodies on the red corpuscles are probably the embryo stage of the parasite. From this stage the organism gradually increases in size to that of a red blood-corpuscle or more, and also gradually takes up pigment granules. These bodies are possessed of amœboid movement, live free in the plasma, attach themselves to the red blood-corpuscles, deriving their nutrition and also the pigment granules from these. The flagella develop inside of these bodies, and at a certain stage become liberated. Laveran, moreover, holds that there is no relation between the different forms of the organism and the different clinical types of malaria. He claims that the most that can be said is that certain of the forms are oftenest seen in certain types of malaria, as, for example, the crescents in relapsing fever and malarial cachexia.

The attitude of the Italian school has been well formulated by Golgi. Golgi claims that the plasmodia develop inside the red corpuscles, and the first stage is the appearance of a small, colorless, amœboid body in the red

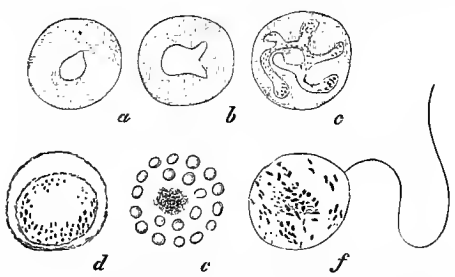

FIG. 711.—Plasmodium Malariæ of a Tertian Fever in Different Stages of Development (according to Golgi). *a*, First stage; *b*, *c*, plasmodia increased in size with amœboid processes; *d*, plasmodium before sporulation, blood-corpuscle decolorized; *e*, sporulation; *f*, free parasite with flagellum. (Ziegler: Lehrbuch der All. Path. Anat., 7te Auflage, p. 623, Fig. 685.)

corpuscles (Figs. 710, *a*, 711, *a*, 712, *a*, *b*). In this stage the organisms of different types of malaria are indistinguishable. The character of the further development depends upon whether the organism is that of quartan, tertian, or quotidian fever.

In quartan fever further development consists in a gradual increase in the size of the plasmodium (Fig. 711, *b*, *c*, *d*, *e*), which occupies more and more of the red blood-corpuscle; at the same time pigment granules appear inside the parasite, which are made up of the coloring matter of the blood-corpuscles. After the plasmodium has attained a certain size the pigment granules accumulate toward the centre, and at the same time a radiating segmentation takes place, producing a rosette-like figure

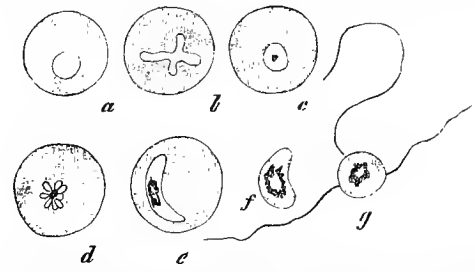

FIG. 712.—Plasmodium Malariæ of a Quotidian Fever in Different Stages of Development (according to Celli and Sanfelice). *a*, First stage in the development; *b*, plasmodium with amœboid processes; *c*, plasmodium which has become round and contains pigment, before segmentation; *d*, sporulation; *e*, intra-globular crescent; *f*, *g*, free forms. (Ibid., p. 624.)

(Fig. 710, *f*, *g*), consisting of a pigmented centre surrounded by from six to twelve colorless, radiating, pear-shaped bodies, with the clubbed extremities toward the periphery. Subsequently the pear-shaped bodies are liberated and assume a spherical shape. These phases are completed in three days in the quartan type of fever, and the appearance of fever takes place simultaneously with the segmentation of the plasmodium. The red corpuscles which contain the parasites are destroyed, and the liberated plasmodia force their way into the bodies of other red corpuscles and begin development anew. The pigment granules are some of them set free, while others are taken up by the cells of various organs, notably the spleen and liver.

In tertian fever the development of the plasmodium takes place in two days. The amœbæ in this case show a much more active amœboid movement, and decolorize the red blood-corpuscles much more quickly than in the quartan form. In the tertian fever the red corpuscles become decolorized on the first day of the fever, while the plasmodia are still small. The protoplasm of the tertian plasmodium is more delicate and less sharply outlined, and the pigment granules are finer than in the quartan type (Fig. 711, *a*, *b*, *c*). The number of segments into which the plasmodium of tertian fever breaks up is about double that of the quartan fever (Fig. 711, *e*). Machiafava and Celli regard this segmentation as a sporulation, and have noticed it taking place before the red corpuscle is destroyed, and have seen red corpuscles containing from five to ten spores. In tertian, moreover, the red corpuscles generally retain their shape till they are destroyed, whereas in quartan malaria the red blood-corpuscles become wrinkled.

In quotidian fever and pernicious malaria, according to Celli and Sanfelice, the parasite consists of a small body with very active amœboid motion inside the red blood-cell. Shortly before an attack of fever the parasite becomes pigmented and globular, and then segments into spores.

Besides all these forms the Italian observers substantiate Laveran's observations of intra-corpuscular, and free, round, oval, or half-moon-shaped bodies as well as round bodies with filaments (Figs. 710, *i*, *k*, and 711, *f*, and 712, *f*, *g*).

The semilunar forms and the filamented forms are regarded as sterile; they are not capable of reproduction, and sooner or later are destroyed. Some authors regard the crescentic bodies as the cause of the typical more or less continued fevers of summer and autumn, the æstivo-autumnal fevers, which are apt to be pernicious. It is also claimed by some that they are not seen inside the blood-corpuscles, and neither inside nor outside in quartan or tertian, but only in æstivo-autumnal fever.

The plasmodia are taken up by the leucocytes at any and all stages. Leucocytes can be consequently observed with whole plasmodia in them, or with fragments of these, or simply with pigment granules.

Dr. W. S. Thayer, of the Johns Hopkins Hospital, who has had a great deal of experience in examining the blood of malarial patients, tells me that he has never found organisms such as are represented by *i*, *k*, Fig. 710, in quartan fever, but that they are only met with in quotidian.

Machiafava and Bignami [3] sum up the facts thus far established in regard to the etiology of malaria about as follows:

1. Malaria is a parasitic disease caused by a hæmatozoön belonging to the protozoa, and not to the schizomycetes.

2. The malarial hæmatozoa are amœbæ, which develop inside the red blood-corpuscles, changing the hæmoglobin of the latter into melanin, or causing a rapid toxic necrosis of these; this is the source of malarial anæmia.

3. The malarial amœbæ complete their cycle of life in the bodies of the red blood-corpuscles. They begin as unpigmented but actively moving bodies, and these develop, finally becoming pigmented, and then multiply by segmentation into spores. The spores become amœbæ and enter into the red corpuscles, thus completing the cycle.

4. This cycle corresponds with the periodic recurrence of the attacks; the sporulation (segmentation) is coincident with the beginning of every attack of fever.

5. Everything points to the probability that during the course of their development and growth the amœbæ produce a pyrogenic poison, though this has not yet been demonstrated. The fundamental changes in the red blood-corpuscles, and the changes in the parenchyma of some of the organs, are almost certainly due to the action of this poison.

6. Each type of fever has a parasite with certain biological and morphological peculiarities, so that the necessary conclusion is that there are several varieties or species of amœbæ in malaria. The difference in the biological and pathogenic peculiarities of the parasites is in each case an index of the type of the fever. Differences can now be made out between the amœbæ of quartan fever, the amœbæ of tertian fever, the amœbæ of the æstivo-autumnal fever, and the amœbæ of quotidian fever. The pernicious fevers are only caused by the last two varieties of amœba, and the presence of these amœbæ always indicates a pernicious type of fever. So that benign and malignant fevers may be differentiated by examination of the blood alone.

7. The malarial amœbæ cause changes not only in the blood, but also in the blood-vessels of all the organs, and in the parenchyma of many of these (spleen, kidney, bone-marrow). The changes in some of the organs are temporary and explain the symptoms which accompany the acute infection. In other organs (spleen, liver, bone-marrow) the changes are permanent, and account for the chronic anæmia and the symptoms of chronic infection and malarial cachexia.

Meade Bolton.

[1] Otto Barbacci: Ueber die Aetiologie der Malariainfektion nach der heutigen Parasitenlehre, Centralblatt für Allgem. Path. u. s. w., Band iii., Nos. 2 u. c. Jena, 1892.
[2] Laveran: Du Paludisme et de son Hématozoaire. 8vo, Paris, 1891.
[3] Deutsche Med. Wochenschrift, Nos. 51 and 52, 1892.

INDEX TO SUPPLEMENT.

An asterisk (*) indicates that the subject referred to is treated at length in a separate article. (Fig.) following a reference shows that the subject is further explained by wood-cuts.

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